ORIGINAL ARTICLE

The distribution of *Aedes aegypti* (diptera, culicidae) in eight selected parks of Lahore, using oviposition traps during rainy season

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Abstract

Objective: To investigate the seasonal distribution of immature habitat of *Aedes aegypti* mosquito species and its association with environmental and climatic conditions.

Methods: This descriptive study was conducted in eight parks in Lahore, Pakistan, over three years from 2011 to 2013.A total of 2,496 ovitraps were placed in environmentally different conditions near water channels, thick vegetation cover/shades, clean/unclean sites and places where there was lot of human activity. Each trap was monitored weekly in early rainy, late rainy, early post-rainy and late post-rainy seasons of each of the three years to determine the presence of *Aedes aegypti* larvae by measuring ovitrap index. SPSS19 was used for data analysis.

Results: The value for ovitrap index was found highest in late rainy season (20.83). High association was observed with environmental conditions ($p<0.05$) as this index was high in micro-habitats close to water channels, shades and residences. The association of ovitrap index with water channel, vegetation cover, cleanliness and human activity was significant in all four seasons (p=-0.000). With temperature, this association was significant only in early post-rainy (p=-0.000) and late post-rainy seasons (p=0.024). With humidity, it was significant in early post-rainy and late post-rainy seasons (p=-0.000 and p=0.024) while with rainfall, the association was significant in all seasons (p=0.000).

Conclusion: Abundance and occurrence frequency of *Aedes aegypti* had a positive association with deteriorating environmental and seasonal climatic conditions.

Keywords: *Aedes aegypti*, Environmental and climatic conditions, Ovitrap index, Oviposition. (JPMA 67: 1493; 2017)

Introduction

Aedes (Stegomyia) *aegypti* is considered to be the main vector of dengue, an infectious disease which is increasing with the passage of time all over the world and is endemic in many countries.[1] As surveillance strategies for the vector are complex due to its high capacity to spread and adapt, it is important to develop sensitive methods capable of identifying the presence of the vector, measure its density and correlate this with the risk of dengue transmission.[2,3] Traditional methods like container index (CI), house index (HI) and Breateau index (BI) have been used for larval surveillance since long, but these methods are not cost-effective and do not reveal its actual distribution in high-risk areas.[2] Oviposition traps have been used for *Aedes (Ae.) aegypti* population surveillance,[4] but the dengue control programmes in many countries do not consider the oviposition trap to be an effective method as it is influenced by ecological/environmental and climatic variables.[5] So, these variables deserve special attention in larval surveillance pre-programmes. In addition to this, it is also important to find out the best period for the use of these methodologies.

The importance of understanding vector ecology has been recognised at least since the early 1900's.[6] Even though *Ae. aegypti* (Diptera: Culicidae), the vector of yellow fever and dengue, is one of the most extensively studied mosquitoes, its ecology remains largely misunderstood.[7] Furthermore, little information about the prevalence of dengue mosquitoes is available in subtropical countries like Pakistan, especially in small-scale habitats.

The favourable environment for *Ae. aegypti* proliferation includes water-filled containers,[8] preferentially human, for egg development, and shady habitats for resting and oviposition.[4,9,10] These requirements are fulfilled by some of the areas in different public parks of Lahore, thereby acting as important foci for vector proliferation. Microhabitat characteristics may affect the suitability of containers as breeding sites for *Ae. aegypti*.[11] Two of the most frequently mentioned factors influencing micro-habitat quality are shade[12,13] and vegetation.[14,15]

The association between temperature, high precipitation

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and increasing dengue vector populations, has often been observed in *Ae. aegypti*. Common perception is that lengthy periods of hot and dry weather may kill most eggs and render adult vectors inactive,[16] reducing vector populations, but *Ae. aegypti* have been observed to exist in a dry climate.[17] Although these studies generally reported that temperature played a significant role, other environmental aspects, like humidity and diet and their effect on mosquito behaviour, were not considered. The results of ovitraps during the wet and dry seasons can be used to identify key oviposition behaviours. Foo et al. found a strong relationship between dengue fever and degree of rainfall.[18] Okogun et al. also reported strong correlation between rainy season and mosquito breeding.[19] According to Igbinosa, the onset of rainfall and high relative humidity facilitate the development of more breeding places and in turn help in hatching of mosquito eggs.[20]

The current study was planned to monitor the immature form of dengue vector population in different seasons in open places, such as parks, and to correlate it with climatic and environmental factors. The aim was to identify microhabitat factors (such as water channels, shade status, vegetation height, human activity and presence of litter) affecting dengue vector proliferation. These conditions were frequently available in most of the open areas. So, these places act as important focal points for the proliferation of vectors. The study is expected to provide a platform for further investigations on ecology of dengue vectors by providing details of dengue vector microhabitats.

Materials and Methods

This descriptive study was conducted in eight parks in Lahore, Pakistan, during three years from 2011 to 2013. The study area, and its environmental conditions, including vegetation cover and nearby spatial conditions, were assessed in a pilot study before starting the actual study. Meteorological data was obtained from the local meteorological office.

A total of 2,496 ovitraps were placed. The parks included in the study were: Jallo (JP), Jinnah Garden (JG), Gulshan Iqbal (GI), Liberty (LP), Mader-e-Millat (MM), Minare-e-Pakistan (MP), Model Town (MT) and Samanabad Sports Complex (SSC). These parks were selected because of their distinct ecological/environmental conditions like the prevalence of water channels, extent of vegetation cover, cleanliness and human activity near ovitraps placement. As most of the grounds where the ovitraps were placed were below the adjacent road level, the possibility of rain water accumulation, leading to proliferation of dengue vectors could not be ruled out, especially in monsoon and post-monsoon seasons, when the water remains fresh and clear presenting an ideal habitat(s) for breeding and growth of dengue vector mosquitoes. In each park, 12 ovitraps were placed in environmentally different conditions (three each near water channels, thick vegetation cover/shades, clean/unclean sites and places where there was a lot of human activity). Each trap was monitored weekly in early rainy (27th to 32nd week), late rainy (33rd to 38th week), early post-rainy (39th to 45th week) and late post-rainy (46th to52nd week) seasons of the three years of the study.

Mosquito larval density was estimated by employing ovitraps in the field. Each ovitrap consisted of a pot that could hold 230 ml of water. The trap was painted black to attract mosquitoes and have a detachable paddle/filter, a thin strip of hard-board (10-12.5 cm x 2.5 cm) for mosquito to lay eggs on them. All field ovitraps were examined weekly for the presence of ova, larvae or pupae forms of *Aedes* mosquito. After examining an ovitrap, the water therein was replaced, paddles/filter were washed and sometimes replaced. After emptying the pot and before replacing fresh water in the pot, the pot was scrubbed thoroughly so that eggs, if any, attached to inner surface of containers were removed.

Larvae were identified and counted in the laboratory by using key (a catalogue of the mosquitoes of the world (Diptera: Culicidae), Maryland).[21] Larval density in ovitraps was estimated by measuring ovitrap index (OI) according to the 2009 guidelines of the World Health Organisation (WHO), by the following formula:[22]

OI= number of positive ovitraps/total number of ovitraps inspected x100

Monitoring of environmental/ecological and climatological conditions around ovitrap placement environmental/ecological conditions such as vegetation cover, presence of water channel, presence of shades, cleanliness, human activity and presence of residences near the oviposition sites around each ovitrap placement site were also recorded during the study period. In addition, weekly air temperature, relative humidity and total rainfall were obtained from the local meteorological office.

SPSS19 was used for data analysis. Association between ovitrap positivity and environmental and climatic factors was found out by chi-square test. $P<0.5$ was considered significant.

Formal permission to conduct this study was obtained from the ethical committee of the Government College

University and Institute of Public Health, Lahore, Pakistan. Written consent from officers in-charge of the parks was obtained prior to the placement of ovitraps.

Results

In 2011, the highest OI values were observed in late rainy season in all parks; the value was the highest (20.83) in Liberty Park, followed by16.66 each in Jinnah Garden, Gulshan Iqbal and Minar-e-Pakistan parks. During early post-rainy and late post-rainy seasons, none of the ovitraps was positive in any park, except in Jallo Park where the OI value was 4.16 in late post-rainy season.

In 2012, same pattern was observed as in 2011 with the difference that OI values were the highest (20.83) in GI park, followed by 16.66 in JG and LP, 12.5 each in JP, MT and SSC, and the lowest (8.33) in MP and MM parks.

In 2013, the pattern of ovitrap positivity in early

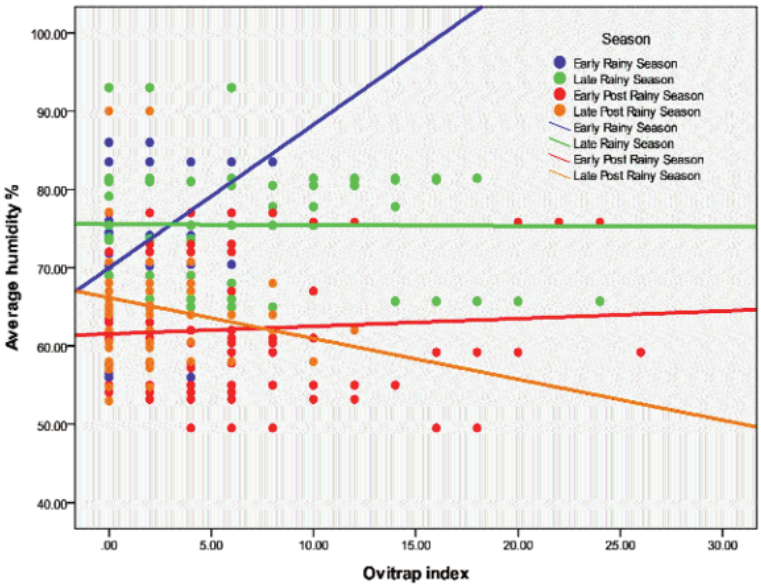

Figure: Correlation coefficient (r) and coefficient of determination (r2) OI values with average humidity in different seasons.

Table: Ovitrap Index (OI) in different seasons from 2011-2013 in all towns if the city Lahore.

Year / season	Parks							
	Jallo Park (JP)	Jinnah Garden (JG)	Gulshan Iqbal (GI)	Model Town Park (MT)	Liberty Park (LP)	Minar-e- Pakistan Park (MP)	Samanabad Sports Complex (SSC)	Mader-e-Millat Park (MM)
2011								
Early rainy (Wk: 27-32)	0	4.11	0	4.11	8.33	8.33	0	4.11
Late rainy (Wk: 33-38)	12.5	16.66	16.66	12.5	20.83	16.66	8.33	12.5
Early post rainy (Wk: 39-45)	0	0	0	0	0	0	0	0
Late post rainy (Wk 46-52)	4.11	0	0	0	0	0	0	0
2012								
Early rainy (Wk: 27-32)	4.1	0	8.33	8.33	12.5	0	8.33	4.11
Late rainy (Wk: 33-38)	12.5	16.66	20.83	12.5	16.66	8.33	12.5	8.33
Early post rainy (Wk: 39-45)	0	0	0	0	0	0	0	0
Late post rainy (Wk 46-52)	0	0	0	0	0	0	0	0
2013								
Early rainy (Wk: 27-32)	16.66	12.5	12.5	8.33	16.66	12.5	4.11	4.11
Late rainy (Wk: 33-38)	12.5	0	16.66	16.66	12.5	12.5	8.33	12.5
Early post rainy (Wk: 39-45)	8.33	0	8.33	12.5	8.33	8.33	0	0
Late post rainy (Wk 46-52)	0	0	0	0	0	0	0	0

Wk: Week.

rainy season was slightly different from 2011 and 2012 as it was high (16.66) in JP and LP parks, followed by 12.5 in JG, GI and MP parks. In late rainy season, OI was the highest (16.66) in GI and MT parks, followed by 12.5 in JP, LP, MP and MM parks. No ovitrap was found positive in JG during this season. Unlike 2011 and 2012, ovitraps were positive in most the parks; the index value was12.5 in MT, followed by 8.33 in JP, GI, LP and MP parks, and none was positive in any park in late post-rainy season (Table, Figure).

Discussion

In the late rainy season, (33rd to 38th week of the year), climatic and environmental conditions were such that abandoned rainfall was received and pools of stagnant water were seen all over the place. Moreover, the drains and channels were full of water to their maximum capacity. The parks had high turnover rate as during summer vacations, and people tend to visit outdoor recreational places. During this time, ovitraps were still positive at these places and reduced availability of food outdoors caused shifting of adult mosquito population indoors.

In the early post-rainy season (39th to 45th week of the year), ecological conditions in the parks were reversed as water was not available in abundance which resulted in decreased vegetation cover and shades. Cleanliness also improved as the excessive water was either drained or evaporated. Moreover, human activity also declined as the summer vacations ended and the recreational visits of children/ adults in parks became less frequent. All these factors contributed to the decline in ovitrap positivity in open places in 2011 and 2012. On the contrary, in 2013, the ovitraps were positive in all parks except three (JP, SSC and MM). Heavy rainfall during this period (345.46 mm) contributed to the standing water in these locations. However, air temperature decreased (25.7-26.2°C), relative humidity ranged from 58.7 to 68.8% and food for mosquitoes became less available outdoors.

In the late post-rainy season when air temperature (range: 15.8-17.4°C), relative humidity (range: 15.8-17.4°C) and total rainfall (range: 0-75.18 mm) declined significantly compared to earlier seasons, climatic conditions no longer remained favourable for the proliferation of mosquitoes and OI values were found to be relatively much lower in this season for all the three years of observation.

The study revealed that the association of temperature with OI was not significant in early rainy (p=-0.133) and late rainy seasons (p=-0.823) while it was significant in early post-rainy (p=-0.000) and late post-rainy seasons (p=0.024). Similarly, the association of humidity with OI was not significant in early rainy season (p=-0.644) while it was not computed in late rainy season. Like temperature, the association of humidity with OI was significant in early post-rainy and late post-rainy seasons (p=-0.000 and p=0.024, respectively). Unlike temperature and humidity, the association of rainfall with OI was significant in all seasons (p=0.000).

Environmental conditions surrounding the oviposition sites revealed that OI values were high in places of abundant water channels near the traps, perhaps serving as mosquito breeding sites. It has also been reported that gravid *Ae. aegypti* tend to lay eggs in tree holes and plant axils. In addition to water channels, another important environmental condition that increased OI was extensive vegetation, providing more moist condition near the ovitrap. It was found that OI values were higher in the parks where the vegetation cover around the ovitrap was high as compared to the parks. The Pan American Health Organisation (PAHO) in 1994 also reported increased rate of mosquito breeding and mosquitoes resting oviposition in shady habitats. Similarly, Martinez-Ibarra et al. reported that shade and vegetation were the two most important key factors which influenced mosquito oviposition,[4,15] while Schweigmann et al. reported that neighbourhood with less sunlight, tall and extensive vegetation with more dense shadows are the most favourable microhabitats where *Ae. aegypti* mosquito breed.[23] The dense shades of trees and bushes may act as buffer for high air temperature along with low relative humidity, which are considered unfavourable for adults and larval survival. Tun Lin et al. reported the same type of effect on breeding of dengue vectors.[24] The present study also showed that mosquitoes were less likely to breed in un-shaded locations, possibly because of high air temperature. Likewise, high values of OI in densely shaded places have been reported in Thailand, United States, Mexico and Venezuela.[25] This study also showed that ovitraps which were placed in shaded places in parks were generally preferred by *Ae. aegypti* mosquitoes for oviposition. Similar types of results were reported by the PAHO.[4]

Human activity and the presence of homes near the oviposition sites increased the OI. In parks where human activity was more and/or homes of gardeners or other people were present near the oviposition sites, the OI value was generally high. *Aedes* mosquitoes have short flight range and bites victims in close vicinity. This observation corresponds with the study conducted by Getis et al. who concluded that many adult *Ae. Aegypti* mosquitoes probably do not have the ability to fly far from their breeding sites and rather rest, bite and take

blood feed and oviposit in nearby suitable habitats.[26]

Conclusion

Increased level of vegetation cover, presence of water channels, human activities and un-cleanliness resulted in increased population density of immature forms of *Ae. aegypti* mosquitoes.

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Conflict of Interest: None.

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