INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

RAINY SEASON AND PHYSICO-CHEMICAL PROPERTIES OF MOSQUITO BREEDING HABITATS STIMULATE THE PREVALENCE OF *AEDES AEGYPTI* IN OLD DHAKA CITY, BANGLADESH

[1]Afroza Sultana, [2]Sharmin Hasan, [3]Magfur Raheman & [4]Mohammad Al Mamun
[1,3]Department of Zoology, Jagannath University, Dhaka-1100, Bangladesh
[2]Department of Botany, Jagannath University; Dhaka-1100, Bangladesh
[4]Deaprtment of Chemistry, Jagannath University, Dhaka-1100, Bangladesh
*Corresponding authors email: afrozasultana82@gmail.com

ABSTRACT
The dengue vector *Aedes aegypti*, is ubiquitous throughout the tropical and temperate regions. Favorable climatic condition along with human activities and poor waste management make Old Dhaka city a harbor to this vector at an alarming rate. The objective was to investigate the seasonal larval variation and physico-chemical properties of breeding habitats to evaluate the potential determinants of this vector's prevalence. Sampling was carried out in each month from March to October 2014 during summer and rainy season from the three artificial habitats in three study sites. Dipping method was used to collect mosquito larvae. The physico-chemical characteristics of breeding water including Temperature, pH, Dissolved oxygen, Conductivity, Total Dissolved Solids, and free Carbon Di Oxide were measured. In our study, the maximum larval occurrence was recorded in August and September during rainy season ranging of 5.7-17.2 and 9.6-17.9 respectively followed by a range of 0- 4.1during summer season. The factorial ANOVA revealed that larval density of different months was significantly ($F=6.31$; $p=0.00$) contributed to the seasonal variation regardless an insignificant effect of breeding habitats on the study sites ($F=0.026$; $p=0.99$). Among all the parameters, Dissolved Oxygen (2.6-7.2) was significantly affected the larval occurrence in the study sites. While, Total Dissolved Solids (74.2-530.5) in Bahadur Shah Park and both Total Dissolved Solids (77.3-596.7) and Conductivity (741.4-1658) in Ahsan Manzil had significant impact on the proliferation of larval occurrence. Free CO_2 (14.8-33.3) and high pH (>7.0) might limit the larval density in Jagannath University. Therefore, the highest larval occurrence recorded in Ahshan Manzil followed by Bahadur Shah Park and Jagannath University. Despite significant larval fluctuation over months, the maximum prevalence of *Aedes aegypti* larvae occurred during rainy seasons, as most of the physicochemical parameters might remain optimum for the growth and survival of larvae. These findings might be helpful in implanting an effective vector control program.

KEY WORDS: *Aedes aegypti*; larval density; physico-chemical properties; breeding habitats; rainy season; vector control program.

INTRODUCTION

Aedes aegypti represents the world's most important arboviral diseases including dengue fever, dengue hemorrhagic fever that posse a perilous risk to more than 2.5 billion people living in high-risk areas (Gubler, 1998a; Lam, 1998). *Aedes aegypti* (L.) is reported as one of the dominant vectors that causes dengue fever and dengue hemorrhagic fever in many urban areas of the South-east Asia (Sim *et al.*, 2012). In Bangladesh, these fevers were not rampant until a very first outbreak of dengue hemorrhagic fever and dengue fever hit the country severely during the 1950s and during early 1964 respectively (Rahman *et al.*, 2002; Aziz *et al.*, 1967). In every year since 2000, the dengue fever outbreak occurs during the rainy season in this country (Aziz *et al.*, 1967; Ahmad, 2000). The population of *Ae. aegypti* fluctuates with temperature, rainfall and humidity. The influence of climatic factors on the growth and development of *Aedes aegypti* in the life cycle is specific; the adult mosquitoes are directly susceptive to rainfall, temperature and relative humidity, whereas larval life is mainly affected by rainfall and water temperature (Micieli and Campos, 2003). In winter and summer, *Aedes aegypti* larvae die because of low and high temperature. The proliferation of this vector in Bangladesh is very rapid, as this country lies to the subtropical region with varying temperature and rainfall in different seasons. *Ae. aegypti* to the culicidae family of the genus *Stegomyia* can breed both in natural habitats, especially in tree holes, leaf axils, rock pool sand the artificial breeding habitats such as earthen, porcelain, plastic and coconut shells, discarded tires and waste buckets (Hawley, 1988, Barrera *et al*., 2002). The increased artificial larval breeding habitats that are pandemic in urban areas resulted from the rapid urbanization, high population growth rate and globalization. Like climatic factors, water chemistry of aquatic habitats also plays a vital role in determining the survival rate of mosquitoes (Chen *et al*., 2009; Rajesh *et al*., 2013). As the quality of breeding water determines whether female mosquito will lay eggs or undergo the developmental stages (Piyaratne *et al.*, 2005) the physicochemical characteristics of breeding water including P^H, Temperature, Total Dissolved Solids, Total Suspended Solids, and Electrical Conductivity influence the development and survival of mosquito larvae (Mutero *et al*., 2004; Devi *et al*., 2014). Hence, better understanding of the biology of *Aedes aegypti* in terms of the characteristics of larval developmental site (Schneider *et al*., 2004) coupled with exact information with seasonal occurrence of mosquito in a region is essential for vector control strategies (Alten *et al.*, 2000). However, lack of such information about *Aedes aegypti* has reported in the Old Dhaka city in Bangladesh. Therefore, the present study was carried out to understand the biology of *Ae. aegypti* in Old Dhaka city, Bangladesh. For this purpose, we aimed to determine: (1) the seasonal abundance of *Ae. aegypti* larvae, and (2) the potential relationship of physico-chemical variables of mosquito breeding habitats with the larval occurrence and distribution in Old Dhaka city.

MATERIALS & METHODS

Study area

Three areas were selected for the present study from the Old part of Dhaka city in Bangladesh. These are Jagannath University, Bahadur Shah Park, and Ahsan Manzil, located between 90º 24’ 24” E and 23º 42’29”N (Figure 1). The city has three distinct seasons categorized as a dry winter (November - February), humid summer (March - May) and rainy season (June- October) (Shahjahan *et al*., 2012).

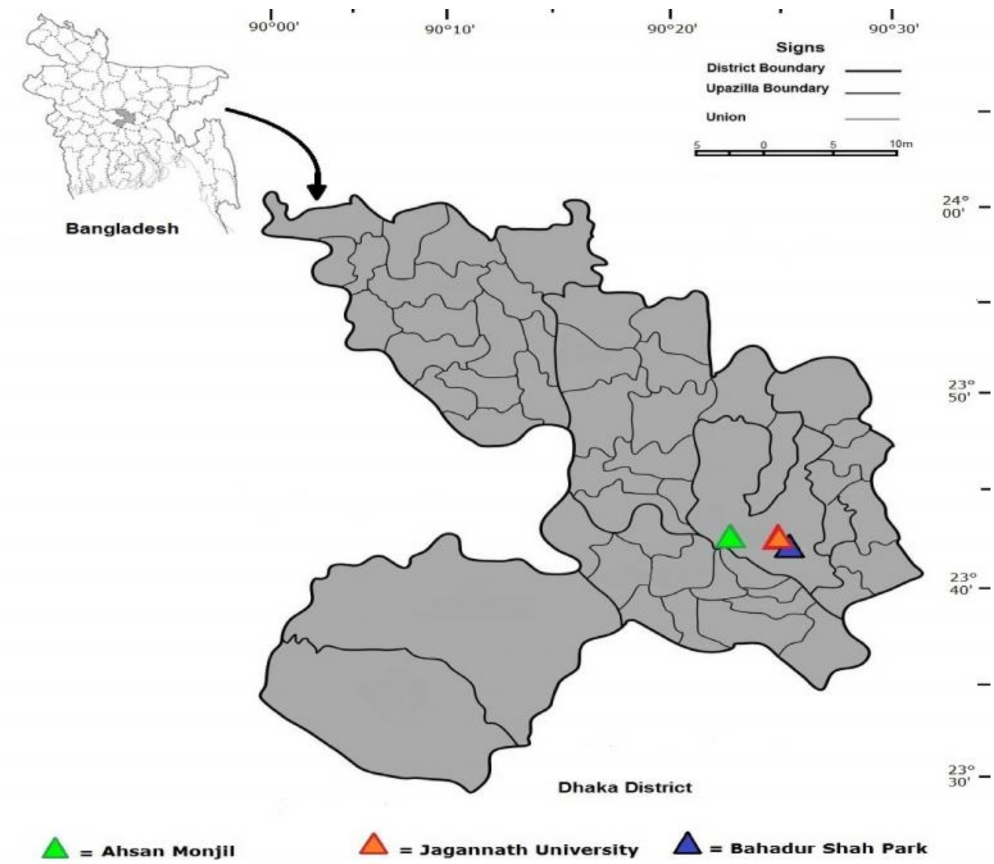

FIGURE 1. Map of Dhaka City showing three study sites namely Ahsan Manzil, Jagannath University and Bahadur Shah Park.

Identification of potential breeding sites

A thorough investigation for outdoor potential breeding sites was carried out at each study site. All breeding sites were inspected for the presence of larvae. Tire water, discarded containers and waste buckets were chosen in this study as these artificial habitats were more abundant in the study sites.

Mosquito larvae collection, processing and identification

Larval collection was done once in a month during humid summer seasons from March - May and during a rainy season from June – October in 2014. Larval collection was not taken during a dry winter season between November and February due to the scarcity of water in the mosquito breeding habitats. In extremes of weather eggs could survive over several months during the dry season or over winter, which is known as diapauses condition (Chowdhury *et al.*, 2014). A total of 72 samples were taken from three breeding habitats at the three study sites over eight months. Sampling was performed by dipping method as described by (Malley, 1995) between 0900hrs and 1100 hrs using a standard 250 ml capacity dipper. The dippers were always immersed slowly in the breeding places at an angle 45^0 and an interval of 2-3 minutes was maintained between subsequent dips, to allow the immature to return to the surface. A total of 10 dips were conducted in each and every breeding sites found. Larval density was expressed as the average number of larvae counted in each breeding habitats per 10dips (Thangamathi *et al*., 2014). The larvae collected from the field were transferred to the laboratory for culture and morphological identification. Collected larvae were placed in labeled WHO standard plastic vials with the information of location, sample number and date of sampling and kept in a humidified cooler and then transported to the laboratory for further sorting and identification. When larvae were found under light microscope, the samples were further identified with the help of Pictorial key (Rueda, 2004).Only *Aedes* mosquito larvae were considered and the other mosquito larvae were discarded.

Physico-chemical analysis of water from larval habitats

Water samples were collected together with larvae from three habitats using 200ml capacity specimen bottles. The sampled water was fixed immediately following standard procedures (APHA, 2005). The water samples were brought to the Chemistry laboratory of Jagannath University and preserved in refrigerator temporarily until analysis. Water pH was determined by glass electrode using a pH meter (Sense Ion, 156; HACH USA), Temperature (ºC) by the digital temperature meter (Fisher, USA) and Carbon Di Oxide determined by using the HACH kit box (FF2, USA).The electric Conductivity of water samples was directly determined by EC meter (Sense Ion, 156; HACH USA) in µs/cm, Total Dissolved Solids (TDS) by TDS meter (2100Q; HACH, USA) and Dissolved Oxygen by DO meter (HQ 30 D; HACH, USA).

Statistical analysis

To determine the effect of seasons on the prevalence of mosquito larvae, factorial ANOVA was executed to measure the effect of two independent variables on the larval density and distribution. To do this, in each time, a combination of two independent variables, from the three determining independent variables, namely, study sites, artificial breeding habitats and months, was chosen. When significant effects observed, the mean values of larval density were separated by Tukey (HSD) test. One way ANOVA was performed to determine the differences in physico-chemical properties of mosquito breeding habitat over a consecutive eight months. Along with, Pearson's correlation coefficient was also executed to find out the potential role of physico-chemical parameters of breeding water that led to the occurrence and the distribution of mosquito larvae. One way ANOVA, factorial ANOVA and Tukey (HSD) test were done by the STATISTICA 8.0 software and Pearson correlation coefficient's were done by SPSS version.

RESULTS

Larval density in the study sites

A total of 1339 larvae of *Aedes aegypti* mosquitoes were collected during the study period. The density of larvae collected from the three artificial breeding habitats was varied in three study sites. Mean larval density ranged 0-3.2 at Jagannath University, 0.33- 4.33 in the Bahadur Shah Park, and 0.4-5.97 in Ahsan Manzil (Table1). In Jagannath University, mean larval density was primarily highest in September (3.2) followed by August (1.9), October (0.80) and July (0.53), June and May (0.23), and in April (0.17) in decreasing order along with the zero larval density count in March. Bahdur Shah Park and Ahsan Manzil was likely to have the highest larval density in September, amounting to 4.33 and 5.97 respectively.

TABLE 1. Larval density of *Aedes aegypti* (counts/10dips) in the three artificial habitats over eight months in all the study sites (Number of larvae given within the bracket)

Study Sites	Breeding habitats	Summer season				Rainy season			
		March	April	May	June	July	August	September	October
Jagannath University	Tire water	0	0.2 (2)	0.3 (3)	0.4 (4)	1.2 (12)	1.4 (14)	1.7 (17)	0.4(4)
	Container	0	0.3 (3)	0.2 (2)	0.3 (3)	0.4 (4)	2.0 (20)	3.8 (38)	1.3 (13)
	Waste bucket	0	0	0.2 (2)	0	0	2.3 (23)	4.1 (41)	0.7 (7)
	Mean	0	0.17 (1.7)	0.23 (2.3)	0.23 (2.3)	0.53 (5.3)	1.9 (19)	3.2 (32)	0.8 (8)
Bahadur Shah Park	Tire water	0	1.1(11)	1.6 (16)	2.7 (27)	2.3 (23)	2.9 (29)	3.9 (39)	0
	Container	1.0 (10)	1.7 (17)	0.9 (9)	2.0 (20)	2.3 (23)	4.5 (45)	5.3 (53)	1.9 (19)
	Waste bucket	0 0.3	1.3 (13)	1.1(11)	2.5(25)	2.8 (28)	4.0 (40)	3.8 (38)	1.7 (17)
	Mean	0.33(3.3)	1.4 (14)	1.2 (12)	2.4 (24)	2.45 (24.5)	3.8 (38)	4.33 (43.3)	1.2 (12)
AhsanManzil	Tire water	0	1.0 (10)	0	3.0 (30)	4.6 (46)	5.6 (56)	5.7 (57)	0
	Container	1.5 (15)	1.4 (14)	1.0 (10)	2.8 (28)	4.3(43)	5.4 (54)	6.0 (60)	0
	Waste bucket	0	1.1 (11)	0	2.4 (24)	3.2(32)	6.2 (62)	6.2 (62)	1.2 (12)
	Mean	0.5 (5)	1.17 (11.7)	0.33(3.3)	2.73 (27.3)	4.03(40.3)	5.73(57.3)	5.97 (59.7)	0.4 (4)

However, the lowest larval density (0.33) recorded in March for Bahadur Shah Park and in October (0.4) for Ahsan Manzil. During this time, highest rainfall was observed in July (337 mm) and September (392mm) and *Ae. aegypti* was prevalent in the area of Old Dhaka. While considering the abundance of larvae in each habitat during the whole study period, the highest mean larval density recorded from discarded container amounting to 2.80 in Ahsan Manzil, 2.21 in Bahadur Shah Park and 1.04 in Jagannath University. Whereas the lowest mean larval density was counted from tire water in Bahadur Shah Park (1.81) and in Jagannath University (0.65), however, the lowest larval density of 2.39 was only recorded from waste bucket in Ashan Mazil. The outcome of factorial ANOVA revealed that the larval density was not significant among breeding habitats (F= 0.693, p= 0.50). The effect of different breeding habitats was also insignificant in the prevalence of larval density among the three study sites (F=0.0261, p=0.997) and among the months (F=0.286, p=0.993) (Table 2).Larval density not only was significantly differed among study sites (F=6.036, p=0.004), but also did it varied significantly among month in all sites (F=6.312, p=0.000).The result of the Tukey (HSD) test, further, explained the larval density varied significantly (F= $p<0.01$) within and between both months (Figure. 2). According to Tukey test, the larval density calculated in September was the most significant that variation within the other months in Jagannath University, and between the months in Bahadur Shah and Ahsan Manzil. Whereas, August and September appeared to be themost significant months having the maximum larval occurrence in both Bahadur Shah Park and Ahsan Manzil than that of the other months within and between the sites.

TABLE 2. Summary of ANOVA for the determination of the association among months, breeding habitats and study sites with larval density

Sources	SS	DF	MS	F	P
Months	154.605	7	22.087	13.834	0.000
Habitats	2.214	2	1.107	0.693	0.504
Study sites	38.162	2	19.081	6.036	0.004
Months*habitats	6.398	14	0.457	0.286	0.993
Study sites*months	30.509	14	2.179	6.312	0.000
Habitats*study sites	0.331	4	0.083	0.0261	0.997

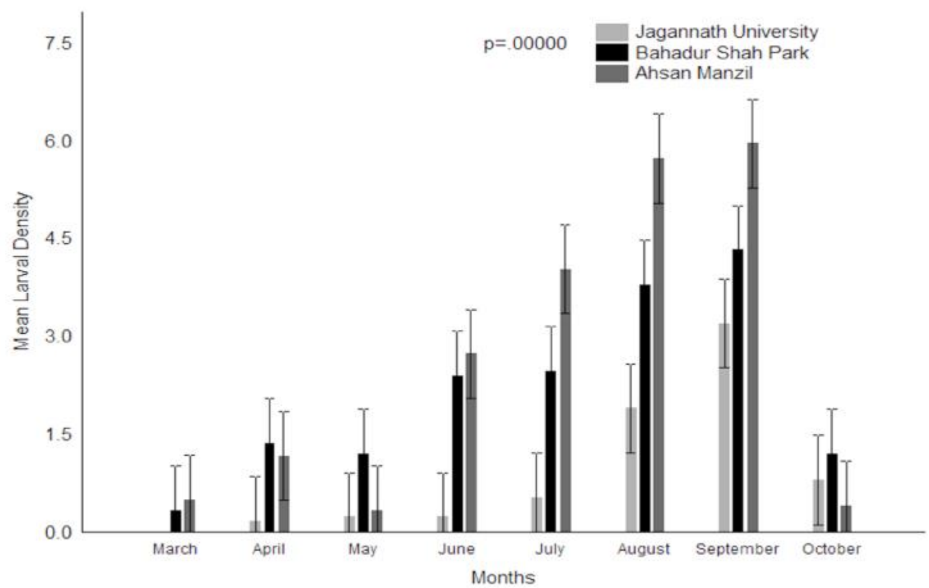

FIGURE 2. Monthly mean larval density in three study sites.

Physico- chemical properties of breeding habitats

The physico-chemical properties of breeding water, including Temperature (ºC), pH, Conductivity (µS/cm), Dissolved Oxygen (mg/l), Total Dissolved Solids (mg/l), and free Carbon Di Oxide (mg/l) were determined. In Jagannath University, mean water temperature was ranged of 28.7 ± 0.96 - 31.8 ±1.79ºC in which the highest and lowest value measured in June and October respectively. The mean water Temperature was highest in August both for Ahsan Manzil (32.5±6.31) and Bahadur Shah Park (32.4 ± 6.37). Similarly, these two sites had the lowest mean water Temperature in October, representing a value of 26.3±1.10 and 25.7±0.57 respectively (Table 3). Water pH was recorded highest (7.2 ± 0.10) in March in both Jagannath University and Bahadur Shah Park and the lowest water pH (6.7 ±0.36) found in both Ahsan Manzil and Bahadur Shah Park in March and June respectively. In case of Conductivity, the highest Conductivity of (1656 ±189.8) was founded in August and the lowest Conductivity (741± 54.1) was in October in Ahsan Manzil in comparison with the other sites.

ISSN 2229 – 6441

TABLE 3. Monthly physico-chemical properties of breeding water of *Aedes aegypti* in three study areas (Mean ±Standard deviation)

Jagannath University

Parameters	Mar.	April	May	June	July	Aug.	Sept.	Oct.
Temp(^{0}C)	28.8 (1.20)	31.1 (1.12)	31.2 (1.98)	31.8 (1.79)	31.6 (1.41)	30.8 (0.95)	29.4 (1.45)	28.7 (0.96)
pH	7.2 (0.10)	7.3 (0.10)	7.3 (0.26)	7.1 (0.10)	7.1 (0.15)	7.1 (0.26)	7.0 (0.17)	7.0 (0.00)
DO (mg/l)	4.7 (0.10)	4.8 (0.05)	3.9 (0.20)	5.5 (0.11)	5.5 (0.43)	5.5 (0.49)	5.8 (0.83)	5.4 (0.10)
Free CO_2 (mg/l)	14.8 (2.81)	15.7 (2.58)	15.9 (3.90)	22.3 (7.56)	19.9 (6.49)	32.2 (5.61)	28.3 (2.80)	22.8 (6.87)
TDS (mg/l)	63.2 (9.54)	78.2 (5.08)	120.8 (21.8)	145.5 (25.4)	386.1 (136.6)	384.4 (315.4)	278.7 (80.3)	174.6 (0.34)
Cond. (µS/cm)	875.2 (0.10)	1098 (96.0)	942.6 (0.11)	1283.5 (42.2)	1156.0 (146.4)	1107.7 (111.5)	1242.7 (0.25)	1157.5 (241.5)

AhsanManzil

Parameters	Mar.	April	May	June	July	Aug.	Sept.	Oct.
Temp(^{0}C)	30.1 (0.63)	31.5 (2.80)	31.9 (0.15)	30.8 (3.05)	28.9 (0.05)	32.5 (6.31)	26.3 (1.03)	26.3 (1.10)
pH	6.7 (0.36)	7.0 (0.30)	7.1 (0.10)	6.8 (0.47)	6.9 (0.05)	7.1 (0.10)	6.9 (0.30)	6.7 (0.32)
DO (mg/l)	2.6 (0.11)	3.1 (0.10)	3.7 (0.10)	4.3 (0.49)	5.8 (0.05)	4.8 (0.05)	5.3 (0.01)	4.3 (0.49)
Free CO_2 (mg/l)	21.6 (6.30)	18.8 (1.10)	23.0 (3.66)	27.3 (6.69)	32.3 (0.25)	30.7 (3.23)	29.4 (1.21)	33.3 (0.25)
TDS (mg/l)	77.3 (1.34)	97.3 (13.3)	192.2 (77.6)	300.3 (40.5)	481.8 (194.7)	596.7 (72.1)	230.7 (96.9)	138.7 (63.3)
Cond. (µS/cm)	1254.3 (0.00)	963.3 (0.25)	920.0 (58.5)	1219.6 (99.3)	1300.4 (113.9)	1656.8 (189.8)	1020.0 (218.4)	741.4 (54.1)

Bahadur Shah Park

Parameters	Mar.	April	May	June	July	Aug.	Sept.	Oct.
Temp(^{0}C)	31.0 (1.05)	30.3 (1.03)	32.5 (0.75)	31.1 (0.80)	29.3 (0.80)	32.4 (6.37)	26.9 (0.00)	25.7 (0.57)
pH	7.2 (0.10)	6.8 (0.52)	6.8 (0.66)	6.7 (0.66)	7.0 (0.10)	7.1 (0.10)	7.1 (0.10)	7.2 (0.10)
DO (mg/l)	4.1 (0.10)	4.5 (0.11)	5.7 (0.10)	5.2 (0.10)	5.3 (0.10)	7.2 (0.10)	7.2 (0.10)	4.5 (0.11)
Free CO_2 (mg/l)	32.6 (3.40)	28.7 (8.45)	25.1 (3.69)	32.5 (0.45)	32.3 (0.25)	28.8 (0.11)	28.7 (0.00)	33.3 (0.25)
TDS (mg/l)	74.2 (16.4)	137.4 (41.8)	131.8 (98.9)	252.9 (82.2)	471.6 (90.2)	530.5 (62.0)	229.4 (96.9)	133.4 (20.2)
Cond. (µS/cm)	1247.3 (168.0)	984.1 (0.15)	1031.7 (116.7)	758.2 (0.10)	854.2 (0.10)	847.3 (52.3)	1057.3 (126.6)	802.7 (59.3)

Study sites	Parameters	R	*p*-value
Jagannath University	Temperature(ºC)	-0.135	0.528
	pH	-0.498	0.013
	Dissolved oxygen(mg/l)	0.642	0.001
	Conductivity(µS/cm)	0.352	0.091
	Total Dissolved Solids(mg/l)	0.338	0.107
	Free CO2(mg/l)	0.539	0.002
Bahdur Shah Park	Temperature(ºC)	-0.018	0.932
	pH	0.068	0.752
	Dissolved oxygen(mg/l)	0.843	0.000
	Conductivity(µS/cm)	-0.290	0.169
	Total Dissolved Solids(mg/l)	0.480	0.018
	Free CO2(mg/l)	-0.105	0.626
Ahsan Manzil	Temperature(ºC)	-0.099	0.645
	pH	0.169	0.429
	Dissolved oxygen(mg/l)	0.727	0.000
	Conductivity(µS/cm)	0.526	0.008
	Total Dissolved Solids(mg/l)	0.481	0.017
	Free CO2 (mg/l)	0.397	0.054

TDS: Total Dissolved Solids; Temp: Temperature; Cond.: Conductivity; DO: Dissolved oxygen

TABLE 4. Pearson's correlation coefficient (r) of physico-chemical properties of breeding water and larval densities of *Aedes aegypti* in three sites

The highest mean Dissolved Oxygen (7.2 ±0.10) was measured in two consecutive months of August and September in Bahdur Shah Park and the lowest value recorded in March in Ahsan Manzil. Unlike the mean Dissolved Oxygen, mean Total Dissolved Solids from the Ahsan Manzil had the highest value of (596.7± 72.1) in August and the lowest value of 63.2± 9.54 in March in Jagannath University. Surprisingly, the highest (1656.8 ± 189.8) and the lowest (741 ± 54.1) average amount of free CO2 were measured in August and in October respectively in Ahsan Manzil (Table 3).

Effects of physicochemical factors on larval densities

Pearson's correlation coefficient results clearly showed the association of physico-chemical properties of water with the larval density (Table 4). In Jagannath University, the Dissolved Oxygen ($r = 0.642$; $p < 0.05$) and free CO_2 ($r = 0.539$; $p<0.01$) had a significant positive influence on the larval density. In Bahadur Shah Park and Ahsan Manzil, Dissolved Oxygen and Total Dissolved Solids were significantly related with the occurrence of larval density, amounting to ($r =0.843$; $p<0.01$) and ($r =0.480$; $p<0.05$) respectively, for Bahadur Shah Park ($r = 0.727$; $p<0.01$) and ($r= 0.481$; $p<0.05$) for Ahsan Manzil. Noticeably, only water pH from Jagannath University showed significant but negative association with the larval density ($r =-0.498$; $p<0.05$) and Conductivity showed positive significant association ($r= 0.526$; $p<0.05$) with larval density in Ahsan Manzil. The negative relationship between water Temperature and larval density was also evident in all sites.

DISCUSSION

Two seasons namely wet rainy and dry summer season showeda conspicuous variation in the larval abundance in the study sites. Overall prevalence of *Ae. Aegypti* in old Dhaka city showed a gradual increase during rainy season, however, a sharp decline was observed from the post monsoon to summer season. Notably, during summer season, zero or minimum larval population was observed in March and maximum larval population reported in both August and September. This finding was consistent with the previous studies on *Aedes aegypti* and also on the coexisting of *Ae. albopictus* mosquito in Dhaka city (Nargis *et al.*, 2012). Consequently rainy season turned out to be the most crucial season for the development of mosquito. In Dhaka city, the *Aedes* species were prominent during rainy season with a low population density during winter-summer (Tauhid *et al.*, 2007). The population of *Aedes aegypti* is influenced by rainfall in areas where it is markedly seasonal (Trips, 1972). Therefore, dengue incidences were seen to be frequent during monsoon as the availability of potential breeding habitats were associated with the large amount of rainfall. The observed lowest larval density reported during summer season might be related to high temperature. Also, our study revealed that larval density plunged in October during the late monsoon with falling temperature that usually prevails upon the following months of winter season until the beginning of dry summer season. The water temperature is an important factor of *Ae. aegypti*'s survival and development that limits its distribution and seasonal occurrence in subtropical zones (Christophers, 1960). This finding clearly depicted that the lower larval density might be related to an extreme high or low temperature. Recent studies revealed that breeding habitats were found to be significant in the occurrence of *Ae. aegypti* larvae (Thangamathi *et al.,* 2014). As mean larval density recorded from the three studied breeding habitats varied, however, the variations were not significant among the breeding habitats. As a result, no particular type of breeding habitats identified as a determinants in the occurrence of mosquito larvae. When comparing the larval density among the three study sites, Ahsan Manzil had the highest occurrence of mosquito larvae in all sites followed by Bahadur Shah Park and Jagannath University. Present investigation also revealed that monthly physico-chemical properties of the *Ae. Aegypti* breeding habitats showed variation in all sites. The overall temperature in the study sites lied to the range of 16-32^{0}C specified by USEPA, which is referred as the optimum temperature for the breeding of most mosquito species, including *Culex*, *Anopheles* and *Aedes* in the tropics (Bradley and Kutz, 2006). However, negative relationship between water temperature and larval density in all sites might provide an insight about the optimum temperature that might be beyond the referred optimum temperature for larval occurrence in this region. Water pH of all the breeding sites was also within the recommended pH (4-11) for larval maximum growth (Clark *et al*., 2004), but did not have significant association with the larval density. However, the lower larval density might be resulted in negative association with pH in Jagannath University as this site had highest water pH (7.2). Therefore, our study revealed that larval occurrence might limit beyond water pH of 7.2. The water pH beyond a range of 7-8 could be the limiting factors for larval growth and survival (Thangamathi *et al*., 2014). Like pH, the Conductivity (µS/cm) also showed negative correlation with the abundance of larvae in the Bahadur Shah park area. A similar observation was seen in Nigerian *Aedes aegypti* population (Oleymi *et al*., 2010). However, a significant positive relationship was observed in Ahsan Manzil leading to an extensive proliferation of mosquito larvae, which was consistent with the findings in *Aedes albopictus* mosquito, India (Bradley and Kutz, 2006). In the present study, *Aedes aegypti* was found positively significant in relation to Dissolved Oxygen require for larval growth and development that was also reported by Gopalakrishnan *et al*., 2013 in Assam, India. The range of Total Dissolved Solids (mg/l) in our study 63.2- 596.7 resembledthe range of 79.83-693.00 in different breeding habitats of *Aedes aegypti* (Rao *et al*., 2011). In addition, Total Dissolved Solids showed significant role in the occurrence of *Aedes aegypti* in all sites except Jagannath University. It was reported that the higher concentration of Total Dissolved Solids reduce transparency and increase oxygen deficiency (Webb and Walling, 1992). Therefore, the highest total dissolved solids measured in our study might induce the growth and survival of mosquito in this area. Previously published reports on the effects of Carbon Di Oxide, *Aedes aegypti* are too limited. In our findings, Carbon Di Oxide (mg/l) only significantly correlated with *Aedes aegypti* in Jagannath University that might act as another limiting factor in the development of larvae in breeding water. It was reported in Srilanka that Carbon Di Oxide (ppm) ranged of 0.0-65.0 from an irrigated mosquito breeding area referred to a good factor for mosquito population (Amerasinghe *et al*., 1995). Despite our measured Carbon Di Oxide (14.8-32.2) fitted in the referred range, this parameter had insignificant influence on larval density in areas like Ahsan Manzil and Bahadur Shah Park where the most larval density was reported. It was also observed that the parameters that showed significant association with larval density had a maximum mean amount in August and September in all sites inferring a strong relationship between larval occurrence and physico-chemical parameters during rainy seasons.

CONCLUSION

Data obtained from this study clearly showed a distinct seasonal variation in larval density in all the study sites where rainy season might be the most favorable to the occurrence of *Ae. aegypti.* In addition, physico-chemical parameters, including pH, Dissolved Oxygen, Total Dissolved Solids, Conductivity and free Carbon Di Oxide except Temperature of breeding water showed either positive or negative significant correlation with larval density. Those parameters including Dissolved Oxygen, Conductivity and Total Dissolved Solid had a positive significant association with the larval density, might affect the maximum occurrence and prevalence of mosquito larvae. However, lower larval density was associated with the pH, free CO_2 in the study sites. Therefore, the highest larval occurrence was in Ahsan Manzil and the lowest in Jagannath University. Manipulation of such determinants in the breeding habitats during rainy season might diminish the larval occurrence in this region. Also, scheme of breeding habitat selimination that holds the rainwater might be incorporated into the mosquito control strategy. Finally, our study postulated that physico-chemical parameters and rainfall exert a significant influence on larval occurrence. Our findings, thus, provide important information that can be of use for developing an effective vector control strategies to reduce the potential breeding habitats and the occurrence of *A. aegypti* larvae in old Dhaka city.

REFERENCES

Ahmad, K. (2000) Bangladeshi Government appeals to WHO. *Lancet* **356**(9227), 409.

Alten, B., Bellini, R., Calgar, S.S.,. Simsek, F.M and Kaynas (2000) Species composition and seasonal dynamics of mosquitoes in the Belek region of Turkey. *Journal of Vector Ecology*, **25**(2), 146-154.

Amerasinghe, F.P., Indrajit, N.G. and Ariyasena, T.G. (1995) Physico-chemical characteristics of mosquito breeding habitats in an irrigation development area in Srilanka. *Cey J. Sci. (Biol Sci).* 24(2), 13-29.

APHA, AWNA and WEF (2005) Standard methods for the examination of water and wastewater (Eaton A.D., Clesceri I.S., Greenberg A.E., eds), 21st ed. Amer pub Hlth Assoc, Washington, DC. 1325p.

Aziz, M.A., Graham, R.R. and Gregg, M.B. (1967) "Dacca fever"-an outbreak of Dengue. *Pak j Med Res.***6**, 83-92.

Barrera, R.N., Delgado, M., Jimenez and Valero, S. (2002) Eco-epidemiological factors associated with hyper endemic dengue hemorrhagic fever in Maracay City, Venezuela. *Dengue Bull.***26**, 84-95.

Bradley, P. and Kutz, F.W. (2006) Proceeedings of the workshop on strom water Management and Mosquito control. U.S. Enviromental protection agency, Office of Research and Development. EPA/903/ R-06/004.

Chen, C.D., Lee, H.L., Stella-Wong, S.P., Lau, K.W. and Sofian-Azirun, M. (2009) Container survey of mosquito breeding sites in a university campus in Kuala Lumpur, Malaysia. *Dengue Bulletin*. **33**(pt 1) pp, 187–193.

Chowdhury, R., Chowdhury, V., Faria, S., Huda, M.M., Laila, R., Dhar, I., Maheswary, N.P. and Dash, A.P. (2014) How dengue vector *Ae. albopictus* (Diptera: Culicidae) survive during the dry season in Dhaka City, *Bangladesh. J. vector Borne Dis.*51, 179-187.

Clark, T.M., Flis, B.J. and Remold, S.K. (2004) pH tolerances and regulatory abilities of freshwater and euryhaline Aedine mosquito larvae. *J Exp Biol.* 207, 2297-2304.

Devi, N., Pemola, R. Mondal and Jauhari, R.K. (2014) Physico- chemical Assessment of natural breeding habitats of mosquito larvae in Outskirts Dehradun City, Uttarakhand. *J Commun Dis*.46 (3), 29-39.

Gopalakrishnan, R., Das, M., Baruah, I., Veerv and Dutta, P. (2013) Physicochemical characteristics of habitats in relation to the density of container-breeding mosquito in Asom. India. *J Vector Borne* Dis.50, 215-219.

Gubler, D. J. (1998a) Dengue and dengue hemorrhagic fever.*Clin Microbiol Rev*.**11**, 480-496.

Hawley, W. A. I. (1998) Biology of *Aedes albopictus*. *J Am Mosq control AssocSuppl.***1**, 1-39.

Lam, S.K. (1998) Emerging infectious diseases. *Southeast Asia Emerg Infect Dis*.**4**: 145-147.

Micieli, M.V. and Campos, R.E. (2003) Oviposition activity and seasonal pattern of a population of *Aedes (Stegomiya) aegypti* (L.) (Diptera:Culicidae) in Subtropical Argentina. *Mem Inst Oswaldo Cruz.***98**, 659-663.

Mutero, C.M., Ngaanga, P.N., Wekotela, P., Githure, J. and Kondrasen, F. (2004) Ammonium sulphate fertilizer increases larval population of *Anopheles arabiensis* and culicine mosquitoes in rice field. *Acta Trop*. 89:187-92.

Nargis, S., Tanzin, A. and Shefali, B. (2012) Population studies of tree hole breeding *Aedes* species (Diptera: Culicidae) in Dhaka University campus and its adjacent

Suhrawardipark, Dhaka city, Bangladesh. *Bangladesh J Zool*. **40**(1), 1-11.

O'Malley, C. (1995) Seven ways to a successful dipping career. *Wing Beats.***6**, 23-24.

Oleymi, I.K., Malu, I.C.G., Famotele, O. I., Shegna, S.P. and Idrais, B. (2010) Distribution of mosquito larvae in relation to physicochemical characteristics of breeding habitats in Minna, North Central Nigeria. *Rev Infec*.1, 49-53.

Piyaratne, M.K., Amerasinghe, F.P., Amerasinghe, P.H. and Kondrasen, F. (2005) Physico-chemical characteristics of *Anopheles culicifacies* and *Anopheles varuna* breeding water in a dry zone stream in Srilanka. *J Vect Borne Dis*.**42**, 61-67.

Rahman, M., Rahman, K., Siddique, A., Shoma, S., Kamal, A.H.B. and Ali, K.S. (2002) First outbreak of dengue hemorrhagic fever, Bangladesh. *Emerg Infect Dis*.**8**, 738-740.

Rajesh, K., Dhanasekaran, D. and Tyagi, B.K. (2013) Survey of container breeding mosquito larvae (Dengue vector) in Tiruchirappalli district, Tamil Nadu, India." *Journal of Entomology and Zoological* Studies **1**(pt 6), 88–91.

Rao, B.B., Harikumar, P.S., Jayakrishnan, T. and George, B. (2011) Characteristics of Aedes (Stegomyia)albopictusSkuse (Diptera :Culicidae) breeding sites. *Southeast Asian J. Trop Med Public Health*.42: 1077–82.

Rueda, L.M. (2004) Pictorial keys for the identification of mosquito associated with dengue virus transmission. Magnolia press, Auckland New Zealand. *Zootaxa*. 589, 1-60.

Schneider, J.R., Morrison, A.C., Astete, H., Scott, T.W. and Wilson, M.L. (2004) Adult size and distribution of *Aedes aegypti* (Diptera: Culicidae) associated with larval habitats in Iquitos, Peru. *J. Med. Entomol*. **41** (4), 634-42.

Shahjahan, M., Saiful Islam, A.K.M. and Madhu, M. K. (2012) Spatial and Temporal Distribution of Temperature, Rainfall, Sunshine and Humidity in Context of Crop Agriculture, Institute of Water and Flood Management Bangladesh. University of Engineering & Technology.54 (3), 797-811.

Sim, S., Ramierz, J.L. and Dimopoulos, G. (2012) Dengue virus infection of the *Aedes aegypti* salivary gland and chemosensory apparatus induces genes that modulate infection and blood-feeding behavior. *Plos Pathog*. **8**(3),e 1002631.

Tauhid, U. Ahmed, G.M. SaifurRahman, Kabirul Bashar, Mohammed Shamsuzzaman, ShiperSamajpati andSamima Sultana (2007) Seasonal prevalence of dengue vector mosquitoes in Dhaka city, Bangladesh. *Bangladesh J Zool*.**35** (2), 205-212.

Trips, M. (1972) Seasonal change in the larval populations of *Aedes aegypti* in two biotopes in Dar es Salaam, Tanzania. *Bull. World Health Organ*.**47**, 245-255.

Thangamathi, P., Ananth, S., Kala, N., Maheshwari, R., Gnanasoundral, A. and Nagamani, N. (2014) Seasonal variations and physico-chemical characteristics of the habitats in relation to the density of dengue vector Aedesaegypti in Thanjavur, Tamil Nadu, India. *I J S N*.5 (2): 271-276.