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TEMPORAL DISTRIBUTION AND ABUNDANCE OF MOSQUITO VECTORS IN DHAKA CITY

M.G. SHAROWER[1]*, M.A. LATIF[2] AND S.M. UDDIN[3]
[1]*Department of Public Health, North South University, Bashundhara, Dhaka-1229, Bangladesh*
[2]*Department of Entomology, Sher-e-Bangla Agricultural University, Sher-e-Bangla nagar, Dhaka-1207, Bangladesh*
[3]*Dhaka North City Corporation, Gulshan-2, Dhaka-1212, Bangladesh*

Abstract

Species of *Anopheles*, *Aedes* and *Culex* mosquitoes showed that *Anopheles gambiae* s.s had the highest number (43.5%) out of the three malaria vectors (*viz. Anopheles gambiae, An. arabiensis* and *An. funestus)*. For *Aedes* and *Culex* species, *Aedes aegypti* (37.6%) and *Culex fatigans* (37.1%) had the highest prevalence out of their sibling species. Temperature and rainfall were highly correlated with the abundance of mosquito vectors. It was observed that the rainy season (March to October) recorded the highest number (Total 11 specie) of mosquito vectors collected with the peak (*Aedes aegypty,* 140*)* in the months of July (932) and August (976) while the lowest (333) collection was in the dry season (November to February) with lowest (333) in the month of February when there was little or no rains.

Key words: Temporal distribution, Abundance, Mosquito vectors

Introduction

In warm and tropical climatic regions of the world, climatic factors have been associated with relative mosquito abundance and transmission of mosquito borne infections. Approximately half of the world's population is at the risk of malaria and an estimated 243 million infected cases resulted in nearly 86300 deaths in 2008 (WHO 2009). In Sub-Saharan Africa, 91% of malaria was detrimental and caused death. Malaria was estimated by calculating the result in an annual loss of 85% of the deaths amongst children below five years (WHO 2010). In addition 40% of all the public health spending is related to malaria (Haque *et al*. 2010). Out of all the diseases, such as malaria, filariasis, dengue and yellow fever caused by mosquito vectors, malaria is the most important tropical and parasitic disease in the world. Malaria alone accounts for up to 25% of hospital attendance, with young children under five years accounting for about 40% in Bangladesh (WHO 2012). Filariasis also has been shown to be a public health problem in Bangladesh, particularly in the Dhaka City Corporation (Ahmed *et al.* 2009). Studies

*Corresponding author: sharower_bau@yahoo.com

throughout the world have shown that incidence of malaria and other related diseases associated with mosquito vectors are linked to the pattern of rainfall, temperature and humidity (Briet *et al.* 2008). Rainfall is considered to be a major factor influencing malaria outbreak in Bangladesh (Haque *et al.* 2007) and a causal relationship between rainfall and malaria transmission is well recognized (Thomson *et al.* 2005). In the highland of Kenya, malaria cases increased by 1.4 to 10.7% per month for each 10 mm increase in monthly rainfall (with 2-3 months lag) (Hashizume *et al.* 2009). Natural climatic disasters such as floods and cyclones may also have significant relationship with malaria outbreaks (Lindsay and Birley 1996). Temperature, rainfall and humidity have been widely associated with the dynamics of malaria vector population and therefore with the spread of the disease.

However, at the local scale, there is lack of a systematic quantification of these factors of malaria transmission (Githeko and Ndgwa 2001). In East African Highland the research findings of Zhou *et al.* (2004) revealed that 1^{o}C temperature increase in minimum temperature having a lag of time of 1–2 months and 1^{o}C increase in maximum temperature with a lag time of 2-5 months led to an 80 - 95% increase in the number of malaria outpatients. Meteorological factors are important drives of malaria transmission. Ambient temperature plays a major role in the life cycle of the malaria vector. Temperature between 15 and 40ºC and humidity between 55 and 80% are suitable for the completion of the *Plasmodium falciparum* and *P. vivax* malaria parasites life cycle (Zhou *et al.* 2004). The development of the parasite within the mosquito (sporogonic) cycle is dependent on temperature. The sporogonic cycle takes about 9-10 days at 28ºC but stops at temperature below 16ºC (Lindsay and Birley 1996). The daily survival of vector is dependent on temperature as well. The suitable survivality of daily temperature is between 16 and 36^{0}C and the daily survival capability drops rapidly at temperature above 36ºC. The highest proportion of vector surviving incubation period is reported at temperature between 28 and 32ºC (Craig *et al.* 1999). The gonotrophic cycle which is the time between blood meals of the vector is short at higher temperatures because digestion speed increases (Haque *et al.* 2010). The mosquitoes survivality was prolonged at high temperature along with frequent rainfall and suitable relative humidity of at least 50 - 60% by providing breeding sites to lay eggs. Relative humidity below 60% shortens the life span of the mosquito vectors (Rogers and Randolph 2006). The goal of this work is to study the effects of these climatic factors on the distribution and abundance of mosquito vectors in the study area.

Materials and Methods

The study was carried out in some selected houses of all the 91 words of Dhaka City Corporation (both North and South) from July, 2014 to June, 2016 (two years). Adult mosquito samples were collected from the houses between 05.00 and 07.00 hrs in the morning and 19.00 and 21.00 hrs in the evening when the mosquitoes attracted to the light trap (CDC-LT) baited in the CO_2 and pyrethrum were collected with an aspirator. Human Landing Catches (HLC) were also performed by two trained collectors (adult male volunteers) working alternatively for one hour and resting for one hour. Medical nurses provided medical supervision of the collectors. Light trap per net catches was performed using a CDC mini light trap placed adjacently and above an occupied bed net. Pyrethrum Spray Catches were performed at 7 a.m. by spraying pyrethrum for 30 - 45 seconds in the room. After 10 minutes, dead and immobilized mosquitoes were collected. Two sites per location were randomly selected. In each site, three rooms were randomly chosen within a 15 m distance. Each night, a different sampling method was tested in each room. The houses used for mosquito collection were randomly selected close to the sites of larval habitats. Paper cups covered with netting materials, which contained cotton pad soaked in 10% glucose, were used for collection. The cups were placed in a cool box and transported to the laboratory where the mosquitoes were anaesthetized with ethyl acetate. They were sorted out and identified by morphological characteristics with the key aids of Strickland and Choudhury (1927), Giles (1968) and Koekemoer *et al.* (2002). Data were collected in dawn and just after sun set for maintaining lowest temperature and at noon for recording highest temperature. Aspirator was used to count the number of mosquitoes. They were later counted and recorded.

The data on minimum and maximum temperature, rainfall and relative humidity for these periods were collected from different parts of Dhaka city every month. The water from the sample sites was collected using rain barrels. A pH meter was used to test the pH level of the water.

Results and Discussion

A total number of 7,468 adult mosquito was collected in the whole year, out of which 1808 (24.2%) were *Anopheles* sp., 2900 (38.8%) *Culex* sp. and 2760 (36.9%) for *Aedes* sp. *Anopheles gambiae*, *An. funestus* and *An. arabiensis* were the malaria vectors found during the survey. *An. gambiae* had the highest prevalence of 787 individuals (43.5%) followed by *An. arabiensis* of 616 individuals (34.1%) and the least in number was found in case of *An. funestus* 405 (22.4%) (Table 1).

Table 1. Monthly mosquito species abundance in Dhaka city from July, 2014 to June, 2015.

Mosquito species	Monthly abundance of mosquitoes												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Anopheles gambiae	21	21	32	68	80	99	118	131	80	64	41	32	787
An. arabiensis	30	28	38	35	74	84	82	84	64	30	39	28	616
An. funestus	17	14	18	15	56	57	60	70	36	15	19	18	405
Total	68	63	88	118	210	250	260	285	180	109	99	78	1808
Aedes aegypti	58	54	55	87	83	100	140	142	95	98	96	84	1091
Ae. albopictus	35	40	41	70	64	80	101	98	70	75	77	64	816
Ae. vittatus	38	32	41	58	58	68	80	81	47	58	46	48	655
Ae. qalpalis	18	28	22	37	46	57	20	20	28	24	24	14	338
Total	149	154	159	252	251	305	341	341	240	255	243	210	2900
Culex fatigans	55	50	50	87	79	108	128	128	98	90	90	69	1025
Cu. pipens	36	29	47	64	66	71	110	110	75	70	71	50	792
Cu. quenquefascia	29	21	30	48	58	61	87	87	46	53	51	42	605
Cu. tigripes	20	16	24	17	44	51	33	33	24	22	28	29	338
Total	140	116	151	247	247	291	358	358	243	235	240	190	2760
Grand total	357	333	408	586	708	846	932	976	663	599	582	478	7468

The highest numbers of mosquito species were recorded in the month of August with *Aedes aegypti* and *Culex fatigans* was found to be the most common of all the species. The distribution and abundance of the mosquito with temperature and rainfall are shown in Fig. 1.

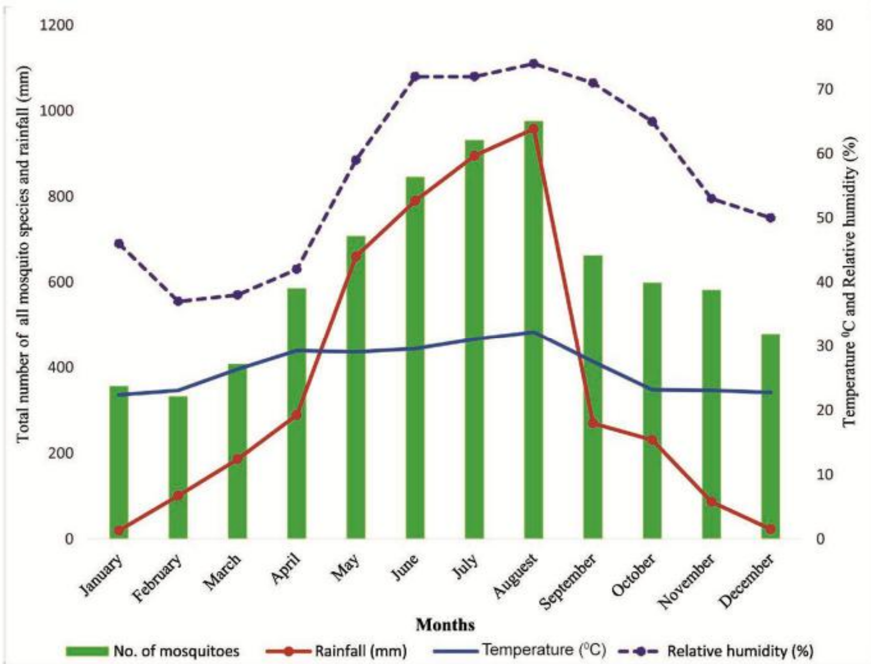

Fig. 1. Monthly prevalence of all mosquito species with temperature, rainfall and relative humidity in Dhaka city from July, 2014 to June, 2015.

Correlation coefficient between the average temperature and the total number of mosquitoes per month showed that the average temperature exhibited high correlation ($r^2=0.27$) with the total number of mosquito ($p<0.05$) which indicated that temperature had a significant effect on the abundance of mosquito vectors (Table 2). The correlation analysis between monthly rainfall and the total number of mosquito collected revealed that there was a very high correlation ($r^2=0.79$). Rainfall had a significant effect on the distribution and abundance of the mosquito vectors ($p<0.05$, Table 2). The result of the t test analysis carried out on the effects of both temperature and rainfall on the monthly abundance of mosquito vectors showed that they had a significant effect on climatic factors (Table 2).

Table 2. Analysis of correlation between the meteorological parameter and abundance of mosquito vectors (n=12).

Variables	CC	p values	r2
Rainfall vs TNMVs	0.85	0.001	0.79
Temperature vs TNMVs	5.02	2.200	0.27
Rainfall and temperature vs TNMVs	4.77	2.080	

CC=Correlation coefficient, TNMVs=Total number of mosquito vectors, $p<0.05$.

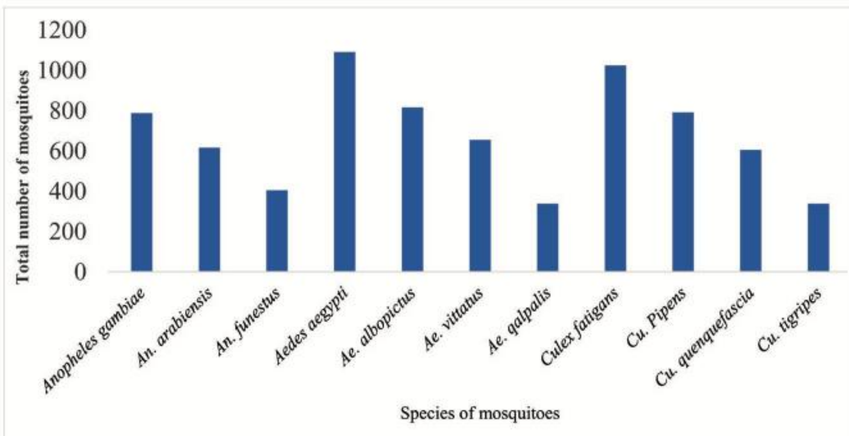

Fig. 2. Distribution pattern of all mosquito species in Dhaka city.

It is important to study the impact of weather on the transmission of malaria and other diseases associated with mosquito vectors, as global warming might change the pattern of temperature and rainfall which may directly or indirectly influence mosquito density or distribution (Wu *et al.* 2007). In this present study, the temperature was between 22.4 and 32.2^{o}C (Fig.1) with average humidity of 56.5% (Fig. 1) which might have facilitated the higher mosquito abundance. Similar kind of results has also been previously reported on the maximum survival rate of mosquito for the related temperature and humidity (Murty *et al.* 2010). Thu *et al.* (1998), also explained in their report that humidity was one of the vital factors affecting the population density of mosquitoes and it had been observed that the temperature at 28^{o}C with 55-55% relative humidity was the most appropriate condition for the elevation in mosquito density or abundance than the condition of lower temperature with higher humidity (22^{o}C/80-85% RH). Three main species of mosquito vectors were found, *viz.*, *Anopheles*, *Culex* and *Aedes*. Among the three malaria vectors species *Anopheles* found, *An. gambiae* had the highest number (Table 1) during the rainy periods (May - August). For *Aedes* mosquitoes, four species (Table 1) were found out of which *Ae. aegypti* had the highest number of abundance (Table 1) while *Ae. palpalis* had the least number. *Cx. fatigans* had the highest number (Table 1) and *Cx. tigripes* had the least abundance (Table 1). This result may be as a result of the fact that their larvae can colonize and survive in almost all habitats, such as the water or barrels, drainages, tyres, pots, discarded plastics and bottles and tanks. The pattern of rainfall also affects larval habitat and vectors population size. On the basis of rainfall, increased rainfall may increase larval habitats and vector population by creating a new habitat. Excessive rain could also eliminate habitats through flooding, thus decreasing the vector population especially malaria vectors because they prefer sunlit pools of water. During the dry season, limited rainfall can also create new habitats of *Anopheles gambiae, Aedes aegypti* and *Culex fatigans* species when water in the rivers is drawn into pools, providing the perfect breeding site for a number of mosquito species, thus favouring disease transmission as also observed by Gubler *et al.* (2001).

The temporal change in mosquito abundance is mainly caused by rainfall. *An. gambiae* adults were more abundant during the rainy season than during the dry season which is consistent with the finding that the number of larval habitats was substantially higher in the rainy season than in the dry season as previously reported by Zhou *et al.* (2007). The lower abundance of *An. funestus* adults than *An. gambiae* was caused by the lack of suitable, long-lasting larval habitats for *An. funestus* because its larvae normally take three weeks to develop into adults, and *An. gambiae* s.s larvae require approximately 10 days in sunlit habitats. However, it was revealed that tree canopy coverage exhibited a significant effect on the mosquito abundance in houses because it reduces the water temperature of larval habitats surrounding the houses because canopy cover reduces the amount of solar radiation reaching the larval habitats. It was also observed that the air temperature inside a house is affected by tree canopy.

Apart from the importance of congenial environmental and ecological factors such as breeding sites, humidity, temperature and rainfall, human activities such as agricultural practices, lumbering etc. also contribute to the distribution and abundance of these mosquito vectors especially the availability of host for blood meal. In conclusion, there was a high correlation of temperature and rainfall on the distribution and abundance of malaria and other related diseases associated with mosquito vectors. A small temperature rise either through seasonal variability, local microclimatic changes due to modification in vegetation cover or to global warming can increase disease transmission. The meteorological parameters are good prediction of malaria and associated disease risk.

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