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Research Article

Seasonal Variation of *Culex Quinquefasciatus* Densities Emerged from Pit-Latrines in Rural Settings, Muheza, Tanzania

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Abstract

Background: *Culex quinquefasciatus* is a vector of lymphatic filariasis and a biting nuisance in many developing countries with a warm and humid climate. In north eastern part of Tanzania, the burden of chronic lymphatic filariasis disease is still high. There is limited information on the factors that contribute to higher abundance of this mosquito species in rural areas. This study was therefore aimed at assessing the seasonal variation of *Cx. quinquefasciatus* abundance in pit latrines in rural areas in Muheza.

Methods: A cross-sectional study was conducted in rural settings of Muheza district for the duration of 11 months consecutively in 24 villages which were randomly selected. Collection of adult *Culex* mosquitoes emerged from wet pit latrines was done by using emergence traps. In each village three houses were selected basing on the presence of pit latrines.

Results: A total of 12,762 mosquitoes consisting of *Culex quinquefasciatus* (12%) and *Culex cinereus* (88%) species were collected from 24 villages. Majority of *Cx. quinquefasciatus* mosquitoes were collected during cool and dry season followed by long rains season with 48.52% (n=722) and 41.53% (n=618), respectively. Only one *Cx. quinquefasciatus* (0.07%) was collected during hot and dry season.

Conclusion: The present study has revealed the variation in the densities of *Cx. quinquefasciatus* emerged from pit latrines across the seasons. Wet pit latrines were found to be potential breeding sites for *Cx. quinquefasciatus*. The present study has provided important information on mosquito seasonality density in rural setting for employing alternative vector control such as larviciding in wet pit latrines.

Introduction

Culex quinquefasciatus is the main vector of Lymphatic filarias (LF) [1-4] and rift valley fever [5]. The species is also a biting nuisance mosquito [6-8]. Other mosquito vectors which transmit LF to humans include, Mansonia uniformis, Mansonia africana [9], Anopheles gambiae s. l. and Anopheles funestus in most of the sub-Saharan countries [1,2,4,10,11]. In Tanzania, *Cx. quinquefasciatus*, Anopheles gambiae s. l. and Anopheles funestus are the main LF vectors [12-14].

Cx. quinquefasciatus breed mainly in organically polluted water such as drains, soakage pits and open sewage systems [3,12,15,16]. Pit latrines are common disposal system of human excreta in many least developed countries. Despite being the sources of ground water contaminants [17], pit latrines have been reported to be the sources of *Cx. quinquefasciatus* breeding sites [18,19]. These types of habitats are commonly found in urban areas [2,12,20], hence a popular belief that, the high biting rate of *Cx. quinquefasciatus* is a good indicator of degree of urbanization of an area [21]. However, this mosquito species has increasingly been reported to be colonizing rural areas [22]. There have been some evidences of increased densities of *Cx. quinquefasciatus* in rural areas of Tanga region and this situation has persistently remained stable throughout the year [1,23]. Previous findings in Nigeria have shown that, this species has invaded rural areas especially on container-type breeding sites and in pools [22,21].

It is believed that, the increased widely use of pit latrines in rural settings have influence on the density of *Cx. quinquefasciatus* [3,11]. There is limited information on the seasonal variations of *Cx. quinquefasciatus* densities in rural settings. Surveys of pit latrines status whether they are wet or dry during the dry and rainy season together with the productivity of emerged *Cx. quinquefasciatus* may provide important information for alternative vector control interventions such as larviciding [24] in pit latrines. Therefore, this study aimed to assess the seasonal variation of *Cx. quinquefasciatus* densities emerged from pit latrines in rural settings of Muheza, Tanzania.

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Figure 1: Map of Tanga region showing Muheza district.

Material and Methods

Study area

This was a cross-sectional study conducted in Muheza district (Figure 1). Muheza district (latitude: 5° 10' °S, longitude: 38° 46' °E) is located at the foothills of East Usambara mountains about 30km offshore Indian Ocean and covers a geographical area of 4,922 km^2. Most of its inhabitants are subsistence farmers. The district is well known for small scale orange plantations and raising of livestock. Generally, the district has bimodal pattern of rainfall; long rains from March to June and short rains from October to December, but in recent years there has been some variations in rainfall patterns with long dry and hot seasons. Rainfall ranges from 600 to 1200 mm. However, during implementation of the present study, rainfall ranged from 9.1-353 mm which was below the normal minimum range [25]. According to the 2012 population and Housing Census, Muheza district had a total of 204,461 people, of whom 100,843 were males and 103,618 were females [26].

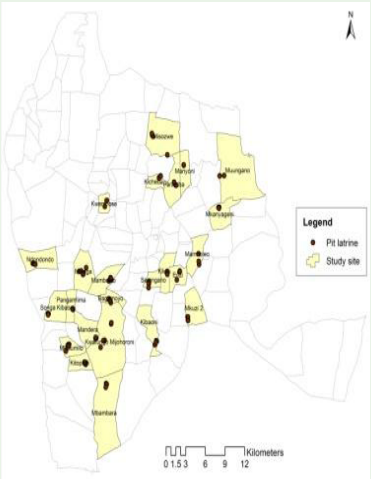

Figure 2: Map of Muheza village showing study sites and distribution of pit latrines.

Study sites

The study was conducted in 24 villages for the duration of 11 months from August, 2015 to June, 2016. In each of the villages, three houses with pit latrines were selected for the purpose of collecting mosquitoes (Figure 2). The villages have different altitude ranges, from 82m to 327m above the sea level. Mean altitude for each village were categorized into low and high. Low altitude ranged from 0 to 200m and high altitude ranged from 201m and above.

Two types of pit latrines were encountered during the survey; those with outside ventilators (Figure 3a) and those without outside ventilators (Figure 3b). Despite the difference in the type of pit latrines, the traps used for collection of emerged mosquitoes were the same.

Mosquito collection

Collection of adult *Culex* mosquitoes was done on monthly basis by using emergence traps [27,28]. Emergence traps were constructed by using a wooden frame with untreated mosquito nets (sized 30cm x 30cm x 30cm). An emergence trap has a large inverted funnel-shaped on one side of the trap which is placed over wet pit latrines mouth or vent [20]. Emergence traps were set in the evening at 6:00 PM. and left overnight until next morning at 6:00 AM. when they were retrieved. Collected mosquitoes were transferred from the traps to the paper cups by using aspirators and then transported to the laboratory for sorting and identification by using a key [29].

Data analysis

Mosquito data collected were entered in Microsoft excel and summarized in table and in a map showing *Cx. quinquefasciatus* densities collection points. Map showing mosquito densities were produced by using Arc Map version (10.3) software.

Ethical considerations

The study has been approved by the National Health Research Ethics Committee (NatHREC) with ethical clearance certificate with number NIMR/HQ/R.8a/Vol.9/1613 and by the Institutional ethical Committee of Kilimanjaro Christian Medical University College (KCMUCo) with No.885. Permission was requested form household heads whose pit latrines were selected for setting emergence traps for collection of adult mosquitoes. All field workers involved in sample collection were protected by wearing gum boots and gloves.

Figure 3: Types of Pit latrines; a) with an outside ventilator and b) without an outside ventilator.

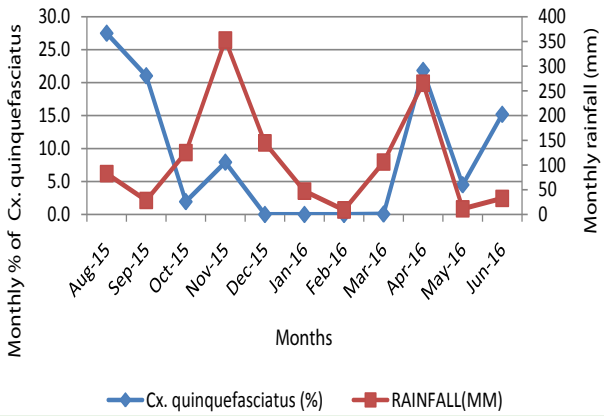

Figure 4: Monthly percentage of *Cx. quinquefasciatus* mosquito and rainfall patterns.

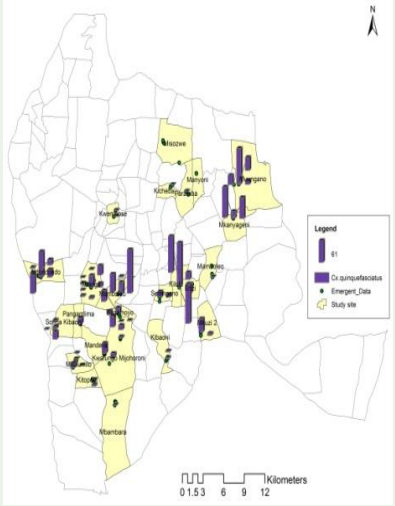

Figure 5: Map showing collection points of *Cx. quinquefasciatus* mosquitoes.

Results

Adult mosquito species collected

A total of 12,762 mosquitoes were collected. Majority of mosquitoes collected were *Cx. cinereus* (n=11,274, 88%) while *Cx. quinquefasciatus* accounted for 12% (n=1,488). Villages with many *Cx. quinquefasciatus* were Kilulu (23.3%), Mamboleo (13.7%), Muungano2 (11.6%), Ndondondo (11.6%) and Mkanyageni (10.9%). Least amount of mosquitoes was collected in Paramba, Mamboleo Lusanga, Kicheba and Mbambara each with 0.1%. No *Cx. quinquefasciatus* mosquitoes were collected in Misozwe and Manyoni villages.

Monthly variation of *Cx. quinquefasciatus* and rainfall patterns

There was monthly variation in *Cx. quinquefasciatus* density. High densities of this species were collected in August, 2015 and April; 2016. No mosquito species were collected from December, 2015 to February, 2016. This was a dry and hot season and most of the pit latrines were dry. Rainfall was highest in November, 2015 followed by April, 2016. Increase in the amount of rainfall in April, corresponded to the increase in *Cx. quinquefasciatus* density. There was also a slight increase in *Cx. quinquefasciatus* density in November, 2015. The densities of mosquitoes were fluctuating according to rainfall pattern (Figure 4).

Seasonal variation of *Cx. quinquefasciatus* densities

Among the four seasons of collection; majority of *Cx. quinquefasciatus* were collected during cool and dry season followed by long rains season. The least number of mosquitoes were collected during hot and dry season (Table 1).

Table 1: Seasonal variation of *Cx. quinquefasciatus* densities.

Seasons	*Cx. quinquefasciatus, n (%)*
Cool and dry (Jul-Sep, 2015)	722 (48.52)
Short rains (Oct-Nov, 2015)	147 (9.88)
Hot and dry (Dec, 2015-Mar, 2016)	1 (0.07)
Long rains (Apr-Jun, 2016)	618 (41.53)
Total	**1488**

During long rain season, majority of *Cx. quinquefasciatus* were collected at Mamboleo, Muungano2 and Mkanyageni villages. During the short rains majority *Cx. quinquefasciatus* were collected in Mkuzi2, Mianga, Bagamoyo and Songa Kibaoni2. In cool and dry season, *Cx. quinquefasciatus* were collected in 15 out of 24 villages. Majority of them collected in Kilulu, Ndondondo and Bagamoyo villages. In hot and dry season most of the pit latrines were dry except at Kicheba village which was wet in March. In this season, only a single *Cx. quinquefasciatus* was collected (Figure 5). There were variations in abundance of *Cx. quinquefasciatus* mosquitoes collected across the seasons. Majority (75%, n=24) of the villages were at high mean altitude (201-314 m). A total of 1070 (72%) *Cx. quinquefasciatus* were collected in high mean altitude while in low mean (0-200 m) altitude areas *Cx. quinquefasciatus* accounted only 38% of the total collection.

Discussion

Culex quinquefasciatus is the main vector of Lymphatic Filariasis (LF) [4,30]. In the present study, majority of mosquito collected emerging from pit latrines were *Cx. cinereus* (88%) while *Cx. quinquefasciatus* accounted for 12%. Despites the low density of *Cx. quinquefasciatus*, the species was found in most of the villages. These findings concur with previous studies conducted in the study area [31] and in other rural settings of some African countries that, *Cx. quinquefasciatus* and *Cx. cinereus* breed in wet pit latrines [32-34]. *Cx. cinereus* is also reported to be a competitor of *Cx. quinquefasciatus* in pit latrines [32-34]. *Cx. cinereus* mainly breed in pit latrines which are also used for bathing. Use of pit latrines for bathing is a common practice in rural settings of Tanzania. This finding is similar to other studies conducted in Kenya [35] and Nigeria [22]. *Cx. cinereus* has been rarely reported to bite humans, therefore it is of no medical importance [29,34].

The present study has revealed the variation in densities of *Cx. quinquefasciatus* across the seasons. This is reflected by the wetness status of the pit latrines due to rainfall patterns. During rainy seasons, pit latrines tend to overflows due to rain water percolation hence make them potential breeding sites for *Culex* mosquitoes. Our

findings are consistence with a previous study conducted in rural eco-vegetational zones, Nigeria that, majority of *Cx. quinquefasciatus* were collected during wet season as compared to dry season [36]. Seasonal patterns of mosquito vectors densities have reported to fluctuate according to weather conditions. This situation also has impact on transmission dynamics of LF in East Africa communities as it has been experienced that, during dry season no LF transmission occurs [30]. Therefore, seasonal variation of LF vector density has to be taken into consideration when implementing vector control activities [30].

Prevention of LF also involves mosquito control through utilization of insecticide treated nets and elimination of breeding sites such as environmental management to make them un-favorable for mosquito vectors to breed [30]. During post LF mass drug administration in north-eastern Tanzania, *Cx. quinquefasciatus* was reported to be responsible for most of the LF transmissions [14]. The species being pit latrines breeder [3,11,30], few studies have reported on vector control interventions targeting pit latrines by application of floating layers of polystyrene beads in urban Dar es Salaam. The polystyrene beads has shown to be effective as they suffocates the *Cx. quinquefasciatus* larvae leads to mortality [18,19]. The species being resistant to most of the insecticides commonly used for vector control [37], application of bio-larvicide such as Bacillus Thuringiensis Variety Israelensis (Bti) can be used [38].

Conclusion

Our study has revealed the variation in the densities of *Cx. quinquefasciatus* emerging from pit latrines across the seasons with more mosquitoes during cool and dry seasons as well as during the long rainy seasons. The present study has provided important information regarding wet pit latrine status and their contribution in productivity of *Cx. quinquefasciatus*. These findings are useful in providing guidance on appropriate seasons for treating pit latrines in order to control lymphatic filariasis vectors in rural settings of Tanzania.

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