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DIVERSITY OF MOSQUITOES IN URBAN AND PERI-URBAN DHAKA, BANGLADESH

Farhan Chowdhury Apon[1], Kabirul Bashar[1*], Jannatul Mawa Mim[2] and Mohammad Shafiul Alam[3]

Insect rearing and experimental station (IRES), Department of Zoology, Jahangirnagar University, Savar, Dhaka 1342, Bangladesh

ABSTRACT: As the risks associated with vector-borne diseases continue to rise due to climate change and human activities, understanding the current diversity of mosquito species across different habitats is crucial. The current study aimed to assess the diversity, distribution, richness and relative abundance of mosquito species (Diptera: Culicidae) in Dhaka, Bangladesh. A total of 2,147 mosquito specimens were collected between September to November 2023 from six distinct locations of Dhaka district, employing the BG-1 sentinel traps. Ten mosquito species were identified: *Aedes aegypti, Aedes albopictus, Culex quinquefasciatus, Culex tritaeniorhynchus, Culex fuscochephala, Culex bitaeniorhynchus, Mansonia annulifera, Mansonia indiana, Mansonia uniformis and Armigeres subalbatus*. *Culex tritaeniorhynchus* was the most abundant species (63.68%), found in all surveyed areas followed by *Culex quinquefasciatus* (18.57%) and *Aedes aegypti* (13.02%). Notably, the highest number of *Aedes aegypti* (6.85%) was trapped in Dhaka north city corporation followed by Dhaka south city corporation (5.31%) and savar (1.01%). Dhaka North city corporation had the highest diversity, with a Shannon-Wiener Index of 1.07 and a Simpson Index of 0.62. In contrast, Savar Upazila had the highest species richness (10 species). This study provides a snapshot of mosquito fauna over a three-month period, highlighting variations in species diversity, relative abundance and distribution across peri-urban and urban landscapes of Dhaka District.

Key words: Mosquitoes, biodiversity, surveillance, species abundance, urban-peri urban, Bangladesh

INTRODUCTION

Worldwide, mosquitoes (Diptera: Culicidae) represent a serious threat to human health. (Islam *et al.,* 2020). They spread a wide range of illnesses, including malaria, filariasis, dengue, chikungunya, West Nile Virus, Western Equine viruses, and Japanese Encephalitis. (Ashfaq *et al.,* 2014; Caraballo and

**Author for correspondence: <ires@juniv.edu>, [2]Department of Microbiology, Jahangirnagar University, Savar, Dhaka 1342, Bangladesh, [3]International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b), Mohakhali, Dhaka 1212, Bangladesh*
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King, 2014; Dad *et al.,* 2019; Islam *et al.,* 2020; Negev *et al.,* 2015; Turell *et al.,* 2005). In Bangladesh, approximately 123 species of mosquitoes have been recorded (Irish *et al.,* 2016), including 36 species of Anopheles, of which around 10 are considered malaria vectors (Alam *et al.,* 2010; Bashar *et al.,* 2013). *Aedes aegypti* acts as the primary vector of dengue, Zika, and chikungunya viruses in the country (WHO, 2023c) while *Culex quinquefasciatus* is the only confirmed vector of filariasis (Nur *et al.,* 2021a). To improve control over disease-transmitting vectors and to fully appreciate the diverse Culicidae family, it is essential to maintain a current list of species within the country.

The four sero-types (DENV1, 2, 3, 4) of positive sense, single stranded RNA viruses of the family Flaviviridae are responsible for human dengue viral fever, a tropical and subtropical viral disease spread by mosquitoes (Islam *et al.,* 2020; Kularatne, 2015; WHO, 2023b). *Aedes aegypti* and *Aedes albopictus* are the two main species of female *Aedes* mosquitoes that transmit dengue. Several other species also carry this virus. Usually starting three to fourteen days following a bite from an infected female *Aedes* mosquito, symptoms manifest. (Islam *et al.,* 2020; Kularatne, 2015). Bangladesh has also seen a sharp rise in dengue cases, which is consistent with worldwide patterns. In recent study, the Ministry of Health and Family Welfare (MOHFW) recorded 321,179 dengue cases between January 1 and December 31, 2023, along with 1,705 related deaths (case fatality rate = 0.53%). However, the number of cases began to rise sharply in late June, with 63% of cases (n = 43 854) and 62% of deaths (n = 204) reported in just the month of July. It already suppressed all the previous record of dengue death cases in Bangladesh (WHO, 2023a).

On the other hand, the CHIK virus, a single-stranded positive sense envelope RNA virus belonging to the Togaviridae family, is the source of chikungunya viral fever (CHIKVF) (Kayesh *et al.,* 2023; WHO, 2016). The two mosquito species that transmit the virus to humans are *Ae. albopictus* and *Ae. aegypti* (Kayesh *et al.,* 2023; WHO, 2016). In 2008, 2011, and 2017, there were three outbreaks of CHIK viral fever in Bangladesh (M. A. Islam *et al.,* 2020; Q. Islam *et al.,* 2018). Another tropical disease carried by mosquitoes that is extremely dangerous and results in endemic illness is filariasis. *Wuchereria bancrofti* is the primary cause of filariasis, despite the fact that a variety of thread-like nematode (worm) parasites and their larvae from the family Filarioidea are to blame. Various mosquito species, including *Anopheles*, *Culex*, and *Mansonia* species, are the vector of this filariasis (Nur *et al.,* 2021b; Ottesen *et al.,* 1997). *Cx. quinquefasciatus* is the primary vector of this illness among them. Different debilitating parasite infections impact about 120 million people in tropical and subtropical regions of Southeast Asia, South America, Africa, and

the Pacific islands (Nur *et al.*, 2021b; Ottesen *et al.,* 1997). Climate change combined with the global movement of people, animals, and goods presents chances for invasive and frequently exotic Culicidae vector species to establish themselves (Möhlmann *et al.,* 2017; Schaffner *et al.,* 2009). Warm, humid summers combined with mild winters encourage the rapid growth of vector populations, which increases mosquito nuisance and vector capacity (Möhlmann *et al.,* 2017; Semenza and Menne, 2009). The ongoing rise in arboviruses validates the need for in-depth understanding of the vectors that may carry infections. For instance, increasing vector species richness may promote disease transmission, according to theoretical modeling research by (Möhlmann *et al.,* 2017; Roche *et al.,* 2013). On the other hand, a study by (Chaves *et al.,* 2011; Möhlmann *et al.,* 2017) shown that greater diversity in vector communities reduces the likelihood of disease amplification and propagation. Therefore, understanding the location, number, and richness of vector species is crucial to understanding the role that vector populations play in the spread of illness.

The likelihood of vector-borne illness epidemics has increased due to global climate change, increased anthropogenic activity, and quick communication methods. In order to address the problems posed by vector-borne diseases in the future, an assessment of the current state of the mosquito fauna in a variety of habitats across different geographic locations is required (Attaullah *et al.,* 2023). The study set out to assess the relative abundance, geographic and spatial distribution, and current diversity of mosquito fauna in Dhaka, Bangladesh. In this study we assessed the present diversity of mosquitoes in Dhaka, Bangladesh and compared the diversity and distribution of mosquito fauna in 3 areas based on landscape heterogeneity and urban–peri-urban gradient.

MATERIAL AND METHODS

Study area: Mosquitoes were collected from six sites within the Dhaka district, Bangladesh. These study areas were selected based on several criteria: vegetation density, population density, the presence or absence of substantial water bodies, infrastructural characteristics, and the occurrence of vector-borne diseases and associated outbreaks. Of them, two were from Savar Upazila and four from Dhaka city. Among the four places in Dhaka city, two were from Dhaka North City Corporation (Mirpur, Mohammadpur) while other two were from Dhaka South City Corporation (Basabo, Dhanmondi). All the four places have a high population density and limited vegetation. On the contrary, the two locations of Savar Upazila have ample vegetation, greenery and wetlands. From each location, mosquitoes were captured from five sites, which was at least 350 meters apart from each other.

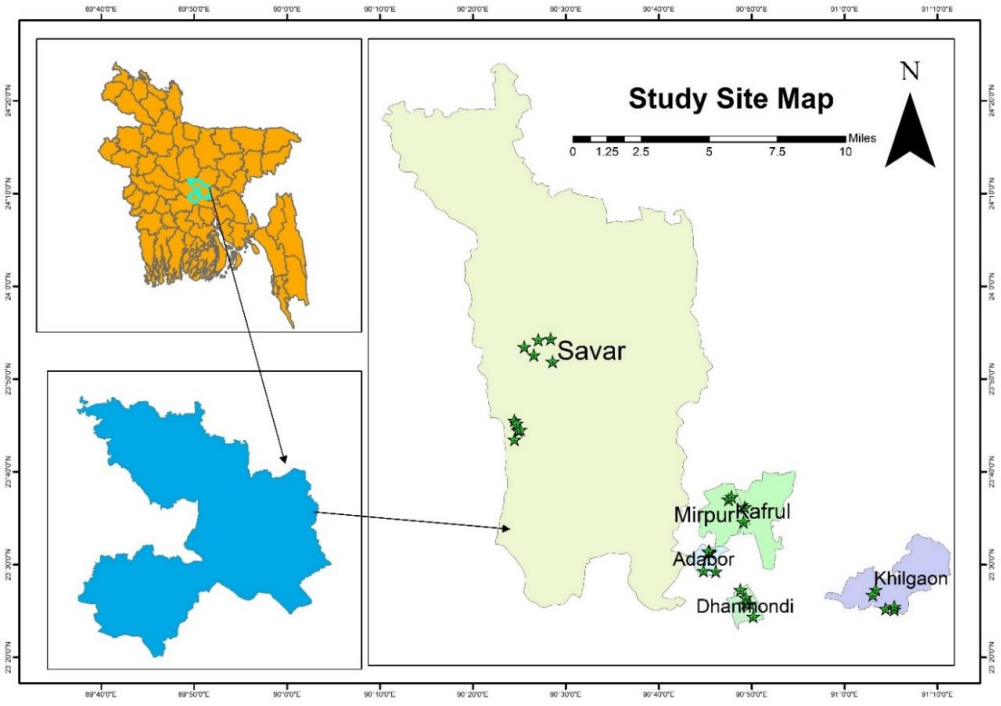

Fig. 1. Sampling Area in Dhaka, Bangladesh

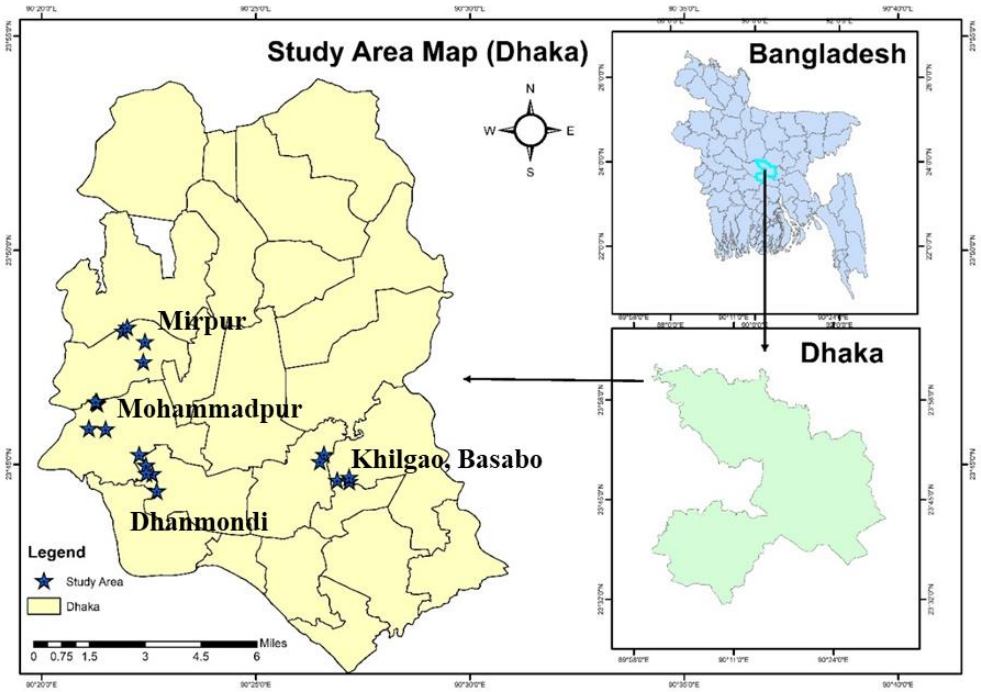

Fig. 2. Sampling Area in Dhaka North and South City Corporation

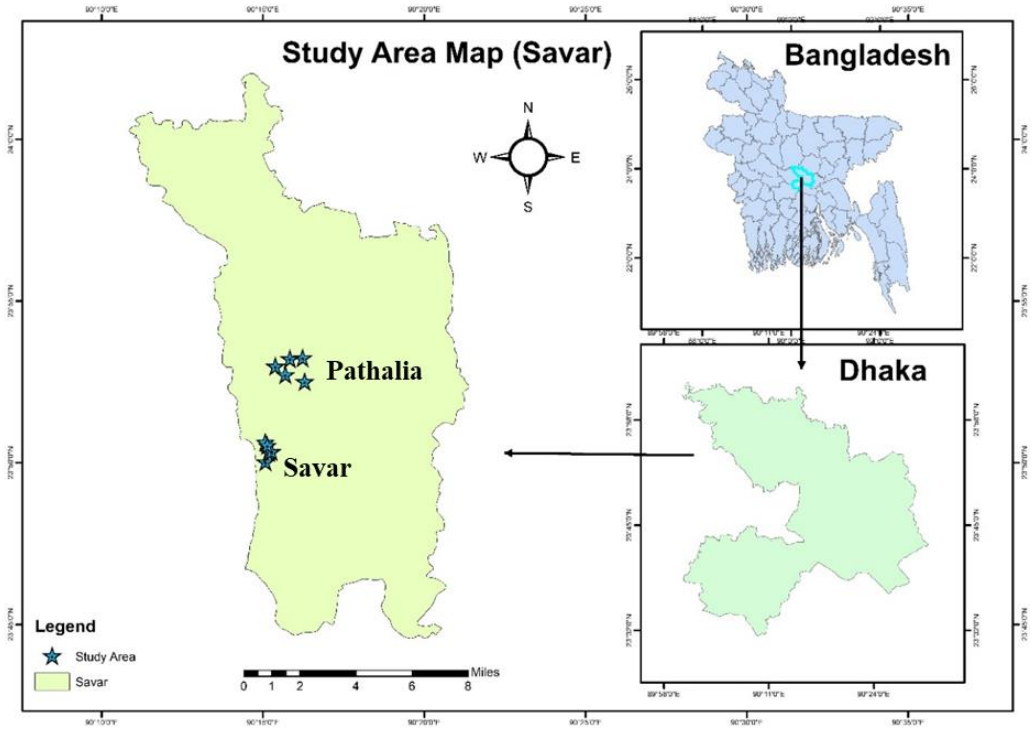

Fig. 3. Sampling Area in Savar Upazila, Bangladesh.

Mosquito collection: Mosquitoes were collected over a three-month period, from 1st September to 30th November 2023. A total of 210 traps were set during this period using BG-1 Sentinel™ traps (BioGents GmbH, Regensburg, Germany) baited with BG-Lure which mimics the scent of a human skin as it contains a proprietary blend of volatile chemicals found in human skin such as, ammonia, lactic acid, and caproic acid (BioGents GmbH, 2024). The traps were deployed at dawn for 24 hours before sample collection. Throughout the study period, traps were operated for 24 hours at biweekly intervals at each site. Following a 24-hour period of operation, the mosquitoes were collected, and the traps were relocated within the sampling sites.

Sample identification: Collected mosquitoes were identified to the species level using a standard identification key (Norbert Becker *et al.,* 2010). Specimens were initially sorted by visual inspection and then further confirmed using morphological identification keys.

Statistical analysis: Species diversity and evenness metrics for Dhaka's two city corporations were computed and contrasted with those observed in Savar. The data from all six core sites were also examined. Simpson's Index of Diversity was calculated by the formula

$$1 - D = 1 - \frac{\Sigma n_i(n_i-1)}{N(N-1)},$$

where n_i is the number of the i'th species and N is the total number of specimens in the studied country or habitat. Simpson's "Index of Diversity" shows the likelihood that two randomly selected individuals from the dataset do not belong to the same species. Simpson's Index of Diversity values fall between 0 and 1, with higher values denoting more diversity (Möhlmann *et al.,* 2017). Another diversity index that was computed was the Shannon-Wiener's Diversity Index.

$$H' = \sum_{i=1}^{R} p_i \, ln(p_i), \text{ where } p_i = \frac{n_i}{N}$$

The Shannon-Wiener Diversity Index quantifies the level of uncertainty in properly identifying a randomly selected individual from a dataset as a specific species, where bigger values indicate a higher level of uncertainty, resulting in a bigger range of differences.(Möhlmann *et al.,* 2017). This technique is influenced by the size of the sample, while the Simpson's Index gives more importance to dominating species and is not significantly affected by a few unusual species. In addition, the Shannon-Wiener's evenness was calculated as,

$$E = \frac{H'}{\ln(S)}$$

Here, S represents the overall number of species present in the given area or location. The values fall within the range of 0 to 1, with 1 representing perfect evenness, meaning that all species have equal abundance (Möhlmann *et al.,* 2017)**.**

RESULTS AND DISCUSSION

Urban and Peri-Urban environments offer valuable settings for testing ecological hypotheses related to the drivers of biodiversity and their associated ecosystem services (Grimm *et al.,* 2008; McIntyre, 2000). Investigating mosquito biodiversity in different spatial context is particularly important as it provides a useful framework for exploring broader ecological questions about biodiversity dynamics across ecosystems (Eisen *et al.,* 2008; Gleiser and Zalazar, 2010; Julião *et al.,* 2010). Findings from our study suggest that mosquito species richness and diversity are closely linked to landscape heterogeneity. This is significant, especially given that the biodiversity dynamics commonly observed in urban biodiversity studies (Helden and Leather, 2004; Zanette *et al.*, 2005) which was not true in our case, as we observed different spatial context.

A combined total of 210 trap collections were conducted across Dhaka North City Corporation, Dhaka South City Corporation and Savar Upazila. Mosquitoes were captured in 195 of these collections, representing a capture rate of 92.85%. During the study, 2,147 female mosquitoes were collected. Of

these, 97.35% were identified to the species level, while the rest were too damaged for morphological identification. A total of 10 mosquito species, belonging to four genera, were identified in this study.

The total number of female mosquitoes trapped during the field study across the three survey areas combined was highest for the genus *Culex* (83.14%), followed by *Aedes* (13.41%), *Armigeres* (2.1%) and *Mansonia* (1.37%). The most abundant species was *Cx. tritaeniorhynchus* with a total of 1275 (60.35%) out of all identified female mosquitoes (n = 2111) from the three areas followed by *Cx. quinquefasciatus* (18.57%) and *Ae. aegypti* (13.02%).

Dhaka North City Corporation exhibited the highest mosquito species diversity, with a Simpson's Index of 0.62 and a Shannon-Wiener Index of 1.07, compared to the other two survey areas. In contrast, Dhaka South City Corporation showed the lowest diversity, with a Simpson's Index of 0.54 and a Shannon-Wiener Index of 1.05 (Table 1). On the other hand, Savar Upazila recorded the highest species richness (10.00), evenness (0.21), and effective number of species (3.76), indicating a more balanced species distribution. Meanwhile, Dhaka South had the lowest species evenness (0.15) and a relatively low effective number of species (2.85). Although Dhaka North had high diversity indices, it had the lowest species richness, with only six species identified (Table 1).

The species richness differed among our 6 different spots. In Savar Upazila, most species were trapped in the peri-urban environment of Savar Union, while most individuals were trapped in highly populated urban region of Mohammadpur in the Dhaka North City Corporation, and wetlands of Basabo in

Table 1. Mosquito Species Diversity and Taxonomic Indices Across Six Sites in Dhaka (Simpson's, Shannon-Wiener, and Evenness)

Species	Dhaka North			Dhaka South			Savar Upazilla			Total
	Moham madpur	Mirpur	total	Dhan mondi	Basabo	Total	Pathalia	Savar	Total	
No. of samples	231	190	421	502	646	1148	121	400	520	2111
Species richness	6.00	4.00	6.00	5.00	6.00	7.00	8.00	8.00	10.0	10.0
Simpson's index of diversity	0.53	0.56	0.62	0.55	0.52	0.54	0.73	0.51	0.58	0.58
Shannon-Wiener's diversity	0.99	0.94	1.07	1.00	1.01	1.05	1.54	1.05	1.32	1.21
Shannon-Wiener's evenness	0.18	0.18	0.18	0.16	0.16	0.15	0.32	0.18	0.21	0.16
Effective No. of species	2.68	2.56	2.92	2.71	2.75	2.85	4.66	2.87	3.76	3.36

Dhaka South City Corporation. Densely inhabited urban region, Mirpur had the lowest species richness about only 4, while peri-urban habitats both Savar Union and Pathalia Union had the highest species richness (8), in Savar Upazila (Table 1). Species diversity was highest in the Pathalia Union, whereas it was lowest at Savar Union within the Savar Upazila. Pathalia Union had the highest level of evenness (0.32) and effective number of species (4.66) whereas Basabo had the lowest value of species evenness (0.16). In the case of effective number of species Mirpur had the lowest value (2.56), (Table 1).

Table 1. Mosquito Species Composition Collected Using BG-1 Sentinel Trap in Six Sites in Dhaka, Bangladesh, From September to November 2023

Species	Dhaka North			Dhaka South			Savar Upazilla			Total
	Moham madpur	Mirpur	total	Dhan mondi	Basabo	Total	Pathalia	Savar	Total	
Ae. aegypti	34	109	143	87	24	111	0	21	21	275
Ae. albopictus	0	0	0	1	0	1	3	4	7	8
Cx. quinque fasciatus	44	19	63	97	140	237	6	78	84	392
Cx. tritaenior inchus	148	61	209	309	422	731	53	268	321	1274
Cx. fuscoc hephala	1	0	1	8	46	54	0	16	16	71
Cx. bitaenior hynchus	1	0	1	0	12	12	2	3	5	18
M. annulifera	0	0	0	0	0	0	15	0	15	15
M. indiana	0	0	0	0	0	0	1	1	1	2
M. uniformis	0	0	0	0	0	0	12	0	12	12
Ar. subalbatus	3	1	4	0	2	2	29	9	38	44

Out of the 421 mosquitoes captured in Dhaka North City Corporation, six species were identified. The most prevalent mosquito species were *Cx. tritaeniorhynchus* (49.6%), *Ae. aegypti* (33.97%), and *Cx. quinquefasciatus* (14.96%) (Table 3). Among the 231 mosquitoes captured from Mirpur, *Ae. aegypti* was for the dominant species, accounting for 57.37% of the total collection followed by *Cx. tritaeniorhynchus* accounted for 32.11%. The most prevalent mosquito species among the 231 captured at Mohammadpur were *Cx. tritaeniorhynchus* (64%), *Cx. quinquefasciatus* (19%), and *Ae. aegypti* (14.72%), respectively.

The Dhaka South City Corporation exhibited a greater species richness compared to Dhaka North, with a total of 1,148 mosquitoes collected. *Cx. tritaeniorhynchus* accounted for the biggest proportion (63.68%), while *Ae. Albopictus*

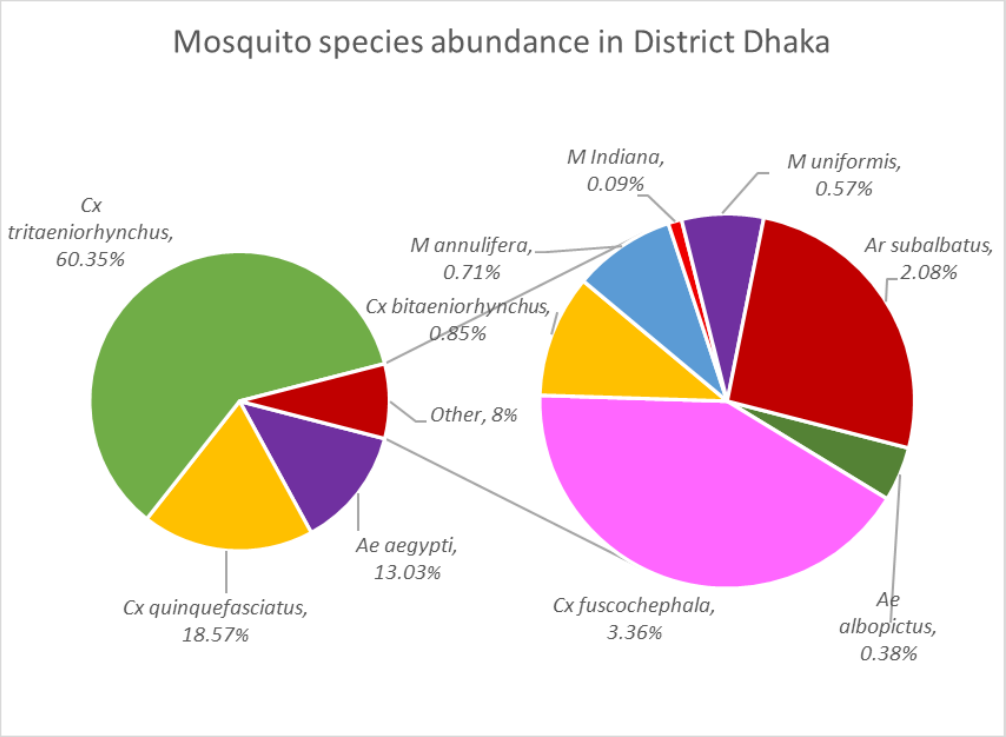

Fig. 4. Mosquito species composition in Dhaka, Bangladesh.

The Dhaka South City Corporation exhibited a greater species richness compared to Dhaka North, with a total of 1,148 mosquitoes collected. *Cx. tritaeniorhynchus* accounted for the biggest proportion (63.68%), while *Ae. albopictus* was the least abundant species (0.09%). The largest percentage of mosquitoes obtained from Dhanmondi was *Cx. tritaeniorhynchus* (61.5%), followed by *Cx. quinquefasciatus* (19%) and *Ae aegypti* (17%). However, Basabo exhibited a higher level of species richness. The majority of the collected mosquitoes were *Cx. tritaeniorhynchus,* accounting for 84% of the total. This was followed by *Cx. quinquefasciatus* (27.9%), *Cx. fuscochephala* (9.16%), *Ae. aegypti* (4.78%), and *Cx. bitaeniorhynchus* (2.39%), respectively. Peri-urban landscapes, characterized by greater environmental heterogeneity, typically support higher mosquito species richness compared to more homogeneous urban environments (Chaves *et al.,* 2011). Savar Upazila exhibited this trend having the highest species richness, with a total of 10 mosquito species identified. The most prevalent species was *Cx tritaeniorhynchus* (60%) followed by *Cx. quinquefasciatus* (18%), *Ae. aegypti* (13%), *Cx. fuscochephala* (3.36%), *Ar. subalbatus* (2.01%), *Cx. bitaeniorhynchus* (0.85%), *M. annulifera* (0.71%), *M. uniformis* (0.56%), *Ae. albopictus* (0.31%) and *M. Indiana* (0.09%). However, *M.*

annulifera and *M. uniformis* were absent among the 10 identified species in Savar Upazila, while *Ae. aegypti* and *Cx. fuscochephala* were not found in Pathalia Union. A standardized trapping methodology was employed in this study to assess the diversity of mosquito species in the study areas. Mosquito community composition differed among Dhaka North City Corporation, Dhaka South City

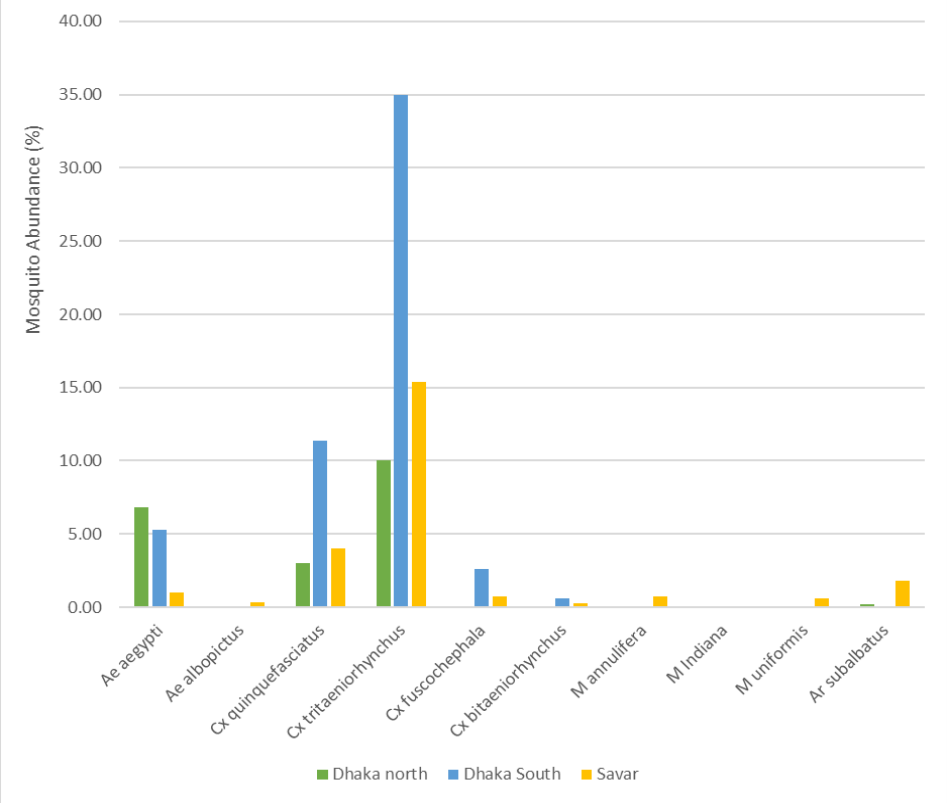

Fig. 5. Relative abundance of the mosquito fauna in some selected areas of Dhaka district

Corporation and Savar Upazila which is shown in table 1. Among them, Dhaka North City Corporation had the highest level of species diversity followed by Savar Upazila and Dhaka South City Corporation. Moreover, 6 out of 10 mosquito species were found in all three area. Among them *Cx. tritaeniorhynchus, Cx quinquefasciatus* and *Ae. aegypti* were the most abundant species.

It was also observed in Savar Upazila had the highest species richness, where species diversity was highest in Dhaka North City Corporation. Most number of *Ae. aegypti* were founded at Mirpur. However, most of the *Cx.*

tritaeniorhynchus, Cx. quinquefasciatus were founded in Basabo. *Ae. albopictus* were only present in Pathalia Union and Dhanmondi whilst *M. indiana* were only founded in Savar Upazila. Among the 5 collected *Culex* species *Cx. bitaeniorhynchus* had the lowest number while *Cx. tritaeniorhynchus* being the most.

CONCLUSION

Mosquitoes play a crucial role in transmitting diseases, and their variety and distribution have a significant influence on the transmission of diseases and the ecological condition of the local environment. Dengue, a widespread disease in the local population, and its transmission is closely linked to the abundance of mosquito vectors specially *Ae. aegypti*. The most abundant *Ae. aegypti* was found in Mirpur, followed by Dhanmondi and Mohammadpur which are densely populated areas with limited vegetation, while Pathalia Union had zero *Ae. aegypti* which have greater vegetation and lower population rates. On the other hand, Savar Upazila had the highest values for *Ae. albopictus* which was almost absent in Dhaka North and South City Corporation suggesting that it preferred somewhat peri-urban areas with ample vegetation. Moreover, in this study some species were only founded in Savar Upazila, which are *Mansonia annulifera, M. indiana and M. uniformis*.

Future studies should undertake a comprehensive assessment of mosquito diversity by including all potential habitats during the whole year. Furthermore, it is imperative to utilize modern facilities molecular and biotechnological techniques in order to obtain a more accurate and authentic representation of the mosquito population in the study region. It is also important to consider climatic elements such as temperature, humidity, and rainfall when studying the population dynamics of mosquitoes. Understanding how these environmental variables influence mosquito diversity, distribution, and abundance will enhance our ability to predict the future spread of vector-borne diseases.

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