Bangladesh J. Zool. ***52**(3): 247-267, 2024* *Article*
ISSN: 0304-9027
eISSN: 2408-8455

MOSQUITO BREEDING STATUS IN DRAINS OF MOULVIBAZAR MUNICIPALITY AREA, SYLHET, BANGLADESH

Musammath Amina Bagum[1*], Md. Ashek Kabir Chowdhury[1] and G. M. Saifur Rahman[1]

Department of Zoology, National University, Gazipur-1704, Bangladesh

ABSTRACT: Mosquitoes can be vectors of several infectious and life-threatening diseases including bancroftian filariasis, which is endemic in Eastern hilly and forest parts of Bangladesh together with Moulvibazar district. To assess its vector breeding situation a yearlong (September 21 to August 22) intensive survey was conducted in different drains in the nine administrative wards in the municipality areas of Moulvibazar. Three species of mosquito immature were identified in the stagnant water of different types of drain habitats. Among them, *Culex quinquefasciatus* was the dominant species (88.4%) followed by *Armigeres sp* (11.2%) and *Cx. tritaeniorhynchus* (0.2%). The highest population was found in Drain-4 in Ward-1 and the fewest mosquito larvae were observed in Drain-55 under Ward 6. ANOVA suggested that mosquito immature varied significantly in different months in different Wards. Pearson correlation analysis indicated rainfall and relative humidity are the most important meteorological factors influencing the occurrence of mosquito-immature populations. Specifically, water temperature is positively correlated with total immature (r = 0.645, p = 0.000), *Cx. quinquefasciatus* (r = 0.470, p = 0.000) and with *Armigeres sp* (r = 0.271, p = 0.000). Water P^H has a positive correlation with *Armigeres sp* (r = 0.528, p = 0.000), but a negative correlation with *Cx. quinquefasciatus* ($r = -.380^{**}$, p = 0.000). Water depth has shown a negative correlation with *Cx. quinquefasciatus* ($r = -.413^{**}$, p = 0.000) and *Armigeres sp* ($r = -.194^{**}$, p = 0.000). Furthermore, average temperature is positively correlated with total rainfall ($r = 0.631^{*}$, p = 0.028) and rainfall days (r = 0.770, p = 0.003), whereas total mosquito immature is negatively correlated with total rainfall ($p = -.585^{*}$, p = 0.046), rainfall of days ($r = -0.673^{*}$, p = 0.016) and humidity ($r = -.922^{**}$ p = 0.000). These findings will provide a basic guideline to plan future mosquito control operations in the present study area.

Key words: Mosquito, immature, drains, Moulvibazar, physiochemical parameters, Bangladesh.

INTRODUCTION

The rural population of Bangladesh is moving towards urban areas to avail various facilities of city life. The expansion of cities into rural peripheries and collective changes in urban land cover have led to dramatic differences in

**Author for correspondence:* <aminabegum1500@gmail.com>
 DOI: https://doi.org/10.3329/bjz.v52i3.80785

the habitat of mosquito larvae, and this expansion has been accompanied by changes in strategies to control the aquatic stages of mosquitoes (Jacob *et al.* 2005). It has long been recognized that human land use changes cause an increase in mosquito populations and the spread of diseases transmitted by mosquitoes. These changes occur in several broad, overlapping areas, such as urbanization, canal irrigation, agricultural growth, deforestation, and water retention systems. Moreover, vector and disease transmission may be considerably aided by human activities connected to any of these landscape changes (Patz *et al.* 2000, Norris 2004 and Bashar *et al.* 2016).

Mosquitoes are cosmopolitan organisms, and can be vectors of several infectious and life-threatening diseases (Khatun *et al.* 2019). Among >3,000 mosquito species in the world, 117 mosquito species have been identified in Bangladesh, including 36 anopheline, 79 culicine, and two toxorhynchitine (Khan *et al.* 2014). One of the main public health problems in Bangladesh is mosquito-borne diseases (Hossain *et al.* 2000, Farjana *et, al.* 2015). Mosquito-borne diseases such as dengue, malaria, and filariasis are in some epidemics in the regions of Bangladesh (Hossain *et al.* 2000). In Bangladesh, *Culex quinquefasciatus* is the only vector for nocturnal periodic bancroftian filariasis (Khanum *et al.* 2018). Although this disease is found in almost all the districts it is endemic in Eastern hilly and forest parts of Bangladesh including Moulvibazar district (Nur *et al.* 2021).

Some other mosquito species such as *Armigeres subalbatus* are commonly found close to human dwellings especially in urban and suburban areas (Bhattacharyya *et al.* 2000). It has also been reported to be a vector of the filarial worm *Wuchereria bancrofti* in India (Muslim *et al.* 2013). *Mansonia* breeds on aquatic plants, while *Cx. tritaeniorhynchus* prefers to nest in rice fields (Khan *et al.* 2014). This species of mosquito changed its ovipositional habit considerably due to environmental changes (Karlekar *et al.* 2013, Wilke *et al.* 2014). The temporal and spatial distribution of mosquitoes may be influenced by human activities that change the environment, such as irrigated fields and land settlements (Zeilhofer *et al.*2007, Zhou *et al.* 2007, Vanwambeke 2007). Physicochemical factors affect the oviposition, survival, and temporal distribution of mosquitoes (Gimnig *et al.* 2001). Lack of proper waste disposal, inadequate sanitary and drainage systems, unplanned urban growth, and resource shortages have all contributed to the rise of numerous suitable mosquito breeding grounds, which has led to high mosquito population densities (Norris 2004).

Vector species tend to expand with increasing density and is strongly influenced by environmental or ecological factors, which is poorly understood (WHO 1975). It is necessary to have a thorough understanding of both the local environment and the vector's behavior to concentrate efforts to manage the mosquito population (Molineaux 1997). There is a notable gap in knowledge regarding the physicochemical properties of mosquito breeding sites and larval habitat preferences. Furthermore, the lack of detailed information on the urban mosquito situation in the Moulvibazar district headquarters has prevented the implementation of adequate mosquito control measures. Consequently, the annoyance of mosquito bites and the prevalence of various mosquito-borne diseases are escalating daily in these regions. At present, no published reports detail the larval ecology and breeding habitat characteristics of mosquitoes in these areas. This survey aims to identify the species complex, population density, seasonal variations of mosquitoes, and contributions of the larval habitats to the overall mosquito population in the study areas. The results will undoubtedly aid in developing an effective mosquito population management program and enhance awareness of society to prevent mosquito-borne diseases.

MATERIAL AND METHODS

Study area: The present study took place in the Moulvibazar municipality area, a district headquarters in northeastern Bangladesh, approximately 62 km south of the Divisional headquarters in Sylhet. It is located at 24°29'00'' North and 91°47'00″ East latitude. Moulvibazar municipality covers a densely populated area of around 10.36 km², housing 56,537 households. Geographically, the study area is segmented into hills, midlands, and plains. The southern part of the town is a hilly region abundant in vegetation, while its northern boundary is marked by the Manu River. To the east lies the midland, and the west is characterized by flat land. The climate of the area is noted for moderately high temperatures lasting about eight months of the year, coupled with high humidity and substantial rainfall during the summer (April–September). The hot, wet season begins in early April and lasts until September, with a subtropical climate that has an annual average temperature ranging from 13.7 to 30.6˚C and an annual rainfall of approximately 2805 mm.

The Moulvibazar municipality is divided into nine administrative wards (Figure 1). Ward-1 includes Shoiyarpur and East Girzapara; Ward-2 encompasses Vocational Road and Shonapur; Ward-3 contains Arambag and Kalimabad; Ward-4 covers Shantibag and Muslim Quarter; Ward-5 comprises Barichar Road and Paschim Bazar; Ward-6 consists of Borohat and Upazila Complex; Ward-7 involves Sultanpur and Kazirgaon; Ward-8 includes Gavindasri and Dhorkapon; and Ward-9 consists of Daarok and North Mostafapur. Each ward features a mix of sparse to dense vegetation, paved and unpaved roads, and drains, various sizes of water bodies, slum areas, and both open and pit latrines, many of which serve as effective mosquito breeding sites (Plate 1).

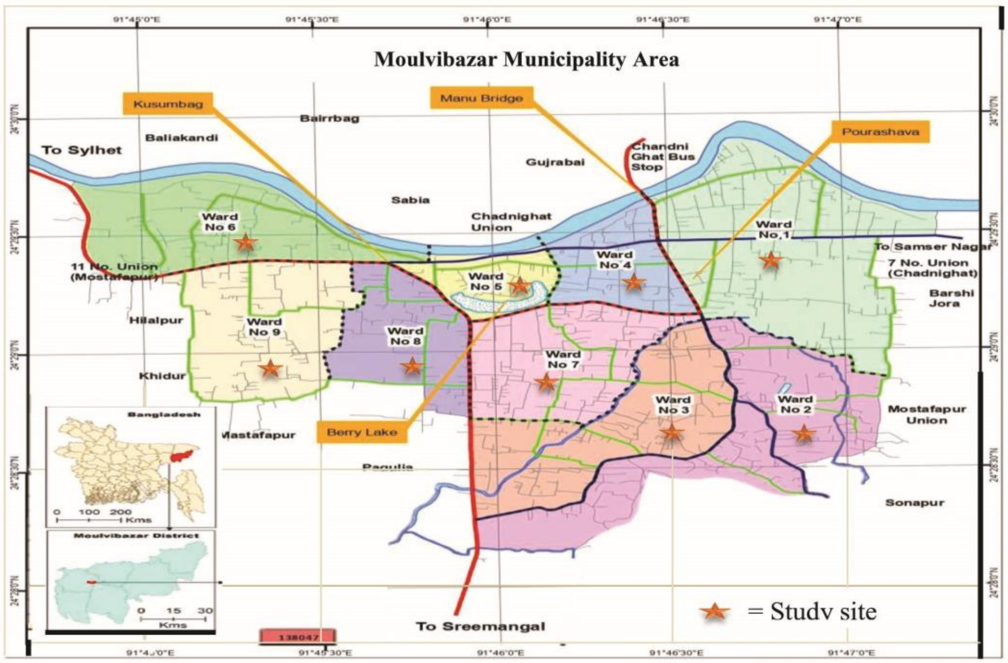

Fig. 1. The map of study sites in the municipality area of Moulvibazar

Plate 1: Visual immature density of mosquitoes in different drains of the study site.

Study period: The study was conducted for one year, from September 2021 to August 2022, covering all nine wards of the Moulvibazar municipality. Immature mosquitoes were collected from eight drains in each ward, totaling 72 drains across the municipality. Routine visits for sampling occurred monthly at each site. The collection of mosquito immatures was performed using the dipping method (Service 1993), with three random dips taken at approximately 50-foot intervals along each drain.

Sample collection and identification: A standard dipper (350 ml) with a long handle (30–35 cm) was used for collecting water samples from each breeding site according to O'Malley (1995) and Mendoza *et al.* (2008). The samples from each site were taken in a 150 ml plastic container labeled with the sample number, date, and code number of the sampling site. Samples were transported to the Entomology Laboratory of Moulvibazar Govt. College for preservation, identification, and further experimental work. The immature mosquitoes were counted and recorded in the laboratory for each dip, according to their instars. Ten percent of the immature were preserved in 70 % Ethyl alcohol until they can be identified in the lab. Approximately 20% of the immature specimens were cultured to adulthood for identification purposes. Both immature and adult mosquitoes were identified using a microscope by preparing both wet and permanent slides, adhering to the morphological descriptions and diagnostic characteristics outlined in the standard taxonomic key (Harbach 1985). The identification of mosquito larvae utilized the keys from Bram (1967) and Knight and Stone (1977). All data were meticulously recorded on record sheets with the appropriate information.

Characterization of larval habitats: To analyze the physical properties of each breeding habitat, various parameters were documented, including length, depth, width, water depth, and the extent of water surface coverage by duckweed, water hyacinth, wastes, or other materials, as well as the level of water pollution. The width and depth at sample locations were gauged using a metal ruler. A square frame (1 m^2) with a grid (100 cm^2) was utilized to determine the percentage of water surface coverage in breeding habitats. Water pollution levels were categorized as Low (1), Medium (2), and High (3), based on the pH and the percentage of the water surface covered with wastes or other substances. The pH of the water in mosquito breeding habitats was measured with a Hanna HI98107 pH tester, and the water temperature was recorded using a multifunction water quality tester, model EZ-9909SP.

Meteorological data: For this study information about rainfall, temperature, and humidity between September 2021 and August 2022 was collected from weather stations in Moulvibazar of Bangladesh Meteorological Department.

Data Analysis: The average mosquito immature population density per dip was calculated. A one-way ANOVA was then used to compare the means and standard deviations. If the ANOVA shows significant differences in the means at a 95% confidence level, pair-wise comparisons were conducted using Tukey's honestly significant difference (HSD) test and Duncan's multiple range test (DMRT). Additionally, Pearson correlation coefficients were calculated to assess the relationships between the total mosquito immature and various physiochemical and environmental factors in all breeding habitats. Furthermore, a multiple regression analysis was performed to examine the relationship between mosquito population densities and environmental factors. The statistical analysis was conducted using IBM SPSS Version 26.

RESULTS AND DISCUSSION

Mosquito population abundance: A total of 130045 immature mosquitoes of three species were collected from 72 different drains in study areas. There were about 80 immature/dip. The identified mosquitoes were from two genera; *Culex* and *Armigeres* (*Ar*) (Plates 2). The available species under the genera *Culex* were *Cx. quinquefasciatus* and *Cx. tritaeniorhynchus*). The most prevalent mosquito species was the *Cx. quinquefasciatus* (88.4%) followed by *Armigeres sp* (11.2%) and *Cx. tritaeniorhynchus* (0.2%) (Figure 2).

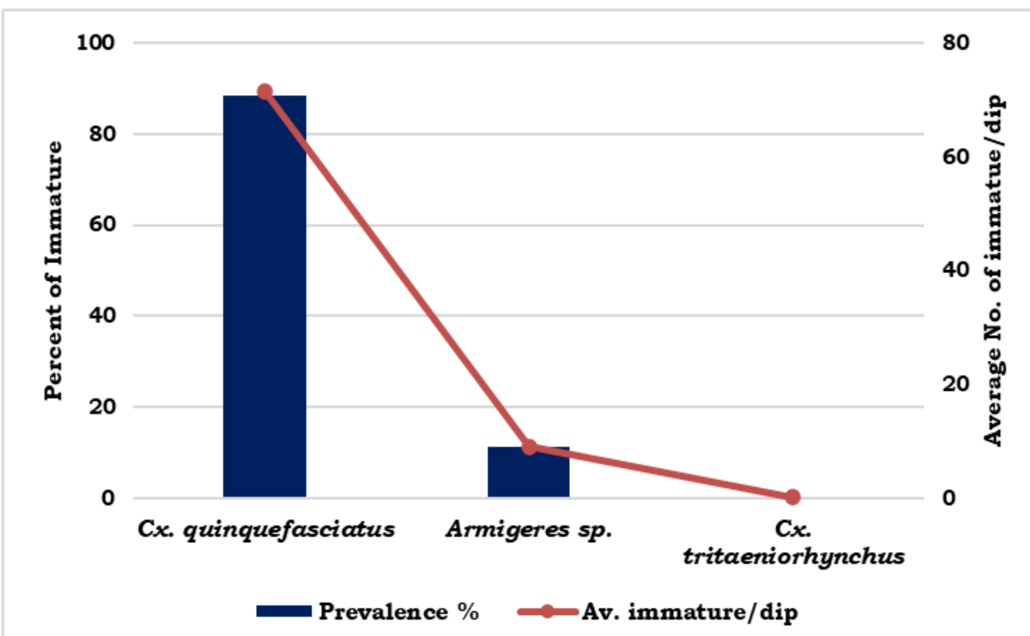

Fig. 2. Prevalence of mosquito immatures in the study area of Moulvibazar municipality.

Plates 2: Different parts of mosquito immature and adult found in the study sites of Moulvibazar municipality area. (a) Larva of *Culex quinquefasciatus* (b) Head and Thorax *Cx. quinquefasciatus* larva (c) Abdominal part with siphon of *Cx. quinquefasciatus* larva (d) Siphon of *Cx. quinquefasciatus* larva (e) Adult of *Cx. quinquefasciatus* (Male) (f) Head and Thorax (lateral) of *Cx. quinquefasciatus* (g) Head of *Cx. quinquefasciatus* (h) Adult of *Cx. quinquefasciatus* (Female) (i) Head and Thorax (Dorsal) of *Cx. quinquefasciatus* (j) Abdominal part with wing of *Cx. quinquefasciatus* (k) Larva of *Armigeres sp* (l) Head and Thorax of *Armigeres sp* larva (m) Siphon of *Armigeres sp* larva**.**

Seasonal prevalence of mosquito population: Mosquito immature was available around the year in the drains of the study area (Fig 3). The population of mosquito immatures varied significantly ($F=89.06$; $df=11$, $P<0.000$) across different. A lower population (less than 100 per month) was found from June to September. The highest population was observed in March followed by April, February, January, December, November, and October. Their mean differences at a significance level of 0.05 have been shown in Table 1. February to April produced a significantly higher number of immature than the prior months indicating rapid population growth during this period and identified as the peak season of *Culex* mosquito, though April showed a reducing trend of its population.

Table 1. Mean and significant differences of mosquito immature in different months

	(Average number of immature) Subset for alpha = 0.05							
Month	1	2	3	4	5	6	7	8
Aug	13.21							
Jun	20.35							
Jul	24.29							
Sep	51.22	51.22						
May		83.99	83.99					
Dec			110.58	110.58				
Oct			119.11	119.11	119.11			
Nov				148.06	148.06			
Jan					163.39			
Feb						263.11		
Apr							348.81	
Mar								500.56
Sig.	**.121**	**.142**	**.138**	**.113**	**.060**	**1.000**	**1.000**	**1.000**

Means for groups in homogeneous subsets are displayed;
Uses Harmonic Mean Sample Size, N = 72. Duncan[a]

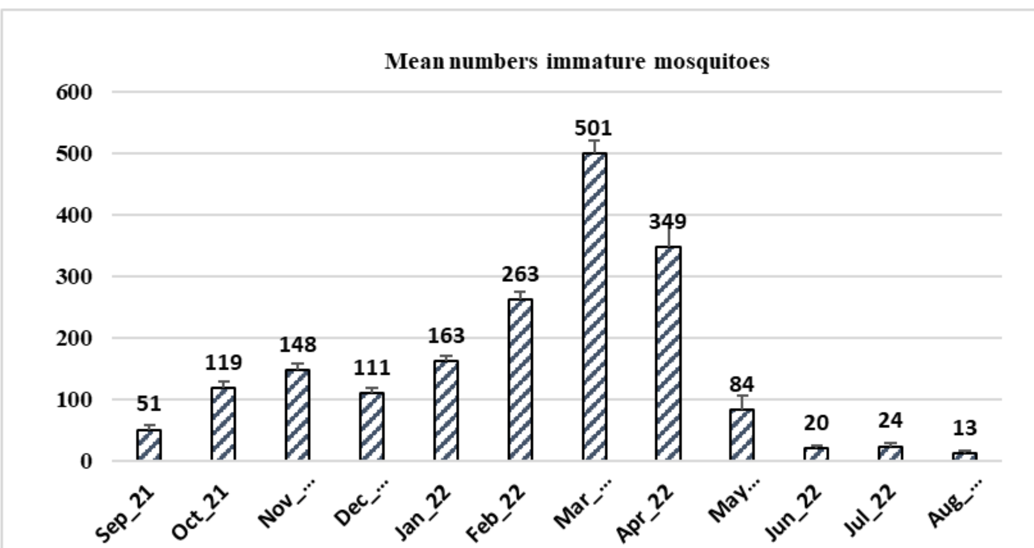

Fig. 3. The mean (±SE) numbers of immature mosquitoes in different months

Mosquito population distribution in different Wards: Mosquito immatures were found in all drains at some time throughout the year (Fig. 4), but their abundances significantly varied in different Wards (F=5.948, df=8, P<0.000). The highest population was found in Ward 1, followed by Ward 3, Ward 2, Ward 3, Ward 8, Ward 5, Ward 7 and Ward 6.

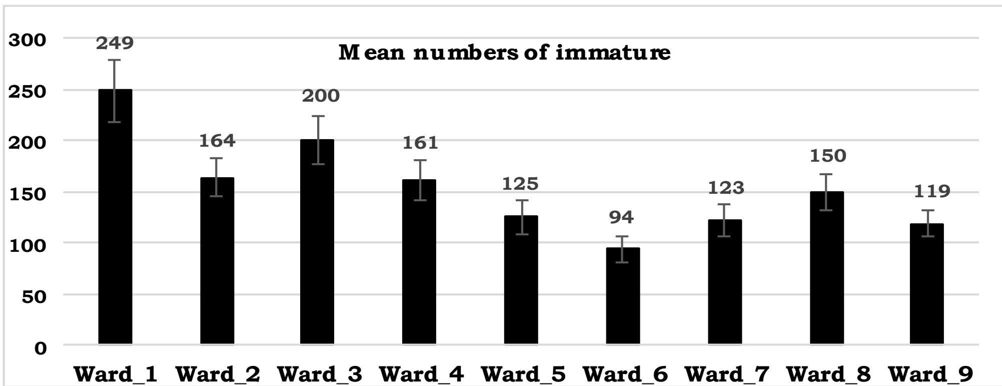

Fig. 4. The mean (±SE) numbers of immature mosquitoes in different administrative wards.

Table 2. Mosquito immature density in different Wards of Moulvibazar municipality

Ward No.	**(Mean No. of *Cx.* Immature) Subset for alpha = 0.05**			
	1	2	3	4
6.00	93.98			
9.00	119.23	119.23		
7.00	122.55	122.55		
5.00	125.24	125.24		
8.00	149.59	149.59	149.59	
4.00		160.83	160.83	
2.00		164.18	164.18	
3.00			200.39	200.39
Sig.	**.071**	**.157**	**.092**	**.077**

Means for groups in homogeneous subsets are displayed
Uses Harmonic Mean sample size (n)= 96

However, according to Duncan's multiple range test (DMRT), the following subgroups for Wards were identified based on lower values, where the means are not significantly different for Wards 6 and 9; Wards 7 and 5; Wards 8, 4, and 2; and Wards 3 and 1 at the alpha level of 0.05 (Table 2).

Mosquito population distribution in different drains: Research findings revealed that mosquito larvae were present in almost every drain (Fig 5), but significant variation in the number of mosquito immature was observed among the drains. The highest number of mosquito larvae were found in drain 4, followed by drain 3, drain 24, drain 2, drain 6, and drain 26 (more than3000). Drain 55 had the fewest mosquito larvae, followed by drain 44, drain 69, drain 39, drain 45, drain 42, drain 40, and drain 41 (less than 1000). The abundance of immature mosquitoes varied significantly with the drain’s length ($F = 2119.5$, $df=71$, $p < 0.001$).

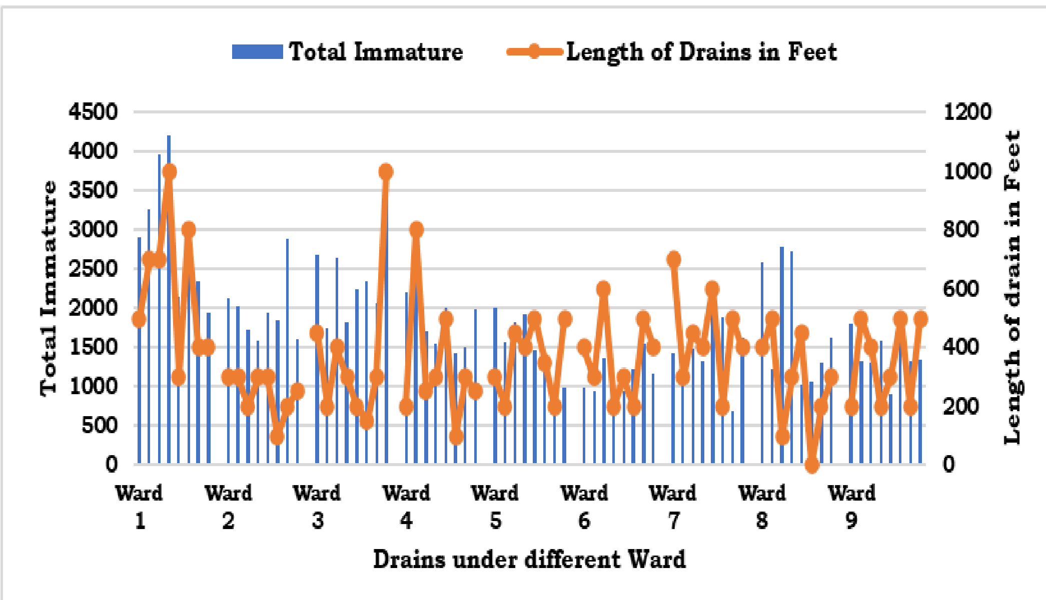

Fig. 5. The population of mosquito immatures in different lengths of drains

Physio-chemical characteristics of mosquito breeding habitats: In our study, we observed significant variations in various physio-chemical parameters such as habitat, pH, depth, surface coverage, temperature, and the quality of drain water across different drains and throughout the year ($F=117.231$, $df=7$, $p< 0.001$). The temperature in the study area fluctuated between 17°C and 27°C, while the pH values ranged from 6.2 to 8.5. The water depth varied from 0.3 to 3 feet over

Table 3: Correlation among the physio-chemical variables to mosquito immature in the municipality area of Moulvibazar

	Month 1	Br. Habitat 2	pH of Water 3	Water Depth 4	Water Surface cov.- 5	Water Temp-6	Water Pollution level-7	Total immature-8	*Cx. quinquefasciatus-9*	*Armigeres sp-10*	*Cx. tritaeniorhynchus-11*
1	1										
2	.001	1									
	.984										
3	.008	.13**	1								
	.815	.000									
4	.33**	-.015	-.07*	1							
	.000	.654	.033								
5	.097**	-.04	-.00**	.18**	1						
	.005	.193	.004	.000							
6	-.616**	-.10**	.088*	-.69**	-.218**	1					
	.000	.003	.010	.000	.000						
7	-.313**	-.07*	.076*	-.59**	-.244**	.657**	1				
	.000	.048	.025	.000	.000	.000					
8	-.374**	-.19**	-.044	-.51**	-.048	.645**	.536	1			
	.000	.000	.198	.000	.159	.000	.000				
9	-.322**	-.15**	-.38**	-.41**	-.053	.470**	.441**	.803**	1		
	.000	.000	.000	.000	.118	.000	.000	.000			
10	-.086*	-.004	-.53**	-.19**	-.010	.271**	.251**	.275**	-.188**	1	
	.012	.909	.000	.000	.779	.000	.000	.000	.000		
11	-.051	.028	-.018	-.047	-.009	.058	.082*	.091**	.094**	-.030	1
	.133	.418	.591	.167	.797	.091	.016	.008	.006	.377	

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

the year. Additionally, we found that the water surfaces were covered with waste, aquatic vegetation, debris, and other organic matter, with coverage ranging from 10% to 80% in different drains during various months of the year.

Table 3 presents the Pearson correlation coefficients relating mosquito species to different environmental factors. The results show that the pH level has a significant positive correlation with water temperature ($r = 0.088$, $p = 0.010$) and water pollution level ($r = 0.076$, $p = 0.025$). Additionally, there are negative correlations between pH and water depth ($r = -0.07$, $p = 0.033$) as well as water-covered surfaces (waste/others) ($r = -0.09$, $p = 0.004$). Furthermore, water depth is positively correlated with water-covered surfaces (waste/others) ($r = 0.175^{**}$, $p < 0.001$), and negatively correlated with water temperature ($r = -0.599^{**}$, $p < 0.001$), water pollution level ($r = -0.593^{**}$, $p < 0.001$), and the total number of mosquito immature ($r = -0.513^{**}$, $p < 0.001$). In contrast, water-covered surfaces (waste/others) are negatively correlated with water temperature ($r = -0.218^{**}$, $p < 0.001$) and water pollution level ($r = -0.244^{**}$, $p < 0.001$).The abundance of *Culex quinquefasciatus* immature is positively associated with water temperature ($r = 0.470^{**}$, $p < 0.001$) and pollution level ($r = 0.441^{**}$, $p < 0.001$), and negatively associated with pH ($r = -0.380^{**}$, $p < 0.001$) and water depth ($r = -0.413^{**}$, $p < 0.001$). On the other hand, *Armigeres* sp. abundance is positively associated with pH ($r = 0.528^{**}$, $p < 0.001$), water temperature ($r = 0.271^{**}$, $p < 0.001$), and pollution level ($r = 0.251^{**}$, $p < 0.001$), and negatively correlated with water depth ($r = -0.194^{**}$, $p < 0.001$).

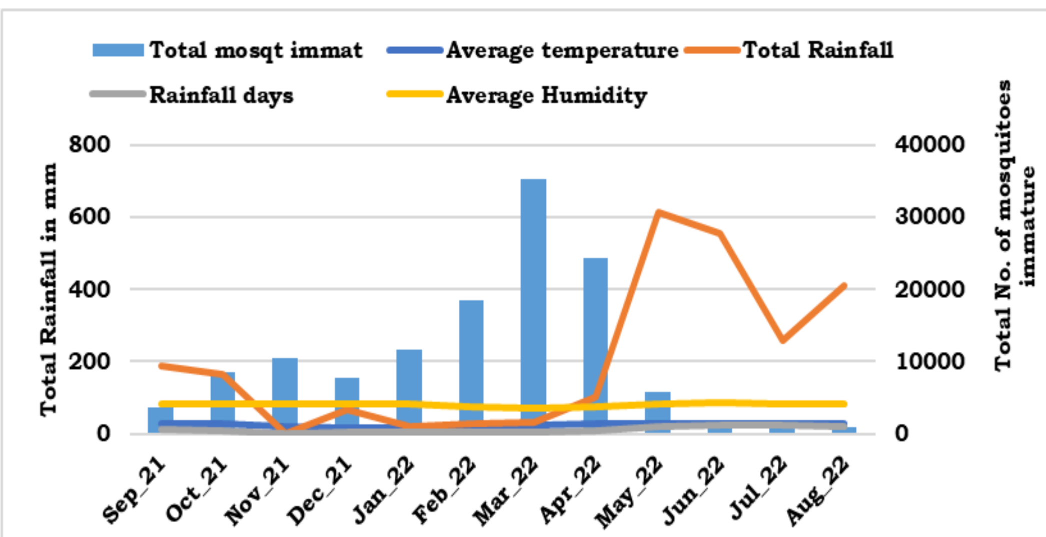

Fig. 6. Effects of environmental variables on total immature mosquito abundance

The total immature population gradually increased from September to November but due to a moderate rainfall in December, the immature population decreased slightly (Fig 6). Afterward, there was a rapid increase from January to March. A decline started again in April due to 102mm of rainfall, and it continued through August with high rainfall (averaging 458 mm). Total mosquito immature is negatively associated with total rainfall days, humidity, and average temperature. The average temperature had a positively significant correlation with total rainfall ($r = 0.631$, $p = 0.028$) and rainfall of the days ($r = 0.770$, $p = 0.003$). Total rainfall, Rainfall of the days, and average humidity were found negatively correlated ($r = -0.585$, $p = 0.046$), ($r = -0.673^{*}$, $p = 0.016$), ($r = -.922^{**}$, $p = 0.000$) with total mosquito immature.

DISCUSSION

The present study regarding the Culicinae mosquito breeding situation in different drains in the municipality of Moulvibazar provides valuable information as a first-time study. The predominant mosquito species in this study is *Cx. quinquefasciatus* (>88.4%). This scenario is more or less common in the city areas of Bangladesh. Previously Dhaka, the highly urbanized and capital city, identified more than 99% of mosquitoes of the same species, which varies slightly in different seasons. The present study was conducted in different drains though they breed in a variety of aquatic habitats (Khan *et al.* 2014). Stagnant drains provide a perfect environment with organically rich food and the multiplication of a huge bacterial population as nutritional supplementation for *Cx. quinquefasciatus* to survive (Sultana *et al.* 2018). In addition, low dissolved oxygen levels, have created an unfavorable environment for insect larval predators that helps to increase mosquito population within a short period.

Generally, mosquitoes breed on surface water that is contaminated and organically rich or highly polluted, as seen in multifarious previous studies (Rodcharoen *et al.* 1997, Dibo *et al.* 2011). Their population decreases in the winter and rainy seasons but is not completely eradicated. In the winter, low temperature decreases their metabolic function thus growth rate becomes slow, and reduces the population (Ciota *et al.* 2014, Christiansen-Jucht *et al.* 2014) and in the rainy season, heavy rain flashes out the immature and driven to the river, sea, or other unsuitable habitat where they cannot survive (Koenraadt *et al.* 2008, Dieng *et al.* 2012) and remain lower number of immatures in the breeding site that cannot maintain a population over threshold level. But still, they produce a persistent mosquito population that is maintained in the drainage system as a whole. Furthermore, all drains are not equally productive.

The increasing level of organic matter in the water of the older drains led to the largest populations of larvae (Chaves *et al.* 2009).

The present study found a very low population (0.2%) of *Cx. tritaeniorhynchus* in drains as observed previously in Bangladesh (Bashar *et al.* 2016 and Farjana *et al.* 2015, Sultana *et al.* 2018). Normally this species has a diverse breeding habitat. Its suitable breeding habitats are temporary and semi-permanent groundwater pools, water leakage, edge of rivers, paddy fields, mostly in flooded rice paddies, streams, swamps, shallow marshes, irrigation ditches, grasslands, rivers and animal hoof prints where the water is not that much polluted (Miller *et al.* 2012, Sofizadeh *et al.* 2015, Tuno *et al.* 2017). Moreover, their main blood-feeding hosts are domestic animals but accidentally they feed on humans at night (Sirivanakarn, 1976). Therefore, they stay around human households. Bangladesh is a densely populated country, and this mosquito is more or less common in suburban to rural areas. In the dry season when there is no available water in rice fields around human habitations, they breed in comparatively less polluted drains to maintain their progeny.

The immature *Armigeres subalbatus* is commonly found in poor sanitation that contain polluted water such as cesspits, drains, septic tanks, and containers either man-made or natural (Wajiha *et al.* 2017). In addition, they also love to breed in rotten things, cow-dung mixed water-holding containers, etc. They are more in urban areas. This area contains a large number of improperly covered drains. Thus, leaves that fall into the drain and decompose aid in the growth of this species. Moreover, unaware city dwellers occasionally throw waste into open drains, which accumulate water and attract *Armigeres* to breed. Sometimes the effluents are over from the *Armigeres* containing septic tank into drains or somewhere drains are connected with septic tanks, becoming a good habitat for this mosquito (Rajavel 1992) as well as the event coexistence of *Armigeres sp* and *Cx. quinquefasciatus*, as seen in the present study.

Breeding of mosquitoes is mostly influenced by water depth, pH, and temperature. The present study found a significantly negative correlation between water depth against water p^H. Abundances of *Cx. quinquefasciatus* larvae were found negatively associated with p^H but *Armigeres sp.* abundance was positively associated. The amount of organic matter in the water rises with decreasing water depth, contributing to increasing mosquito immature through enhanced water pollution. Physicochemical characteristics of mosquito breeding sites had important impacts on different species regarding their density, and development, though they varied in different water bodies and drains (Nikookar *et al.* 2017). Alkaline conditions with a pH of 8.2 or above appeared to be a suitable breeding site for *Ar. Subalbatus* (Alwis and Munesinghe 1986). Somewhere, pH was positively correlated with both anopheline and culicine larvae (Tadesse *et al.* 2011) but in another place, an insignificant correlation was reported (Basher *et al.* 2016, Rohani *et al.* 2010). In another study temperature, pH, conductivity, and magnesium were positively associated and important in explaining the presence and abundance of *Culex* (Donatus *et al.* 2022). However, abundance of *Cx. quinquefasciatus* and *Cx. tritaeniorhynchus* immature was found positively associated with water depth but negatively correlated with plant coverage (Basher *et al.* 2016) as we have seen in our study.

Water-surface coverage decreases sunlight exposure and reduces water temperature in drains, which reduces microbial growth that mosquito larvae feed on. So, larval development decreases and increases the probability of competition and predation (Muturi et al. 2008). The average optimum temperature for mosquito development is around 25-27°C (WHO 1975) but comparatively higher water temperatures make faster development of aquatic stages and heat waves increase mortality (Bayoh & Lindsay, 2004) and decrease the size of the emerging adults (Bayoh & Lindsay, 2003). During the present study, the temperature ranges were from 17-30°C, which was below and higher than the optimum temperature. Therefore, the immature density fluctuates in different seasons. Similar temperature ranges (19°C and 34°C) reported similar mosquito densities in previous studies (Abdel-Hamid *et al.* 2011). Another mosquito species, *Armigeres* is more or less adapted to higher temperatures but none of the parameters was found to be significantly associated with the presence of *Culex* larvae (Moirangthem and Singh 2018).

More humid and warmer weather increases mosquito population growth and disease dissemination (Chowdhury *et al.* 2018). The immature growth rate of maximum mosquito species is slowed down by temperatures below 14–16°C and above 30°C (Clements 1992). The present study observed a positive association between water temperature and mosquito larval abundance. Since warm water speeds up larval growth, the warm water in sunlight settings may play a significant role in the development of larvae. Warm temperatures can promote the development of more microorganisms, which gives mosquito larvae a source of food. A strong positive relationship has also been reported between temperature and rainfall on mosquito occurrences in Bangladesh (Islam *et al.* 2023). Furthermore, a negative association between rainfall and mosquito immaturity also has been observed previously (Basher and Tuno 2014, Hasan *et al.* 2023). However, a lot of rain can cause habitats to be flushed out, which lowers the number of mosquito larvae as was observed in the present study. As a subtropical area, this study area records heavy rain that disrupted breeding habitats, leading to a fall in the number of immature mosquitoes in the rainy season.

CONCLUSION

Moulvibazar municipality is recognized as an A-grade tourist destination, boasting systematically developed roads, highways, drainage systems, and residential zones. However, there is a lack of awareness about mosquito breeding sites and their proliferation. Often, garbage is carelessly discarded into inadequately covered drains, leading to pollutant build-up and creating ideal conditions for mosquito breeding. Therefore, scientists, public health experts, government officials, and residents must collaborate effectively. This collaboration should aim to monitor and identify mosquito breeding areas, assess their densities, and manage them efficiently. A year-long study in the municipality has shed light on the prevalence of nuisance mosquitoes in urban settings. By adopting an integrated approach to mosquito management, focusing on public education, environmental strategies, and biological control, it is possible to diminish these mosquito populations and their breeding grounds. Furthermore, these findings could encourage additional research into mosquito ecology, particularly the chemistry of breeding waters and the influence of environmental and climatic factors, to pinpoint precise locations for vector control.

Acknowledgment: We express our gratitude to the Principal and Head of the Department of Zoology at Moulvibazar Government College for providing laboratory facilities. The authors are also thankful to the authority of the National University of Bangladesh for funding the fellowships

LITERATURE CITED

ABDEL-HAMID, Y.M., SOLIMAN, M.I. and KENAWY, M.A., 2011. Geographical distribution and relative abundance of culicine mosquitoes in relation to transmission of lymphatic filariasis in El Menoufia Governorate, Egypt. Journal of the Egyptian Society of Parasitology, **41**: 109-18.

ALWIS, R. and MUNASINGHE, C.H., 1971. Hydrogen-ion concentration in breeding habitats of *Culex pipiens fatigan*s (Wied.) and associated mosquitos. *Bulletin of the World Health Organization*, **45:** 853-854.

BASHAR, K. and TUNO, N., 2014. Seasonal abundance of *Anopheles* mosquitoes and their association with meteorological factors and malaria incidence in Bangladesh. *Parasites & vectors*, **7:** 1-10.

BASHAR, K., RAHMAN, M.S., NODI, I.J. and HOWLADER, A.J., 2016. Species composition and habitat characterization of mosquito (Diptera: Culicidae) larvae in semi-urban areas of Dhaka, Bangladesh. *Pathogens and Global health*, **110:** 48-61.

BAYOH, M.N. and LINDSAY, S.W., 2003. Effect of temperature on the development of the aquatic stages of *Anopheles gambiae* sensu stricto (Diptera: Culicidae). *Bulletin of Entomological Research*, **93:** 375-381.

BAYOH, M.N. and LINDSAY, S.W., 2004. Temperature-related duration of aquatic stages of the Afrotropical malaria vector mosquito *Anopheles gambiae* in the laboratory. *Medical and Veterinary Entomology*, **18:** 174-179.

BHATTACHARYYA, D.R., PRAKASH, A., TEWARI, S.C., MOHAPATRA, P.K. and MAHANTA, J., 2000. *Armigeres joloensis* (Diptera: Culicidae), a rare mosquito in upper Assam: first report from India. *Entomon*, **25**: 63-66.

BRAM, R.A., 1967. Contributions to the mosquito fauna of Southeast Asia.-II The genus *Culex* in Thailand (Diptera: Culicidae). *Contributions of the American Entomological Institute,* **2:** 1-296.

CHAVES, L.F., KEOGH, C.L., VAZQUEZ-PROKOPEC, G.M. and KITRON, U.D., 2009. Combined sewage overflow enhances oviposition of *Culex quinquefasciatus* (Diptera: Culicidae) in urban areas. *Journal of Medical Entomology*, **46:** 220-226.

CHOWDHURY, F.R., IBRAHIM, Q.S.U., BARI, M.S., ALAM, M.J., DUNACHIE, S.J., RODRIGUEZ-MORALES, A.J. and PATWARY, M.I., 2018. The association between temperature, rainfall and humidity with common climate-sensitive infectious diseases in Bangladesh. *PloS one*, **13:** p.e0199579.

CHRISTIANSEN-JUCHT, C., PARHAM, P.E., SADDLER, A., KOELLA, J.C. and BASÁÑEZ, M.G., 2014. Temperature during larval development and adult maintenance influences the survival of *Anopheles gambiae* ss. *Parasites & Vectors*, **7:** 1-10.

CIOTA, A.T., MATACCHIERO, A.C., KILPATRICK, A.M. and KRAMER, L.D., 2014. The effect of temperature on life history traits of *Culex* mosquitoes. *Journal of Medical Entomology*, **51:** 55-62.

CLEMENTS, A.N., 1992, The Biology of Mosquitoes, Volume **I** "Development, Nutrition and Reproduction", Chapman and Hall, London.

DIBO, M.R., DE MENEZES, R.M.T., GHIRARDELLI, C.P., MENDONÇA, A.L. and CHIARAVALLOTI, N.F., 2011. The presence of Culicidae species in medium-sized cities in the State of São Paulo, Brazil and the risk of West Nile fever and other arbovirus infection. *Revista da Sociedade Brasileira de Medicina Tropical*, **44:**.496-503.

DIENG, H., RAHMAN, G.M.S., ABU HASSAN, A., CHE SALMAH, M.R., SATHO, T., MIAKE, F., BOOTS, M. and SAZALY, A., 2012. The effects of simulated rainfall on immature population dynamics of *Aedes albopictus* and female oviposition. *International Journal of Biometeorology*, **56:** 113-120.

DONATUS, O.O., AUTA, I.K., IBRAHIM, B., YAYOCK, H.C. and JOHNSON, O., 2022. Breeding sites characteristics and mosquito abundance in some selected locations within Kaduna metropolis. *FUDMA Journal of Sciences*, **6:** 70-75.

FARJANA, T., AHMMED, M.S., KHANOM, T.F., ALAM, N. and BEGUM, N., 2015. Surveillance of mosquitoes larva at selected areas of Mymensingh district in Bangladesh. *Bangladesh Journal of Veterinary Medicine*, **13**: 79-88.

GIMNIG, J.E., OMBOK, M., KAMAU, L. and HAWLEY, W.A., 2001. Characteristics of larval anopheline (Diptera: Culicidae) habitats in Western Kenya. *Journal of Medical Entomology*, **38:** 282-288.

HARBACH, R.E., 1985. Pictorial keys to the genera of mosquitoes, subgenera of *Culex* and the species of *Culex* (*Culex*) occurring in southwestern Asia and Egypt, with a note on the subgeneric placement of *Culex deserticola* (Diptera: Culicidae). *Mosquito Systematics*, **17:** 83-107.

HASAN, M.M. and JANNAT, K.N.E., 2023. Larvicidal effect of Bishkatali (*Polygonum hydropiper)* leaf extract against *Aedes aegypti* (Diptera: Culicidae) larvae. *Bangladesh Journal of Zoology*, **51:** 119-127.

HOSSAIN, M.I., WAGATSUMA, Y., CHOWDHURY, M.A., AHMED, T.U., UDDIN, A., NAZMUL SOHEL, S.M. and KITTAYAPONG, P., 2000. Analysis of some Socio-demographic Factors Related to DF/DHF Outbreak in Dhaka City. *Dengue Bulletin,*.**24:** 34-41.

ISLAM, M.A., HASAN, M.N., TIWARI, A., RAJU, M.A.W., JANNAT, F., SANGKHAM, S., SHAMMAS, M.I., SHARMA, P., BHATTACHARYA, P. and KUMAR, M., 2023. Correlation of dengue and meteorological factors in Bangladesh: a public health concern. *International Journal of Environmental Research and Public Health***, 20:** 5152.

JACOB, B.G., ARHEART, K.L., GRIFFITH, D.A., MBOGO, C.M., GITHEKO, A.K., REGENS, J.L., GITHURE, J.I., NOVAK, R. and BEIER, J.C., 2005. Evaluation of environmental data for identification of *Anopheles* (Diptera: Culicidae) aquatic larval habitats in Kisumu and Malindi, Kenya. *Journal of Medical Entomology*, **42:** 751-755.

KARLEKAR, S.R., DESHPANDE, M.M. and ANDREW, R.J., 2013. Present susceptibility status of *Culex quinquefasciatus*, Say to three insecticides in Nagpur District of India. *Indian Journal of Science and Technology*, **1**: 12-14.

KHAN, H.R., ISLAM, M.M., AKTER, T., KARIM, M.R. and FARID, M.S., 2014. Diversity of mosquitoes and their seasonal fluctuation in two wards of Dhaka city. *Dhaka University Journal of Biological Sciences*, **23**: 17-26.

KHANUM, H., HOSSAIN, I., SARKAR, F. and ZAMAN, R.F., 2018. Lymphatic filariasis in Nilphamari district: An endemic area in Bangladesh. *Bangladesh Journal of Zoology*, **46**: 11-20.

KHATUN, R., HOSSAIN, K.S., AKTER, S., MANDAL, R.N. and MANDAL, B.K., 2019. Entomopathogenic fungus spores in the larval habitat water of *Culex quinquefasciatus* mosquito in Dhaka city, Bangladesh. *Journal of Entomology and Zoology Studies,* **7**: 512-522

KNIGHT, K.L. and STONE, A., 1977. A catalog of the mosquitoes of the world (Diptera: Culicidae). *Entomological Society of America,* 621 p.

KOENRAADT, C.J.M. and HARRINGTON, L.C., 2008. Flushing effect of rain on container-inhabiting mosquitoes *Aedes aegypti* and *Culex pipiens* (Diptera: Culicidae). *Journal of Medical Entomology*, **45:** 28-35.

MENDOZA, F., IBÁÑEZ-BERNAL, S. and CABRERO-SAÑUDO, F.J., 2008. A standardized sampling method to estimate mosquito richness and abundance for research and public health surveillance programmes. *Bulletin of Entomological Research*, **98:** 323-332.

MILLER, R.H., MASUOKA, P., KLEIN, T.A., KIM, H.C., SOMER, T. and GRIECO, J., 2012. Ecological niche modeling to estimate the distribution of Japanese encephalitis virus in Asia. *PLoS Neglected Tropical Diseases*, **6**(6), p.e1678.

MOIRANGTHEM, B.D. and SINGH, D.C., 2018. Two *Armigeres* species of Manipur, the easternmost Northeast India. *International Journal of Mosquito Research,* **5**: 39-43.

MOLINEAUX, L., 1997. Malaria and mortality: some epidemiological considerations. *Annals of Tropical Medicine & Parasitology*, **91:** 811-825.

MUNESINGHE, Y.D., MENDIS, K.N. and CARTER, R., 1986. Anti-gamete antibodies block transmission of human vivax malaria to mosquitoes. *Parasite Immunology*, **8:** 231-238.

MUSLIM, A., FONG, M.Y., MAHMUD, R., LAU, Y.L. and SIVANANDAM, S., 2013. *Armigeres subalbatus* incriminated as a vector of zoonotic *Brugia pahangi* filariasis in suburban Kuala Lumpur, Peninsular Malaysia. *Parasites & Vectors*, **6:** 1-5.

MUTURI, E.J., MWANGANGI, J., SHILILU, J., JACOB, B.G., MBOGO, C., GITHURE, J. and NOVAK, R.J., 2008. Environmental factors associated with the distribution of *Anopheles arabiensis* and *Culex quinquefasciatus* in a rice agro-ecosystem in Mwea, Kenya. *Journal of Vector Ecology*, **33:** 56-63.

NIKOOKAR, S.H., FAZELI-DINAN, M., AZARI-HAMIDIAN, S., MOUSAVINASAB, S.N., AARABI, M., ZIAPOUR, S.P., ESFANDYARI, Y. and ENAYATI, A., 2017. Correlation between mosquito larval density and their habitat physicochemical characteristics in Mazandaran Province, northern Iran. *PLoS Neglected Tropical Diseases*, **11:** p.e0005835.

NORRIS, D.E., 2004. Mosquito-borne diseases as a consequence of land use change. *EcoHealth*, **1:** 19-24.

NUR, J., SULTANA, B., RAHMAN, M.H. and MONIRUZZAMAN, M., 2021. Detection of vector mosquito of filariasis in the endemic areas of Bangladesh. *European Journal of Medical and Health Sciences*, **3:** 103-107.

O'MALLEY, C., 1989. Guidelines for larval surveillance. In *Proceedings of the Seventy-Sixth Annual Meeting of the New Jersey Mosquito Control Association, Inc* (pp. 44-55).

PATZ, J.A., GRACZYK, T.K., GELLER, N. and VITTOR, A.Y., 2000. Effects of environmental change on emerging parasitic diseases. *International Journal for Parasitology*, **30:** 1395-1405.

RAJAVEL, A.R., 1992. Larval habitat of *Armigeres subalbatus* (COQ) and its characteristics in Pondicherry. *Southeast Asian Journal of Tropical Medicine and Public Health*, **23:** 470-470.

RODCHAROEN, J. AND MULLA, M.S., 1997. Biological fitness of *Culex quinquefasciatus* (Diptera: Culicidae) susceptible and resistant to *Bacillus sphaericus*. *Journal of Medical Entomology*, **34:** 5-10.

SERVICE, M.W. 1993. Sampling the adult resting population. Mosquito Ecology. Field Sampling Methods, UK: Chapman and Hall, pp. 210-290.

SIRIVANAKARN, S., 1982. New World Subgenus *Melanoconion*.of *Culex* (Diptera, Culicidae)'. *Mosquito Systematics*, **14:** p.265.

SOFIZADEH, A., SHORAKA, H.R., MESGARIAN, F., OZBAKI, G.M., GHARANINIA, A., SAHNEH, E., DANKOOB, R., MALAKA, A., FALLAH, S. and NEMANI, S., 2018. Fauna and larval habitats characteristics of mosquitoes (Diptera: Culicidae) in Golestan Province, northeast of Iran, 2014–2015. *Journal of Arthropod-Borne Diseases*, **12:** 240-251.

SULTANA, A., HASAN, S., HOSSAIN, M., ALIM, A., AL MAMUN, M. and BASHAR, K., 2017. Larval breeding habitats and ecological factors influence the species composition of mosquito (Diptera: Culicidae) in the parks of Dhaka city, Bangladesh. *Bangladesh Journal of Zoology*, **45:** 111-122.

TADESSE, F.G., PETT, H., BAIDJOE, A., LANKE, K., GRIGNARD, L., SUTHERLAND, C., HALL, T., DRAKELEY, C., BOUSEMA, T. and MAMO, H., 2015. Submicroscopic carriage of *Plasmodium falciparum* and *Plasmodium vivax* in a low endemic area in Ethiopia where no parasitaemia was detected by microscopy or rapid diagnostic test. *Malaria Journal*, **14:** 1-7.

TUNO, N., TSUDA, Y. and TAKAGI, M., 2017. How zoophilic Japanese encephalitis vector mosquitoes feed on humans. *Journal of Medical Entomology*, **54:** 8-13.

VANWAMBEKE, S.O., LAMBIN, E.F., EICHHORN, M.P., FLASSE, S.P., HARBACH, R.E., OSKAM, L., SOMBOON, P., VAN BEERS, S., VAN BENTHEM, B.H., WALTON, C. and BUTLIN, R.K., 2007. Impact of land-use change on dengue and malaria in northern Thailand. *EcoHealth***, 4:** 37-51.

WAJIHA, R.A., AFRIDI, H. and SAEED, K., 2017. Prevalence *of Culex, Aedes, Anopheles* and *Armigeres* mosquitoes at selected localities of district Peshawar Khyber Pakhtunkhwa Pakistan. *International Journal of Mosquito Research*, **4:** 128-134.

WHO, 1975. Manual on Practical Entomology in Malaria. Part II. Methods and Techniques. *Division of Malaria and other Parasitic Diseases*.

WILKE, A.B.B., VIDAL, P.O. and SUESDEK, L. M., 2014. Population Genetics of Neotropical *Culex quinquefasciatus* (Diptera: Culicidae). *Parasites & Vectors*. **7**: 468.

ZEILHOFER, P., SANTOS, E.S.D., RIBEIRO, A.L., MIYAZAKI, R.D. and SANTOS, M.A.D., 2007. Habitat suitability mapping of *Anopheles darlingi* in the surroundings of the Manso hydropower plant reservoir, Mato Grosso, Central Brazil. *International Journal of Health Geographics*, **6:** 1-14.

ZHOU, G., MUNGA, S., MINAKAWA, N., GITHEKO, A.K. and YAN, G., 2007. Spatial relationship between adult malaria vector abundance and environmental factors in western Kenya highlands. *American Journal of Tropical Medicine and Hygiene*, **77:** 29-35.

(Manuscript received on 25 September 2024 revised on 15 December 2024)