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ORIGINAL PAPER

Quantifying the Effect of Environmental Factors on Mosquito Larvae Control in a Nigerian Community

O. A. Mokuolu[1] · A. O. Coker[2] · M. Adejumo[3] · M. K. C. Sridhar[3]

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Abstract This study quantified the effect of environmental factors on mosquito larvae control in Okelele community, Ilorin, Kwara state, Nigeria. A community-based, cross-sectional study was conducted using a 3-stage random sampling technique to select Zones, Households and 200 parents/guardians and their children under 14 years of age. Interviews were conducted using a semi-structured questionnaire and key informant interview guide. In addition, water samples from potholes, stagnant water and drainages were collected for mosquito larvae counts using the Bourne method. The mean age of houses was 33.4 ± 11.9 years (Range 1–70) and 58.0 % were built with mud. The mean household population was 6.1 ± 3.1 (Range 1–17), 28.0 % of the respondents (fathers) had no formal education. Most of the houses (99.0 %) had open drainages in their vicinities and 91.9 % were stagnant. Some (65.5 %) of the households had door nets, 17.0 % had mosquito nets, while 13.5 % had Insecticide-Treated Nets (ITN). The environmental problems stated by the respondents were inappropriate solid waste disposal methods, lack of potable water and lack of sanitation facilities. Mean anti-vectors practice score of the respondents was 4.9 ± 2.9 and majority (78.5 %) had poor anti-vector practices. Respondents with primary education (OR 0.28; CI 0.09–0.85), secondary education (OR 0.31; CI 0.10–0.94) and tertiary education (OR 0.28; CI 0.07–0.72) were less likely to have poor anti-vector practices compared to those with no formal education. The mosquito's larva distribution values per litre in Amuyankan, Omoboriowo, Lowin, Jagun and Babaladifa were 21 ± 6.7, 12 ± 2.9, 25 ± 4.9, 02 ± 1.0 and 17 ± 5.1 respectively. The estimated Larva counts per square metre were 2658 (Amuyankan), 1519 (Omoboriowo), 3165 (Lowin), 253 (Jagun) and 2152 (Babaladifa). Irrespective of the larval count, majority had poor anti-vector practices and this was most common among those with no formal education.

Keywords Anti-vector practices · Mosquito larvae distribution · Environmental problems · Open drains · Education

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Introduction

The malaria mortality rate among children under five in sub-Saharan Africa is still unacceptably high; accounting for 90 % of the 584,000 global malaria deaths. Nigeria constitutes a third of the global malaria deaths and spending on malaria illnesses is estimated to be $1billion per annum in the country (WHO 2014). The control of malaria involves three living beings and their environment; man, mosquito and the larva. This interrelationship may be described as a malaria chain. Current approaches to malaria control target the various living beings in the malaria chain. These include (i) vector control through the use of insecticide-treated nets (ITNs), indoor residual spraying (IRS) and in some specific settings, larval control; (ii)

chemoprevention for the most vulnerable populations, particularly pregnant women and infants; (iii) confirmation of malaria diagnosis through microscopy or Rapid Diagnostic Tests (RDTs) for every suspected case and (iv) timely treatment with appropriate antimalarial medicines (WHO 2011).

Vector control is among the key strategies that are widely promoted by the World Health Organization (WHO) and the Roll Back Malaria partnership (RBM) for the prevention and reduction of malaria. This approach involves prevention, reduction or interruption of the transmission cycle. The common methods of malaria vector control available include ITNs, Long-Lasting ITNs (LLITNs) and Indoor Residual Spraying (IRS). While ITNs, LLITNs and IRS involve the use of chemical insecticides, some of the other methods of controlling larval or adult mosquitoes apply biological control techniques or environmental management. Currently, the main biological control agents that have been successfully employed against *Anopheles* are predators (particularly fish) and the bacterial pathogens *Bacillus thuringiensis, var. israelensis* and *Bacillus sphaericus* that attack the larval stages of the mosquito. Several fungal pathogens in the genera *Metarhizium* and *Beauveria* show promise as larvicides, although commercial formulations are not presently available for mosquito control (Walker and Lynch 2007).

Environmental control changes the environments of the vectors in such a way that the habitats are no more suitable for them, it involves elimination of all potential mosquito breeding sites and places where water collects whether deep, shallow, stagnant, flowing, dirty, clean, fresh or salty. Larval reduction naturally reduces adult populations. Unfortunately, the prevention of the breeding of mosquitoes has been marred by poor environmental management, particularly indiscriminate refuse disposal practices and presence of stagnant water around the residential areas. Moreover, studies have documented control measures to reduce mosquito populations in human surroundings but the effect of environmental factors on mosquito larvae control has not been adequately quantified (Oluwande 1983; Najera and Zaim 2003). Therefore, this study quantified the effect of such factors on mosquito larvae control in a Nigerian community.

Materials and Methods

Ethical Considerations

This study was approved by the University of Ilorin Teaching Hospital, Ethical Review Committee before the commencement of the field work. Also, permission was obtained from the district authorities and community leaders. Individual interviews and tests for baseline data were only started after the purpose of the study had been clearly explained to the participants and informed consent obtained. Participation was made voluntary and no form of coercion was adopted. There was no undue influence on the participants. Participants were ensured confidentiality of all information obtained from them and respondents' names were not written on the questionnaire in order to ensure anonymity.

Study Area and Location

This study was carried out in Okelele community of Ilorin East Local Government of Kwara state. Kwara State with Ilorin as its capital city has 16 Local Government areas (LGAs). It is located within longitudes 4°30′ and 4°45′ E and latitudes 8°25′ and 8°40′N, covering a land area of 75 km^2 with an estimated population of 1.4 million people (National Bureau of Statistics, Nigeria). It is about 300 km away from Lagos and 500 km away from Abuja the Federal Capital of Nigeria. The climate is tropical with mean annual temperature, relative humidity and rainfall of 27 °C, 76 % and 1800 mm, respectively. The climate presents two distinct seasons: a rainy season between April and November, which peaks in June and August, and a dry season (December–March) completely devoid of rains. The vegetation in Ilorin reflects that of the Guinea savanna zone, characterized by a predominance of tall grasses, which are frequently removed by violent bush burning activities in the dry season (Olayemi and Ande 2008).

Okelele community, with a population of 36,191 (National Population Commission) lies between longitude 04°32′ and latitude 08°26′ and covered an estimated land area of 1.5 km^2. The relief flanking the flood plains around Okelele is between 290 m and 305 m above the sea level (Personal communication through the office of Surveyor General, Kwara State Government and confirmed through GIS). It has a rural setting and was chosen following a review of the records of admissions at the Emergency Paediatric Unit (EPU) of the University of Ilorin Teaching Hospital, the largest and busiest hospital in the state. The records revealed that majority of the patients admitted into the Unit for severe malaria were from Okelele area of the town. Of a total of 226 with severe malaria in a one year period, 121 (53.6 %) of the subjects were from Okelele area. Subjects from this area also accounted for 44 % of the malaria-related mortality rate (Mokuolu et al. 2011). The obvious geographical pattern in the distribution of severe malaria patients seen in this facility raised the consideration of probable environmental factors being the cause of the predominance of malaria in the area.

Study Design

This study was community-based and cross-sectional in design. It involved children below 14 years of age and their respective mothers or guardians in Okelele community, Ilorin East LGA, Kwara state. A 3-stage random sampling technique was used to select zones, households and 200 respondents and their children aged below 14 years to participate in the study. A set of semi-structured questionnaires was developed to collect information on households, anti-vector practices, surroundings and children data from their respective parents. Also, community members were interviewed using a validated key informant interview guide. Thereafter, water samples from potholes, stagnant water and drainages were collected for mosquito larvae tests using the Bourne method (Bourne 2003).

Study Population and Sampling Techniques

Okelele Community was purposively selected and divided into five zones Lowin, Amuyankan, Omoboriowo, Jagun and Babaladifa these are named after the most prominent compound within it. Forty (40) households, each from the 5 zones, were randomly selected by balloting. In each selected household, two or three children aged below 14 years old were randomly selected through balloting. Parents of the children were interviewed using a validated questionnaire. During the planning of the study, the researchers approached the LGA in charge of the selected community particularly the Department of Community Development Inspectorate (CDI) and Environmental Health Unit in the Department of Health in the LGA.

Also, Information about the Community Development Association (CDA) and other relevant associations were collected. From the information collected, a list of landlords and landladies of houses in the community was collected and the community was entered through the leader who usually represents them at the LG Council meetings. Entry into the community was made through the CDA and in conjunction with LG staff in the CDI office. Contacts were made with the chairman of the CDA and a good working relationship was established. All the contacts were made through formal letters to obtain permission to carry out the work in the community; the letters also explained the study objectives. Furthermore, a sensitization talk on the theme and objectives of the study was given at one of the CDA meetings ensuring that they understood all aspects of the study. Completed and signed consent forms were obtained from parents/guardians, and the children. Parents, who accepted their children to be included in the study, presented them at the time of data collection. The simple random sampling technique was used to represent a proportional distribution of the various zones of the community. Consenting children and parents in the community were interviewed using a semi-structured questionnaire containing information on household characteristics, household surroundings and anti-vector practices. A 14-point anti-vector practice scale was developed and practices score of >7 was rated as good anti-vector practice. The interviews were conducted by 10 trained Research Assistants (5 male and 5 female) who are university graduates, acquainted with the questionnaire and key informant interview research. They were trained on how to use the instrument and how to properly introduce themselves and the research objectives to the children and their mothers during the interview.

Mosquito Larvae Count

Five samples from potholes, stagnant water and drainages were collected for mosquito larvae tests from each zone using the Bourne method. Larvae were collected using a calibrated measuring cylinder attached to a handle of an appropriate length as dipper, which was swept through the water until half full then left floating in the water, while the larvae within it were removed. Using a dipper of known capacity allows the number of larvae collected to be related to the surface area of the water examined, allowing calculation of the number of mosquito larvae per unit area of the water habitat.

Data Management and Analysis

Data generated from the field were edited daily. Then they were coded and entered into the computer for analysis using SPSS 17 statistical software package. Data were analysed and presented as mean and standard deviation for continuous variables and percentages for categorical variables. Chi-square statistic and Logistic regression were used to determine the associations between household characteristics associated with anti-vector practices. Statistical significance was defined at $p < 0.05$. Furthermore, qualitative data (from KII) were transcribed, edited and saved appropriately using rich text format, while the content analysis technique was adopted to analyse the data. Qualitative data were presented using thematic approach.

Results

House and Household Characteristics

Overall, 200 households participated in the study. About 58.0 % of the houses were built with mud, ranging from 1 to 70 years with a mean age of 33.4 ± 11.9 years and

40.5 % of the houses were between the age category of >30–40 years (Table 1). The mean household size was 6.1 ± 3.1 (Range 1–17) and 51.5 % of the households had 5–10 members. Twenty-eight percent (28.0 %) of the fathers in the households had no formal education, while 25.0 % of the fathers were engaged in artisanship and clergy work. Less than one-third, 29.5 % had 1 child of less than or equal to 14 years of age, 24.0 % had 2, while 12.5 % had more than 4 children aged below 14 years.

Features of the Household Surroundings and Common Environmental Problems

Table 2 shows that 93.0 % of the households had no weeds in the immediate surroundings, 7.0 % had; however only 1.5 % stated that they cut the weeds immediately around their houses once in a month. Most of the houses (99.0 %) had open drains in their immediate surroundings. Some 74.0 % of the houses had one drain around, 25.0 % had two, while 196 (99.0 %) of the drainages were open. 184 (91.9 %) drains were stagnant, while 14 (7.1 %) had minimal flow. Furthermore, the key informants in their discussion stated that environmental problems such as lack of appropriate solid waste disposal methods, lack of potable water, lack of sanitation facilities and appropriate drainages were common problems that needed urgent attention within the community. During a discussion at Babaladifa zone, respondents expressed their dissatisfaction in wells being dug indiscriminately within the community in order to have access to water sources. Lowin zone *mogaji* (head of community) reported that their area was neglected concerning cleaning of the environment. He further stated that there was no single 'roro' bin for solid waste disposal allocated to areas/community by the state/LG. Quoted below are some of the participants' opinions:

> "The government has neglected the area and nobody is coming to our aid concerning cleaning of the environment, no single' roro' bin is found in the area" (KII, Lowin zone)

> "The environmental problems we have here are lack of potable water and sanitation facilities within the community. Wells were dug indiscriminately around here" (KII, Babaladifa zone)

Table 1 House and household characteristics (N = 200)

Characteristics	Number	%
Type of house		
Brick wall	31	15.5
Sandcrete blockwall	53	26.5
Mud houses	116	58.0
Age of the building (In years)		
≤10	17	8.5
>10-20	6	3.0
>20-30	53	26.5
>30-40	81	40.5
>40 and above	14	7.0
No Response	29	14.5
Mean ± SD = 33.4 ± 11.9, Range 1–70		
Father's level of education		
None	56	28.0
Primary education	50	25.0
Secondary education	54	27.0
Post-secondary education	40	20.0
Father's occupation		
Artisan	50	25.0
Trading	31	15.5
Civil servant	40	20.0
Farming	14	7.0
Driving	15	7.5
Clergy	50	25.0
Number of Children per household		
1	59	29.5
2	48	24.0
3	40	20.0
4	28	14.0
>4	24	12.5

Causes and Problems of Mosquitoes

The main causes of the breeding of mosquitoes described by the survey participants were stagnant water, accumulation of solid waste and bushy areas around the dwelling places. They also mentioned blockage of drainages with solid waste and faecal matter. The *mogaji* of Omoboriowo zone added that laziness on the part of their people to observe environmental day activities on the last Saturday of every month could aggravate environmental problems, thus enhancing mosquito breeding sites. Some of the participants' viewpoints are quoted below:

> "Stagnant water and accumulation of solid waste can cause mosquito to breed in an area" (KII, Jagun zone)

> "Laziness on the part of their people to observe environmental day activities i.e. last Saturday of every month 7am to 9am" (KII, Omoboriowo zone)

Moreover, respondents reported that mosquito breeding and occurrence within the community could cause malaria and other ailments. One of the participants (Amuyankan zone) explained further that malaria is common among children especially those below the age of five, thereby affecting their growth and development. In another session,

Table 2 Features of the household surroundings

Features	Yes (%)	No (%)
Weeds immediately around the surroundings	14 (7.0)	186 (93.0)
Frequency of cutting the weeds		
Monthly	3 (1.5)	0 (0.0)
2–3 month interval	1 (0.5)	0 (0.0)
Never	1 (0.5)	0 (0.0)
No Response	9 (4.5)	0 (0.0)
Number of drains around houses		
One	148 (74.0)	0 (0.0)
Two	50 (25.0)	0 (0.0)
Types of drain		
Open	196 (99.0)	0 (0.0)
Covered	2 (1.0)	0 (0.0)
Flow		
Flowing	14 (7.1)	0 (0.0)
Stagnant	184 (91.9)	0 (0.0)

Babaladifa zone key informant stated that malaria treatment in children less than 5 years within a household could affect the household's economic activities and thus lead to poor income level. Furthermore, Amuyankan zone's key informant explained that the treatment of a malaria episode in a household could take away other resources like time and money which would be profitable if expended on income-generating activities. The respondents' views are presented below:

> "Mosquito' breeding and occurrence within the community causes malaria and other fevers" (KII, Jagun zone)

> "Treatment of a malaria episode in a household could take away other resources like time and money which might be profitable if expended on income generating activities" (KII, Amuyankan zone)

Household Anti-Vector Practices

Majority (65.5 %) of the households had door nets in their houses, only 34.5 % did not, while 82.5 % had window nets as seen in Table 3. Majority (82.5 %) stated that they open their windows at night, while the other 17.5 % said they do not. Less than one-fifth of the households, i.e. 17.0 % had mosquito nets. while 83.0 % had none. Twenty-four (12.0 %) of those with mosquito nets had one per household, while 10 (5.0 %) had more than one. Only 13.5 % had Insecticide-Treated Nets (ITN) and 86.5 % did not have. Seventeen (8.5 %) of those with ITN had one per household, whereas 10 (5.0 %) had more than one ITN in their houses.

Information about the respondents' anti-vectors practices was collected during the interview. Respondents' mean anti-vector practice score was 4.9 ± 2.9 and majority (78.5 %) had poor anti-vector practices. Respondents' anti-vector practices were compared with the type of house, type of family and their fathers' level of education. Table 4 shows that no significant association exists between respondents' anti-vector practices, the type of house or family. However their anti-vector practices were significantly affected by their fathers' level of education. Furthermore, respondents with primary education (OR 0.28; CI 0.09–0.85), secondary education (OR 0.31; CI 0.10–0.94) and tertiary education (OR 0.28; CI 0.07–0.72) were less likely to have poor anti-vector practices compared to those with no formal education.

Table 3 Household anti-vector practices

Practices	Yes (%)	No (%)
Houses with door nets	131 (65.5)	69 (34.5)
Windows with nets	165 (82.5)	35 (17.5)
Open windows at night	165 (82.5)	35 (17.5)
Number of mosquito nets		
One	24 (12.0)	0 (0.0)
>One	10 (5.0)	0 (0.0)
Have insecticide-treated nets	27 (13.5)	173 (86.5)
Number of insecticide-treated nets		
One	17 (8.5)	0 (0.0)
>One	10 (5.0)	0 (0.0)

Mosquito Larvae Distribution

Mosquito larvae count in each of the five zones of Okelele community is shown in Table 5. Although mosquito larvae were collected from the same surface area (0.0079 m^2) of

Table 4 Characteristics associated with anti-vector practices

Characteristics	Ant-vector practice		Total (%)	$\chi 2$ (p value)	OR (95 % CI)
	Poor (%)	Good (%)			
Type of house					
Brick wall	21 (13.4)	10 (23.3)	31 (15.5)	2.694 (0.260)	–
Sandcrete blockwall	41 (26.1)	12 (27.9)	53 (26.5)		–
Mud houses	95 (60.5)	21 (48.8)	116 (58.0)		–
Family type					
Monogamous	97 (61.8)	29 (67.4)	126 (63.0)	0.657 (0.418)	–
Polygamous	60 (38.2)	14 (32.6)	74 (37.0)		–
Father's level of education					
No formal education	51 (32.5)	5 (9.3)	56 (28.0)	7.247 (0.030)	1
Primary education	37 (23.6)	13 (30.2)	50 (25.0)		0.28 (0.09–0.85)
Secondary education	41 (26.1)	13 (30.2)	54 (27.0)		0.31 (0.10–0.94)
Post-secondary education	28 (17.8)	12 (30.3)	40 (20.0)		0.28 (0.07–0.72)

container, larva distributions from the five zones were different. The mosquito larva distribution values in Amuyankan, Omoboriowo, Lowin, Jagun and Babaladifa were 21 ± 6.7, 12 ± 2.9, 25 ± 4.9, 02 ± 1.0 and 17 ± 5.1 respectively. The estimated Larval counts per square metre were 2658 (Amuyankan), 1519 (Omoboriowo), 3165 (Lowin), 253 (Jagun) and 2152 (Babaladifa).

Discussion

The study assessed the effect of environmental factors on mosquito larval control in a peri- urban community. It was found that a large proportion of the houses visited were built with mud. This finding ascertained that the study was carried out in rural/peri-urban settings. In their findings Coker et al. (2008) reported that houses in the high density areas have the worst property and environmental characteristics followed by houses in the medium density area. Furthermore, it has been shown that mud walls are associated with malaria infection (Petersoni et al. 2009). According to DHS (2008), the average number of persons per household is about six (6) in most developing countries. This study revealed that the mean number of household member is 6.1 ± 3.1 (Range 1–17). A high percentage had formal education, most likely due to their proximity to Ilorin, the state capital, where access to essential information about formal education is easily found.

Although most of the households had open drainages close to their houses, a large proportion had no weeds in the immediate surroundings. Open drainages could contribute to an increase in the breeding of mosquitoes. This is similar to Bourne's findings, that mosquitoes can breed anywhere that stagnates water, but smaller man-made potential breeding habitats include household articles and discarded trash such as tyres, drums, pails, garbage cans, plant pots, swimming pools, bottles, discarded automobiles and household appliances (Bourne 2003). Furthermore, irrigation schemes by dam construction have led to an increased risk of malaria in Tigray, Ethiopia (Mekonnen et al. 2005). Key informants also identified stagnant water, accumulation of solid waste and bushy areas around the dwelling places as causes of the breeding of mosquitoes. The maintenance of a hygienic environment would resolve these problems and subsequently reduce the outbreak of malaria among household members especially children under 5 years old. This is in accordance with Fillinger et al. (2009); Worrall and Fillinger (2011) findings where it was

Table 5 Mosquito larva distribution in five zones of Okelele community

Zones	Larva distribution Mean ± SD (Min.–Max.)	Surface area (m^2) of container	Larva count per square metre
Amuyankan	21 ± 6.7 (12–29)	0.0079	2658
Omoboriowo	12 ± 2.9 (8–15)	0.0079	1519
Lowin	25 ± 4.9 (19–31)	0.0079	3165
Jagun	02 ± 1.0 (1–3)	0.0079	253
Babaladifa	17 ± 5.1 (10–22)	0.0079	2152

reported that larval control of malaria vector *Anopheles* mosquitoes is a well-proven preventive method that has become neglected, but deserves renewed consideration for malaria control programmes in the 21st Century. They also explained that mosquito breeding and occurrence within the community could cause malaria and other fevers. It was emphasized during the discussion that treatment of a malaria episode in a household could take away other resources like time and money which could be profitable if expended on income-generating activities. In a study by Bugoro et al. (2011) at the Solomon Islands, their findings support the notion that larval control is a feasible option for vector control that could complement the wide-scale use of LLINs and IRS in the region. Tools such as larval control and source reduction present an excellent opportunity to build complementary integrated vector control programmes that will be able to hit the vector at different stages of their life cycle, something that will be essential for the Solomon Islands. Larval control measures are intended to reduce malaria transmission indirectly by reducing the vector population density near human habitations. In addition, the findings of the study on household risk factors for clinical malaria in a semi-urban area of Burkina Faso suggest that modification of the household environment could be a feasible way to reduce the risk of malaria particularly in semi-urban areas (Yamamoto et al. 2010).

The World Health Organization (2011) in a household survey found that 96 % of people with access to an ITN within the household actually use it. However, this study found that 82.5 % reported they had window nets but only 13.5 % had Insecticide-Treated Nets (ITN). This could be as a result of the attitude of the respondents toward the use of ITN, although this study did not capture the information. Positive attitudes toward ITN might inform the respondents to note the benefits of using ITN. Furthermore, with improved understanding and clarification of the direct (mosquitoes) and indirect (e.g. standing water) causes of malaria, it is likely that ITN usage can be sustained, offering effective household-level protection against malaria (Dye et al. 2010). It has also been reported that when used correctly in suitable transmission conditions, both Indoor Residual Spray and insecticide-treated bed nets (ITNs) can dramatically reduce the burden of malaria by killing adult female mosquitoes when they come to take human bloodmeals (Walker and Lynch 2007). Several challenges have been reported to hinder the use of ITN. These include insufficient financial means to buy new nets to replace old nets and failure to provide nets for everybody especially in large-sized families as reported by Baume et al. (2007). Also the sensation of discomfort when sleeping under bed nets as expressed by some users living in densely populated areas could be a challenge. (Ndo et al. 2011).

Good preventive measures and practices could be introduced by the dissemination of quality information and other effective methods such as education. This study observed that respondents' anti-vector practices had no significant association with the type of house or Family. This shows that neither the type of house nor family had influence on the respondents' anti-vector practices. In a study by Ouattara et al. (2011) and Dike et al.(2006), findings show that the use of long-lasting insecticidal nets (LLINs) was influenced by social economic positions, educational attainment of the heads of households and children under 5 years concurrently living in a household. This study observed that the fathers' level of education is significantly associated with anti-vector practices. The study revealed that respondents with formal education were less likely to have poor anti-vector practices compared to those with no formal education. This implies that all the knowledge acquired from their formal education has been transformed into anti-vector practices in their respective households.

Studies have documented that construction activities like water resources development, road construction have resulted in vector-borne infections like malaria (Coker and Sridhar 2010). Also, malaria has been associated with mismanagement of solid waste including healthcare waste (Sridhar et al. 2009; Sridhar and Coker 2009). Moreover, Ng'ang'a et al. (2008) reported that non-application of environmental management practices contributed to the abundance of malaria vectors and transmission of the disease. This study revealed that larval distribution differs by zones, although the larvae were collected using the same surface area (0.0079 m^2) of container.

Conclusion

The study revealed that larval distribution differs by zones, although the larvae were collected using the same surface area of container. This is an indication that environmental management practices that could increase mosquito larval breeding differ by location and are dependent on environmental problems such as lack of appropriate solid waste management, weeds around the house, open drainages, presence of drains around the house and stagnation of water in the drains. There is a need for regular environmental sanitation, clearing the drains of clog, proper disposal of solid waste, filling of potholes with laterite and periodic environmental management enlightenment.

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