E3 Journal of Environmental Research and Management Vol. 4(10). pp. 0344-0351, November, 2013
Available online http://www.e3journals.org
ISSN 2141-7466 © E3 Journals 2012

Full Length Research Paper

Preferred breeding habitats of *Aedes Aegypti* (Diptera-Culicidae) Mosquito and its public health implications in Dares Salaam, Tanzania

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Accepted 3 November, 2013

The larval habitats of the mosquito *Aedes aegypti* L (Diptera-Culicidae) were investigated in urban Dar es Salaam, using larval traps (old tyres, vegetations, outdoor water storage containers and flower pots). The study was carried out in the four sampling sites namely, Vingunguti, Julius Nyerere International Airport (JNIA), Mbagala and Mkuranga (Vikindu). The aim was to assess the influence of habitat changes in urban Dar es Salaam (the capital city of the united republic of Tanzania) on the preferred breeding habitats of *Ae. Aegypti* mosquitoes and its possible public health implications on the residents of the City. *Aedes aegypti* mosquitoes bred in all the habitats sampled. Old tyres recorded the highest number of *Ae. aegypti* mosquitoes followed by water storage containers and vegetation. Flower-pots habitat was the least preferred, with the lowest number of *Ae. aegypti* mosquitoes.Other mosquito species belonging to five genera were also collected and these were found to live in sympatry with *Ae. aegypti* larvae. Statistical analysis revealed a significant difference in species occurrence in the four larval habitats sampled. The availability of the habitats to support the breeding of *Ae. aegypti* mosquito, which are potential vectors of urban yellow fever, Chikungunya fever, Dengue fever and Rift Valley Fever Viruses implies that theresidents of Dar es Salaam City are at risk of mosquito-borne diseases should an outbreak occur. It is therefore important that, residents of the City are enlightened on environmental factors that contribute to mosquito breeding and that, the Government together with the community institute proper sanitation measures to reduce mosquito breeding habitats.

Key words: *Aedes aegypti*, breeding habitats, urbanization, arboviruses, Rift Valley Fever, Dar es Salaam

INTRODUCTION

Aedes aegypti L. is a mosquito that belongs to the Order Diptera and Family Culicidae. This species is the main vector of Dengue and Dengue haemorrhagic fevers in the Americas and Asia (Lenhart *et al.*, 2005). It is also incriminated in the transmission of Yellow fever in African urban and peri-urban areas. In some areas it is responsible for transmission of Chikungunya fever (India), Rift Valley fever and Nile encephalitis viruses (Eastern Africa), and Dengue and Dengue haemorrhagic fever in East Africa, Indonesia, Asia and Madagascar (http://www.24drtravel. com/ travel-health-news accessed on 24/6/2010). In June, 2010,Dengue fever was reported in Dar es Salaam of which 24 people were infected(http://kagera.go.tz/kurasa/habari_mpya/hm3.php retrieved on March 2012).

Aedes aegypti breeds and develops in artificial containers of small volume such as flasks, bottles, flower vases, tin cans, jars, discarded automobiles tyres, unused water closets, cisterns, rain barrels, sagging roof gutters and in natural sites such as coconut shells, snail shells, leaf axils and tree holes(Christophers, 1960). While mosquito breeding habitats can be natural or man-made, Vanek *et al.* (2006),in a study for surveillance of malaria vector larva habitats in Dar es Salaam Tanzania, found out that man-made larval habitats constitute the bulk of vector sources in this urban environment.

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Tremendous studies to identify larval habitats of *Aedes* species have been carried out in several parts of Dar es Salaam in the past, these are Mkuranga, Njopeke, JNIA and Mbagala (Tonn *et al.*, 1973)and Msasani Penisula (Trpis, 1971) and Buguruni (Trpis, 1972).

A study by Surtees (1968) in Dar es Salaam found out that discarded tins were the most prolific source of *Ae. aegypti* larvae compared with other breeding habitats such as oil drums, leaf axils, old tyres and water storage containers. Similarly, Trpis (1972) identified tyres, tins, wrecked motor cars, water-pots, snail shells, coconut shells, and tree holes as the most common breeding sites of *Ae. aegypti* of which tyres were by far the most important and provided a constant source of *Ae. Aegypti*. The same author also found out that larvae of *Ae. aegypti* occurred in sympatry with larvae of *Ae. simpsoni*. These findings are in tandem with the observations made in the current study. Furthermore, Null (2005) in a survey of the mosquitoes breeding habitats found out that *Ae.aegypti* mosquitoes were abundant in urban areas. This was further linked to availability of breeding habitats in urban environment.In addition, discarded automobile tyres were found to be ideal breeding sites in the USA (Chambers *et al.*, 1986) and in Puerto Rico(Moore *et al.*, 1978), whereas in Colombia large drums were the preferred breeding habitats (Nelson *et al.*, 1984). The breeding of *Ae.aegypti* in containers and around human habitation is no doubt one of the contributory factors towards its success.

Although attempt was made over thirty years ago (Surtees, 1968); Trpis, (1971; 1972); and Tonn *et al.,* (1973), to determine the breeding habitats of *Ae.aegypti* mosquitoes in urban Dar es Salaam, the recent tremendous change in environmental conditions of the City as a result of urbanization, underscores the need for current documentation of this species breeding habitats as well as habits.Dar es Salaam city, like many other urban areas, experiences demographic changes occurring in under developed countries due to intense rural-urban migration.

This has resulted in overcrowded cities with multiple deficiencies, particularly in housing and basic sanitation (Knudsen &Sloof, 1992). Lack of regular water supply and inadequate drinking water supply necessitates water storage appliances and these are potential breeding habitats for *Ae. aegypti* mosquitoes. Owing to population growth, poor levels of hygiene, and increasing urban poverty, the urban environment in many developing countries is rapidly deteriorating. As a consequence, vector-borne diseases are becoming major public health problems associated with rapid urbanization in many tropical countries. Considering the fact that, the species' ecological parameters are subject to changes in time and space, updated information is required so that, it may be used to plan and implement effective control measures against these disease vectors in Tanzania. This study was therefore designed to investigate the current *Ae. aegypti* breeding habitats and its habits in relation to its potential public health implications.

MATERIALS AND METHODS

Study area

This study was carried out in four sites ofDar es Salaam and Coastal regions, which formerly formed part of Dar es Salaam Region. The four sites are Mkuranga (7˚ 06'S-39˚ 11'E), Mbagala (6˚ 54'S-39˚ 15' E), Vingunguti (6˚50' S-39˚13' E) and the Julius Nyerere International Airport-JNIA (06˚ 52'S-39˚ 12'E), Figure 1. Dar es Salaam experiences generally tropical climatic conditions, typified by hot and humid weather throughout much of the year. Annual rainfall is about 1,000 mm with two distinct rainy seasons: "the long rains", which fall during April and May, and "the short rains", which fall during October and November. During the study the temperature range was from 19 to 34°C and the relative humidity ranged from 51 to 85 %, these were recorded daily by the Tanzania Meteorological Agency at JNIA station (TMA, 2009). The basis for selecting these areas was the fact that, previous studies had used these sites to study the ecology of *Ae. aegypti*. During that particular time, there was low human population and the houses were few. It is important to note that over the last 30 years, the habitat conditions that were prevailing during the 1970s in Dar es Salaam have changed over time. According to Trpis (1971), there were banana and pineapple plants, herbs and trees were also abundant in the area during that particular time. The leaf axils of these plants, tree holes and bromeliads were the main breeding habitats of *Aedes* mosquitoes. Today, human activities are highly contributing to environmental modifications especially in urban areas, thereby increasing mosquito breeding habitats. It was assumed that, the current significant increase in human population and associated activities could have led to creation of potential breeding habitats for *Ae. aegypti*. Therefore, it was imperative to carry out this study to establish current vector density in different breeding habitats as a response to increased level of urbanization in and around Dar es Salaam.

Sampling

Sampling of the mosquito larvae and or pupae stages was carried out at the four sampling sites between December 2008 and November 2009 to include both wet and dry seasons. The purpose was to collect the larvae and pupae stages of *Ae. aegypti* mosquitoes from which the adult mosquito abundance was estimated. Larvae and or pupae of other mosquito species apart from *Ae.aegypti* mosquito species were also collected during the time of sampling. All outdoor potential breeding sites

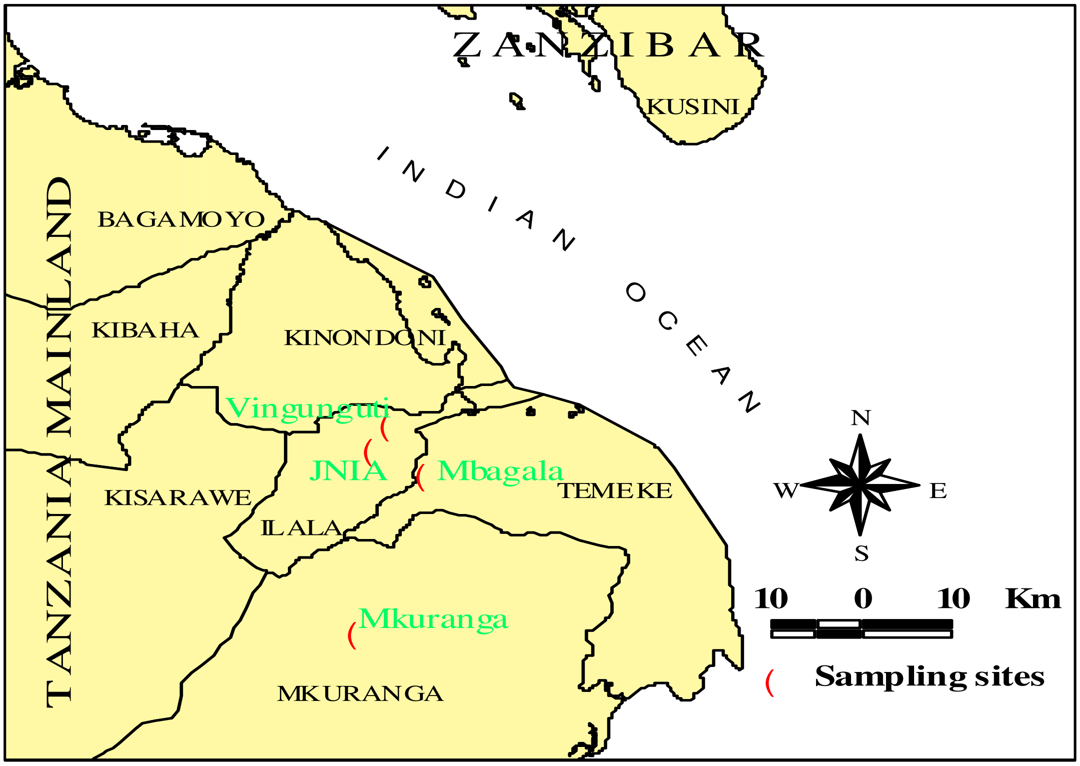

Figure 1: Map showing location of the study sites in relation to the location of Dar es Salaam city, Tanzania

favored by *Ae. aegypti* were sampled, and these were categorized into four main habitats in the following strata; Old tyres, Ornamental plant containers, pots and vases, Outdoor water storage containers and Vegetation (this category includes tree holes, leaf axils, flower bracts, fallen leaves etc.)

The four categories represent the preferred breeding habitats for *Aedes* mosquito species with varying degrees. The first category of old tyres included all obsolete tyres that are not managed; these were plenty and formed important breeding habitats for *Aedes* mosquito species.Furthermore, *Ae.aegypti* mosquitoes exhibit exophilic behavior, therefore sampling from the outdoor water storage containers was purposely to establish the breeding index of the exophilic mosquitoes. The species is also known as container breeders so it was imperative to do the sampling from flower pots and vases to establish the larvae density in these habitats. Tree holes and leaf axils although not many in the area are also potential breeding habitats and were also sampled for the purpose of comparison with other breeding habitats.

The long plastic pipette or dipper depending on the type of the container were used to collect water from various sources that harbored mosquito larvae and/ pupae (Claudia, 1989).All the larvae collected were stored in labeled specimen bottles for identification in the laboratory.Larvae of other mosquito species apart from *Ae.aegypti*,were also collected during the time of sampling.

The larvae were allowed to pupate and emerge into adults inside mosquito rearing containers according to the standard procedures for rearing mosquitoes adopted from the manual of the animal rearing and quarantine unit at International Centre of Insect Physiology and Ecology (ICIPE) (1997, unpublished document). The emerging adults were later on identified with the aid of published identification keys (Edwards, 1941; Gerberg *et al.*, 1970; Gillies *et al.*, 1987), adult mosquitoes were identified based on morphological features. The results were recorded for each site and habitat.
Multiple Analysis of variance (MANOVA) was used to test for significant difference of the mosquito species abundance in different larval habitats and sampling sites.

RESULTS

A total of 9012 and 309 mosquito larvae and pupae respectively, were collected from artificial and natural breeding habitats in and around the city of Dar es Salaam and raised to adulthood, from which 5238 adult *Ae. Aegypti* mosquitoes were obtained.Habitat/container-type

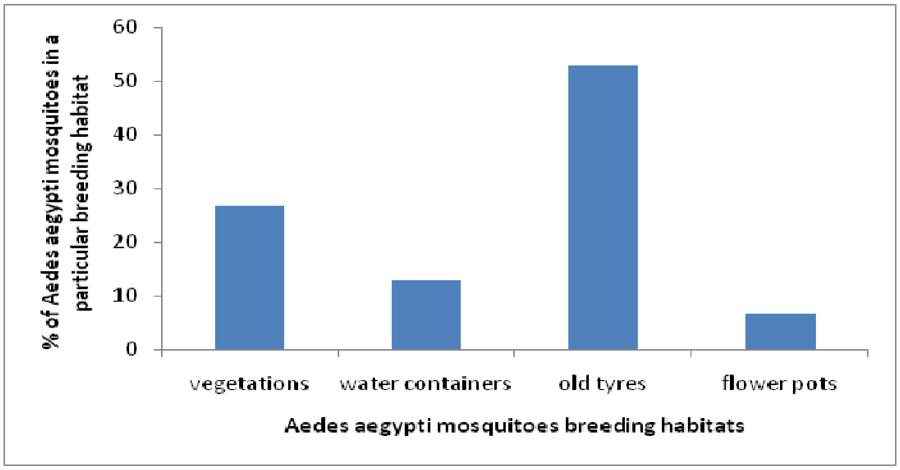

Figure 2: Abundances of *Aedes aegypti* mosquitoes in the four breeding habitats (pooled values for all the sites sampled).

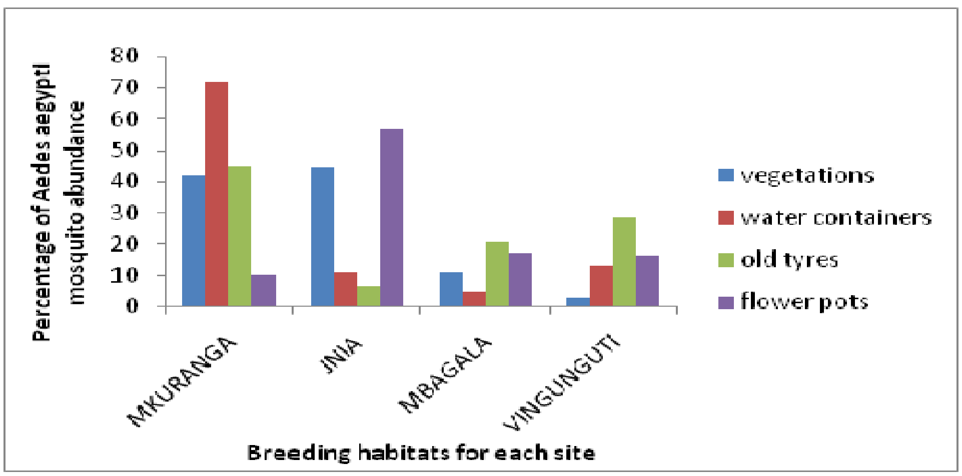

Figure 3: Preferences of*Ae.aegypti* mosquito breeding habitatsfor the four sites sampled in and around Dar es Salaam, Dec 2008- Nov 2009.

related to abundance of *Ae. aegypti* mosquito larval species showed discarded old tyres to support more immature stages of *Ae. aegypti* mosquito species than other species consider figure 2. *Aedes aegypti* occurred in all the four habitats in each site, but the frequency of occurrence was highest in old tyres (53%) and lowest in the flower pots (7%). This trend was observed in almost all the sites surveyed during the wet as well as dry season (Figures 3-7).

Aedes aegypti mosquito abundance were relatively higher at Mkuranga site than the rest of sites sampled. At this site,all the sampled mosquito breeding habitats appeared through out the sampling period unlike in other sites were the habitats were varying with season and in some instances human activities such as building, urban farming and construction destroyed the mosquitoes breeding habitats. Although *Ae.aegypti* is an urban species, this study recorded higher densities in the periurban site compared to to the sites within the urban environments. Within the airport itself, at terminal one, there are residential houses, the police barracks. Human activities within the JNIA terminal one such as watering the vegetables and ornamental plants, car washing, water storage and domestic waste disposal at this site were found to facilitate breeding habitats for *Ae. aegypti* mosquitoes. A lot of discarded tyres both vehicle and plane tyres in this place were observed, and when it rains they form breeding habitats for *Ae. aegypti* mosquitoes and other mosquito vector species that were recorded in this area.

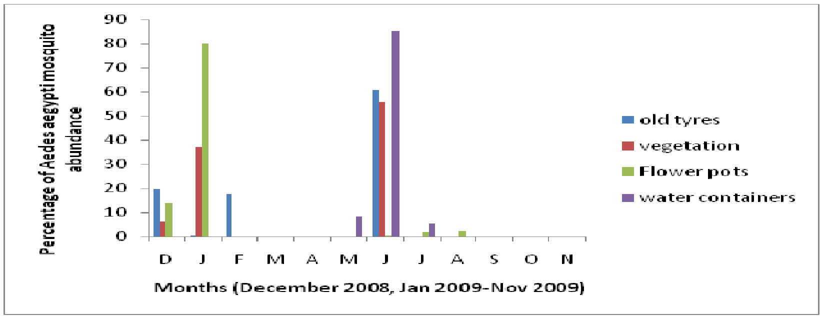

Figure 4: Preferences of *Ae. aegypti* mosquito breeding habitats at JNIA sampling site, Dec 2008- Nov 2009.

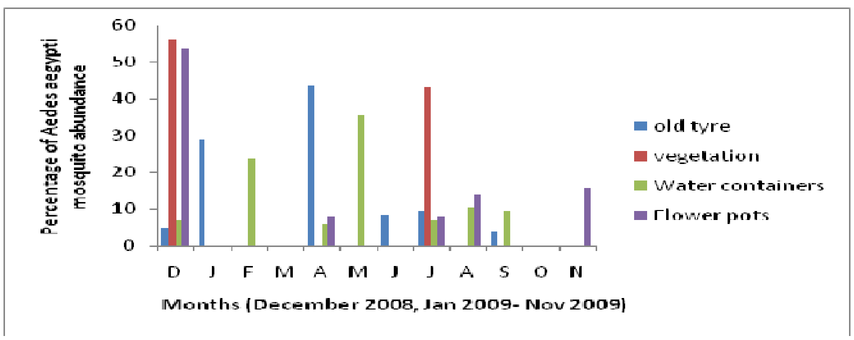

Figure 5: Preferences of *Ae. aegypti* mosquito breeding habitats at Vingunguti sampling site, Dec 2008- Nov 2009.

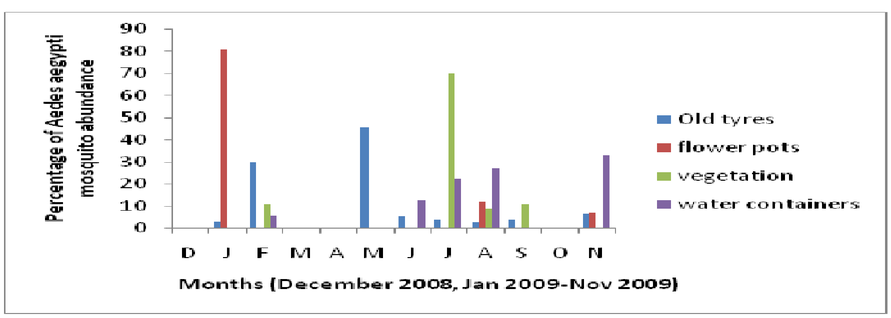

Figure 6: Preferences of *Ae. aegypti* mosquito breeding habitats at Mbagala sampling site, Dec 2008- Nov 2009

The physical infrastructure of Vingunguti Ward is characterized by poorly maintained roads and drainage system. There is no formal constructed drainage along any of the roads, but instead, there are natural drains resulting from erosion. Most of the water flows on to the roads and stagnate around housing premises harbouring mosquito vectors. There is an abattoir within Vingunguti, which is surrounded by human settlements and street vendors including restaurants, which serve meat products. This proximity may provide an increased risk

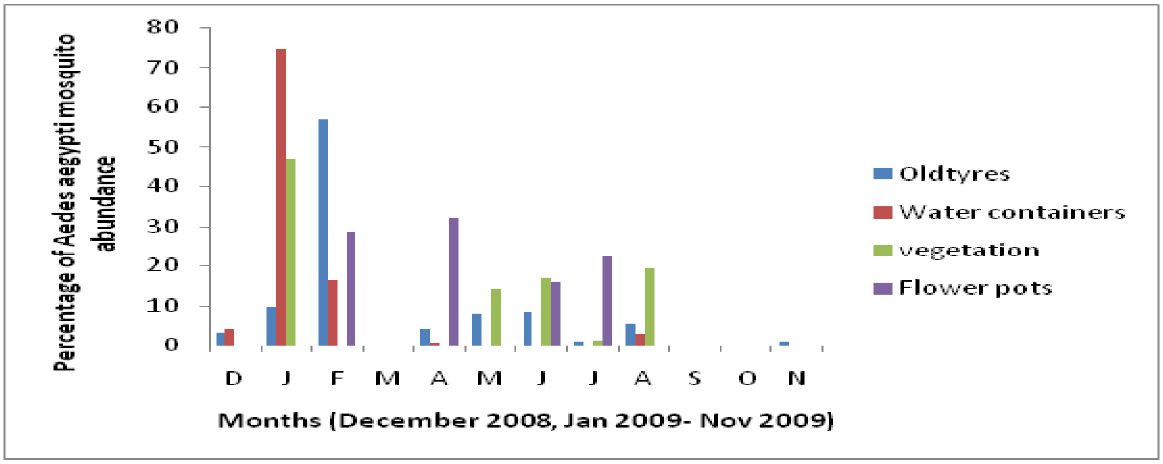

Figure 7: Preferences of*Ae. aegypti* mosquito breeding habitats at Mkuranga sampling site, Dec 2008-Nov 2009

for human-vector-livestock disease pathogens exchange.

At Mbagala, the houses are built close to one another.The rapid uncontrolled densifications in terms of housing and population growths have resulted into creation of mosquito breeding habitats. In addition to the poor state of the roads, the domestic waste (both liquid and solid) disposal system is poorly organized and irregular. Household wastes from within the settlement, such as food left overs, pealing of the different green vegetables and fruits, plastic bags and bottles were poorly managed. The discarded tyres dumped haphazardly within the settlement and the flood water that stagnates within the surroundings contained larvae of *Ae. aegypti* and other vector mosquitoes during sampling.Mkuranga site is peri urban area, residents were found to cultivate such plants as colocasia, bananas and pineapples. In addition, residents store water in water storage appliances due to insufficient water supply, there was flower containers and flower gardens around houses, the tyres were also found in the area, all these are potential breeding habitats for *Ae. aegypti* mosquitoes.

Generally, there was a significant difference in *Ae. aegypti* mosquito abundance among the breeding habitats ($F = 3.25$, $P = 0.023$).The abundance of *Ae.aegypti* was significantly higher in old tyres than the rest of habitats.The old tyres habitats were observed to be most productive for the breeding of *Ae.aegypti* mosquitoes. The flower pots habitats recorded the lowest number of *Ae. Aegypti* mosquitoes collected with only 7% of the total abundance.

Mosquito larvae and pupae of other species were also collected in the course of the study. These were *Ae. simpsoni*, *Ae. africanus*, *Culex sp*, *Anopheles sp, Mansoniasp and Toxoryn chites brevipalpis.* The old tyres habitat was found to host all these species of mosquitoes. In the rest of the breeding habitats some species of mosquitoes were absent. In this study, *Culex* species were observed to frequently breed in habitats mostly favoured by *Ae. aegypti* than other mosquito species sampled. Furthermore, the mosquito larvae of *Toxorn chytes brevipalpis* though not included in the figures were normally collected at JNIA in the discarded old tyres. The species is known to be predators of mosquito larvae of different species especially the *Ae. aegypti* mosquito larvae. However, this species was not recorded in any other site or habitat for the entire period of the study. *Aedes simpsoni* mosquitoes though in low frequency were recorded in all the sampling sites in various breeding habitats, whereas *Ae. africanus* mosquitoes were only recorded at JNIA and Mkuranga especially in the vegetation and flower pots breeding habitats.

DISCUSSION

The four sampling sites and micro-habitats studied were generally found to be favorable for mosquito breeding. *Aedes aegypti* mosquitoes were found to breed indiscriminately in several types of habitat in the area. This indiscriminate breeding habit has been previously reported by Mafiana *et al*.,(1998) in their studies on breeding sites of larval mosquitoes in Abeokuta, Nigeria. In this study, the most preferred breeding habitats were tyres and vegetation. Water storage containers, flower vases, and discarded household equipment were of secondary importance. Artificial container habitats included almost a variety of man-made containers discarded in or near human habitation. These breeding habitats are numerous in many parts of Dar es Salaam due to varied human activities, poor economic conditions, low literacy levels, poor sanitation and improper disposal of discarded household materials.

The abundance of *Ae.aegypti* mosquitoes was significantly higher in old tyres than in other habitats. Similarly, in an extensive survey of containers in American Samoa, Burkot and others (2007) observed high abundance of *Ae. aegypti* mosquitoes in tyres and it was suggested that reduction of these species at source may be one of the effective controls of West Nile Fever disease. This species probably has become highly adapted to breeding in this particular habitat than in other habitats sampled. Nevertheless, in this study, the old tyre habitats appeared to be more stable during study-time unlike other habitats that were varying with season. Tyre dumps are also numerous in Dar es Salaam, due to increased importation of used tyres from abroad. Vehicles and imported used tyres are significantly increasing in Dar es Salaam and therefore, the occurrence of large numbers of *Ae. aegypti* mosquitoes in these habitats is of public health importance.

During this study, tyres were seen in many residential areas with no specific function, and in few cases, they were either used for erosion control or to protect trees from damage especially at Mkuranga site. In addition, there were numerous mango trees and banana plants forming canopies, beneath the canopies there lay the discarded tyres and other obsolete domestic containers. The plant materials falling from the canopy formed the leaf litter in the containers probably contributing to the high productivity of *Ae. aegypti* mosquitoes observed at this site. These observations are corroborated by Barrera *et al.* (2006) findings, in their study on the factors influencing the productivity of *Ae. Aegypti* in artificial containers, they found out that the larvae and pupae productivity in tyres was linked to the number of trees in the area, with more leaf litter helping growth of mosquito larvae. Discarded tyres are important for studies of vector dynamics, because of their abundance near human populations and because they expand the habitat range of mosquitoes that harbour and transmit pathogens. This observation suggests the need to reconsider the potential deleterious health effects of tyre dumps in and around Dar es Salaam. It was of particular interest to determine whether mosquitoes can breed in tyres at disposal sites as they may be a target for a control strategy for mosquitoes should an outbreak of a human/livestock disease occur.

Water storage containers including drums, buckets and bowls in Dar es Salaam are widely used for storing water owing to lack of access to piped water, and even in some areas,like Vingunguti that have access to piped water, the pipes are often poorly installed and break as a result of passing vehicles and most of the gutters are blocked with sewage, therefore rendering the water stagnant.

This consequently enhances the breeding of *Ae. aegypti* mosquitoes and other mosquito vector species thus increasing vector abundance. Domestic water supply in the study area has become a veritable tool for vector-borne diseases by maintaining the breeding foci of mosquito vectors all the year around. It should be noted that water storage often occurs in the presence of piped water systems because of intermittent water supply and due to the necessity of collecting supplementary rainwater. Because of water shortage problems, there is a need to design appropriate covers or biological control methods for water storage containers as an important component of a sustainable control for *Ae. aegypti* and other mosquito vectors that are found in this study area. In addition, many areas in the city of Dar es Salaam are slums, particularly in Vingunguti and Mbagala, houses are close to one another and there is no much space for construction of modern toilets, the pit latrines were normally full and not completely covered thus supporting the oviposition of mosquito vectors.

In this study, mosquito larvae and or pupae found in water, which were organically polluted by domestic waste, were almost always Culicines (*Aedes* and *Culex*). Similarly, Sattler (2005) and his research team in their study of habitat characterization and spatial distribution of *Anopheles* species mosquito larvae in Dar es Salam, found out that mosquitoes of the Culicine group were abundantly breeding in organically polluted habitats. In this study, the occurrence of large numbers of these mosquito species, especially *Aedes* and the *Culex* complex, is of public health significance due to their close proximity to humans. The reported past records of Yellow fever, Rift Valley fever and more recently Dengue fever in the study area is in any case associated to the presence of these vectors in the area. Therefore, a continuous monitoring of this potential vector by the authorities is of importance to avoid potentials that may lead to a possible outbreak of *Ae. aegypti* mosquitoes associated vector borne diseases in the area.

A considerable number of vector mosquitoes (*Aedes* and *Culex* genera) were collected from the vegetation habitats especially from banana and colocasia plants. The growth of vegetation cover provides shade for the oviposition and development of aquatic stages of mosquitoes. Furthermore, adult mosquitoes also need shaded environment for biting and breeding purposes. These factors are of considerable importance for the control of *Ae.aegypti* and other mosquito vectors. However, the availability of vegetation and vegetation cover were highly affected by human activities such as farming, watering, building and construction. In this study there were more *Ae.aegypti* mosquitoes breeding in Mkuranga which is the peri-urban area with high vegetation cover than the rest of the sites which are more of slums, suggesting that clearing of bushes around human habitation can greatly reduce mosquito breeding and biting indexes.From this study it is evident that the surveyed sites provided ample habitats for the mosquitoes to breed and thrive, although some of these habitats like containers with ornamental plants were found to exist for a brief period of time during the study. Thus few mosquito species preferred to ovipost in these habitats leading to low *Ae. aegypti* mosquito abundance recorded in the containers with ornamental plants.

CONCLUSION

In general, the breeding of *Ae.aegypti* mosquitoes was observed virtually in all habitats sampled. *Aedes aegypti* mosquitoes were found to breed in all types of peri-domestic and domestic polluted waters. The poor sanitation and the necessity for storing water in and around Dar es Salaam appear to be responsible for this. There is a great variety of man-made containers in Dar es Salaam that collect rain water or that are filled with water by people where *Ae. Aegypti* mosquito vectors thrive, this increases the risk for the inhabitants to get infected with arboviruses in case of an outbreak epidemic. The fact that most larval habitats were man-made suggests that increased awareness at all levels, as to the benefits of reducing standing water and corresponding mosquito populations, should be enforced and it is essential initially to deal with man's behavior as he creates potential breeding sites for *Ae. aegypti* mosquito and other mosquito vectors in the area.

ACKNOWLEDGEMENTS

The Authors thank the District Councilors of Mkuranga and Temeke, Mr. Clemence Olawia and Ms Chiku Ngalawa respectively, for granting permits to conduct field activities in various sites. We are also indebted to Mr. A. Maro, the Medical Officer of JNIA for granting permit to conduct field activities in the vicinity of the Airport. Mr A. Sungeis thanked for his assistance in field collection of mosquito larvae. The technical assistance of Mr T.B. Suya during mosquito identification is greatly acknowledged. The authors declare that they have no conflict of interest.

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