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Host preference and nocturnal biting activity of mosquitoes collected in Dhaka, Bangladesh

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Abstract
Knowledge of host preference and activity periods of a mosquito species provides valuable insight into the dynamics of disease transmission and allows vector control authorities to design and implement efficient strategies for vector management. In this study, we determined what mosquito species be attracted to humans and their times of biting both indoors and outdoors in Bangladesh. Adult mosquitoes were collected for every first and third week of the month from January to December 2011 in Garua village, Bangladesh. Mosquito trapping was conducted inside, outside the house and in the cattle shed using human-bait (HB), cattle-bait (CB), and light traps. Each team of collectors captured adult mosquitoes between 1800-0600 h. A total of 14,788 adult mosquito samples consisting of 16 species belonging to 4 genera were captured during a year. *Culex quinquefasciatus* (5673/38.36%) was the dominant species followed by *Cx. hutchinsoni* (4644/31.40%), *Cx. tritaeniorhynchus* (3203/21.66%) and *Ar. subalbatus* (506/3.42%). All these dominant species were found throughout the year with a peak in July. The biting activity of various mosquito species in different hours of night varied from each other. The biting activity also varies in different months. *Culex quinquefasciatus* starts to bite human after sunset and gradually increase the density and attain peak at 2300-2400. After 2400 the biting density decreases gradually. *Culex hutchinsoni* start biting soon after the sunset and progressively reach the peak at 2400h and then decline slowly. Species diversity was higher in cattle shed compare to the human house. A significant difference ($p<0.01$) of the mosquito density were found between the cattle bait and human bait catch. *Culex vishnui* mosquito strongly prefers to feed on cattle. *Armigeres subalbatus, Cx. hutchinsoni, Cx. sitiens, Cx. tritaeniorhynchus,* and *Mn. annulifera* were found to feed both on human and cattle. The majority of the Mosquitoes species were seeking hosts between 2400-0300 h. The main filarial vector *Cx. quinquefasciatus* peak biting time was between 2400-0300 h. It seems advisable that during this period, people should be advised to take precautions like the use of appropriate repellents, and proper clothing as well as sleeping under a bed net to avoid vector-host contact.

Keywords: Host preference, nocturnal biting activity, mosquitoes, dengue, malaria, filariasis, zika, chikungunya, Japanese encephalitis, Bangladesh

Introduction
In Bangladesh, altogether 115 species of mosquitoes, including 36 Anophelines and 79 Culicines, have so far been recorded [1-2]. Many species of them are responsible for the transmission of several medically important parasites and pathogens such as viruses, bacteria, protozoans, and nematodes, which cause severe illness such as malaria, dengue, chikungunya fever, encephalitis, filariasis in Bangladesh [2]. Not all species prefer to bite humans; some choose birds, others select horses, and some will even bite frogs and turtle [3].
Knowledge of the distribution, seasonal variation, host preference and activity periods of a mosquito species provides valuable insight into the dynamics of disease transmission and allows vector control authorities to design and implement efficient strategies for vector management [4-5]. Such records are very scanty for Bangladesh in general and Dhaka city in particular. Several workers carried out some studies on the biting activity of mosquitoes in Dhaka, but these inferences were tentative without a proper quantitative survey to support the conclusions [6-9]. While describing the bionomics of mosquitoes, they studied the biting activity pattern very briefly. Nonetheless, information regarding changes in biting activity and biting peaks in different hours are not studied extensively.

The above facts drove us for a further in-depth study to explore host preference and nocturnal biting activity pattern with the changes in different hours of the night. In the current study, we determined what mosquito species be attracted to humans and their times of biting both indoors and outdoors, which make a significant contribution to identifying periods of transmission risk and developing methods of personal protection against vector and nuisance mosquitoes.

Materials and Methods

Study area: The sampling was conducted in Gerua Village (23°52′60″ N, 90°16′00″ E) in Dhaka district of Bangladesh. The village stands on the 34 kilometers away from the capital. The sampling area is a tropical wet and dry climate and has a distinct monsoon season, with an average annual temperature of 25 °C (77°F) and monthly means varying between 18 °C (64 °F) in January and 29 °C (84 °F) in August. Around 80% of the average annual rainfall of 1,854 millimeters (73.0 in) occurs during the monsoon season which lasts from May until the end of September [10]. Gerua is a typical rural village in Bangladesh and water loggings are commonly seen. The majority of the villagers are involved in agricultural practices. Highly dense vegetation covered this place and surrounded by paddy fields. Nearly all inhabitants kept domestic animals (Cattle, goat, and chicken) in their house.

Mosquito collections: Mosquito trapping was conducted inside, outside the house and in the cattle shed. We selected three houses for human-bait indoor (HBI), human-bait outdoor (HBO), and three cattle shed for cattle-baited (CB) collections. Each sampling house is a minimum of 500 meters far from the other house. Human-bait indoor (HBI), human-bait outdoor (HBO), and cattle-baited (CB) collections were made in every first and third week of the month from January to December 2011. All mosquitoes were collected by an expert collector using mouth aspirator for 15 minutes for human-bait indoor, 15 min for human-bait outdoor, and 15 min for cattle bait in each hour. The collections were conducted from 1800 to 0600 h each night during the study period. The bait (an assistant), collection sites and collector remained unchanged during the study. The dusk to dawn mosquito collections on single bait was made during the survey period. Hourly catches of mosquitoes were put in paper cups according to the hour of collection. For light trap collections, we hung the light trap in three cattle shed and three human houses both indoor and outdoor. We hung light traps in 1.5 meters above the ground and collected mosquito from 1800 to 0600 h. Mosquito captured nest of the light traps was changed alternatively with early (1800 to 2400) and late (2400 to 0600) night.

Mosquito processing and Identification: Collected mosquitoes were transported to the entomology laboratory of Jahangirnagar University and anesthetized chloroform. All mosquitoes were identified at the species level using morphological keys [11-15] and the number and species of mosquitoes collected per hour were recorded. After identification, the samples were stored in the Eppendorf tube according to the species and preserved in a freezer for future use.

Data analysis: Data have entered the data in MS Excel 2010 and Statistical Package for the Social Sciences (SPSS) version 16. Pivot tables and diagrams were made using MS Excel 2010 and Co-relation and Chi-square test using SPSS. We did not conduct a Chi-square test on those species of mosquito that we captured less than 10 in number.

Results

Prevalence of mosquito species: Over 12 months of collections, 14,788 mosquito samples consisting of 16 species belonging to 4 genera were captured using human, cattle baits and light traps. *Culex (Cx.) quinquefasciatus* Say (5673/38.36%) was the dominant species followed by *Cx. hutchinsoni* Barraud (4644/31.40%), *Cx. tritaeniorhynchus* Giles (3203/21.66%) and *Armigeres (Ar.) subalbatus* Theobald (506/3.42%) (Table 1). All these dominant species were found throughout the year (January to December) with a peak in July. A good number of *Mansonia (Ma.) annulifera* Theobald and *Ma. uniformis* Theobald was captured during the study period except for winter months (November to January). The density of *Anopheles* mosquitoes was very low in the study area (Table 1 and Figure 1).

Biting activity pattern in the indoor house: Nine species of mosquito were captured in human bait in indoor. *Culex quinquefasciatus* was the dominant species followed by *Cx. hutchinsoni*, and *Cx. tritaeniorhynchus*. The indoor biting activity of various mosquito species in different hours of night varied from each other. The biting activity also differs in different months. Results of the indoor biting pattern of different mosquito species are presented in table 2. *Culex quinquefasciatus* starts to bite human after sunset and gradually increase the density and attain peak at 2300-2400. After 2400 the biting density decreases gradually. *Cx. hutchinsoni* start biting soon after the sunset and progressively reach a peak at 2400h and then decline slowly. The peak biting period varies in different months but it lies in the range of 2100-2400. The less density of this species was found in January and gradually increase in number to become more abundant in July. Japanese encephalitis vector; *Cx. tritaeniorhynchus* start to bite on human almost immediately after the sunset and attain its peak at 2300-2400. *Mansonia annulifera* were found to feed on human-only between 2000 to 0100 h in inside the house. Very small numbers of *An. vagus* Doenitz, *Ar. subalbatus*, and *Cx. gelidus* Theobald was captured in human bait catch in inside the house during 1800-2000 h. All *Anopheles* species were found to bite before 2000 h (Table 2).

Biting activity pattern in the outdoor house: The nocturnal biting activity of the 6 mosquito species collected at human bait outdoor is shown in Table 3. In general, the results are similar to observations in the indoor house with a few exceptions. *Culex quinquefasciatus*, *Cx. hutchinsoni*, and *Cx. tritaeniorhynchus* were collected throughout the night without a discernible peak; however, more specimens were composed during 2000 and 0100 h. Although *Ma. uniformis* was collected between 1900 and 0100 h; peak collections were made between 2000-2300 h. All *Ma. annulifera* were collected before 2200 h. *Armigeres subalbatus* was found to bite soon after dark outside the house (Table 3).

Biting activity pattern in cattle-house: The pattern of mean 'cattle landing' frequency of *mosquito* by the hour is given in Table 4. The species diversity was high in cattle landing as there were 14 species were captured during the study period. Among these 7 were *Anopheles*, 5 *Culex*, 1 *Mansonia and* 1 *Armigeres* species. Cattle biting activity patterns of *Culex quinquefasciatus*, *Cx. hutchinsoni*, and *Cx. tritaeniorhynchus* were relatively similar for a full night, with greater activity occurring in the middle of the night with varying points of

peak attack. Small peaks biting of activity of *Ma. annulifera* was seen from 2100–2200h. A few numbers of different anophelines mosquito species were found to bite cattle, but there were no demonstrable peaks seen throughout the night collections. *Culex sitiens* were observed to bite animals between 2100 to 0200h and peak at 2100-2200h. Similar to outdoor human bait catch *Armigeres subalbatus* was found to bite soon after dark on cattle (Table 4).

Host Preference: Species diversity was higher in cattle shed compare to the human house. A significant difference ($p<0.01$) of the mosquito density were found between the cattle bait and human bait catch. During the study period, only one *Anopheles* species (*An. vagus*) was found in human-biting indoor. Other *Anopheles* mosquito species (*An. barbirostris* Strickland, *An. hyrcanus gr.*, *An. nigerrimus* Theobald, *An. peditaeniatus* (Leicester), *An. subpictus* Grassi, *An. umbrosus* (Theobald) and *An. vagus*) were found to bite on cattle. *Culex vishnui* mosquito strongly prefers to feed on cattle. A Large number of *Cx. quinquefasciatus* was captured during human landing indoor. The density of this species was lower in cattle bait than human bait indoor and outdoor. *Armigeres subalbatus, Cx. hutchinsoni, Cx. sitiens, Cx. tritaeniorhynchus,* and *Mn. annulifera* were found to feed both on human and cattle (Table 5).

Light trap collections: We hung light traps in three cattle houses and three human houses both inside and outside and collect mosquito in the early night (1800-2400h) and late-night (2400-0600h) during the study period. Species diversity and density between cattle bait catch and human bait catch were significantly different ($p<0.01$). *Anopheles vagus* and *Ar. subalbatus* were collected only from the cattle-house using light traps. Five mosquito species were captured from cattle house, while four species from the human house both indoor and outdoor (Table 6).

Discussion

Understanding of the biting behavior of mosquitoes is essential to clarify the respective roles of each species in disease transmission in an area. The nocturnal biting rhythms of the presently stated species for which information is available in other countries of the Asia-Pacific Region, provide interesting comparisons with our results. Mosquitoes were seen biting man throughout the study period outdoor but biting density differed in different months. A maximum outdoor biting density was found in July. The lowest outdoor biting density was seen in January. The vector of Bancroftian filariasis in Bangladesh [16], *Cx. quinquefasciatus;* were found as predominant species and start biting soon after sunset and continued throughout the night in the present study. It was seen that biting builds up to peak around midnight and gradually decreased. A similar observation was reported by Hossain *et al* [6] in the same ecological areas of Bangladesh. They found, *Cx. quinquefasciatus* actively pursuing hosts throughout the night with distinct peak activity in the middle of the night. Pal *et al*. [17], reported that the feeding of this species took place throughout the night but the peak feeding was from midnight to early morning (2400 to 0600 h). Abdulcader [18] reported that the biting cycle of this species commences at about 1800h building up to a peak at around 0200h and declines thereafter in Rangoon. A similar observation was also found by Samarawickrema [19] in Srilanka. But different results were observed by Ameen *et al*. [9] in Bangladesh and Sucharit *et al*. [20] in Bangkok. Ameen *et al*. [9] found peak biting on man just after dusk. In Bangkok, the peak biting time of *Cx. quinquefasciatus* was between 2200-2300h with two other peaks after midnight at 0100h and at 0400h [20]. The inconsistency in the results of various reports might be due to the differences in the sleeping behavior of the host, microclimatic conditions, and the lunar cycle [21-22]. In outdoor and indoor biting collections, *Culex quinquefasciatus* formed the largest group. The difference between indoor and outdoor biting density was rather similar. Meillon and Sebastian [23] and Gubler and Bhattacharya [24] found almost a similar biting frequency both indoor and outdoor. Sasa *et al*. [25] reported in a study in Bangkok, Thailand, that indoor and outdoor biting density slightly differed. They found indoor collections were larger than outdoor.

Temporal variability in the biting patterns of the principal vector of Japanese encephalitis; *Cx. tritaeniorhynchus* were well documented [26-28]. In our study, we found a high density of *Cx. tritaeniorhynchus* and observed peak biting at 2300-2400 h in indoor but in outdoor and cattle shed, we collected this species throughout the night without significant biting time preference. This finding was supported by the study of Hossain *et al* [6] in Bangladesh. A similar result of the nocturnal biting profile has been reported in India with the primary peak towards midnight [26], while a biphasic cycle with dusk and dawn peaks has been observed in studies from Pakistan [28]. A triphasic pattern with dusk, midnight, and dawn peaks has been reported in the Philipines [27]. All three types of biting patterns have been observed in Japan [29]. This variability has been attributed to different climatic conditions, especially temperature and humidity, in these different geographic regions [28].

The other JE vector species, *Culex vishnui* biting activity was maximal during the first quarter of the night in Singapore [30] and Pakistan [28]. In India, however, the species was observed to have a rounded unimodal profile with peak biting at 2300 h [26]. These species were found small in numbers in cattle houses during our study. We did not detect any significant biting pattern of this species. Nonetheless, Hossain *et al* [6] reported its activity throughout the night. A small number of *Cx. gelidus* were found only in inside the house in our study. The three species (*Cx. gelidus*, *Cx. vishnui*, and *Cx. tritaeniorhynchus*) are the recognized vectors of Japanese encephalitis (JE) caused by Flavivirus group JE virus. This disease was found in the Modhupur forest area of Bangladesh [31].

High density with relatively similar hourly night biting pattern of Cx. hutchinsoni were observed in our study. In contrast, Hossain *et al*. [6] showed peak biting between 2100-0300 h. Though this species is known as non-vector it has also been implicated in outbreaks of Japanese encephalitis [32].

A Little number of *Ma. uniformis* were captured in our study from the outdoor and cattle shed and found to bite between 2000-2300h. These results slightly differed from the study of Hossain *et al*. [6], they did not identify any hourly biting preference for a host for this species. Korgaonkar *et al*. [33] observed similar patterns in a study conducted in Goa. In our study, *Ma. uniformis* revealed bimodal patterns in biting densities with peaks in August and September following low and high rainfall, respectively. During the study period, the density of this species was very low. So it was tough to find the actual peak biting hour. A small number of *Ma. annulifera* were captured in the present study and concluded that they

prefer to bite both human and cattle before midnight. In contrast, Hossain *et al*. [6] observed peak biting between 2400-0100 h, which was support for the findings of Kumar *et al*. [34]. They reported that *Ma. annulifera* bites uniformly throughout the night in South India. These two species are found transmitting Brugian filariasis in many countries of Southeast Asia, including India [35]. The eastern districts of Bangladesh are close to India and Myanmar, and the terrain is similar so that Brugian filariasis may be there. This fact demands immediate parasitological studies in this area.

During the study period, less number of *Ar. subalbatus* was captured both in the cattle shed and human house. These species prefer to take blood soon after the dusk. Contrast results were found by Amerasinghe *et al*. [36] and Hossain *et al*. [6], they reported that these species bite throughout the night. The discrepancy between the results of these studies may be due to the climatic conditions, especially temperature falls during the night and level of adaptation of the vector in the different countries [37]. This species has no public health importance in Bangladesh.

Only about 0.28% of anopheline mosquito was collected in the present study. Seven anopheline species were captured from the cattle-house (*An. barbirostris, An. hyrcanus gr., An. nigerrimus, An. peditaeniatus, An. subpictus, An. umbrosus,* and one *An. vagus*) from the human house indoor (*An. vagus*). We did not found the particular pattern of night biting of the anopheline as mentioned above species collected in our study. It may be because of the less density of these species in the study area. *Anopheles barbirostris* showed high biting activity between dusk and midnight in Burma [38], in contrast to a mainly early night biting profile in Sri Lanka [28]. Similar to Pakistan *An. nigerrimus* showed high activity between dusk and 2200h in Sri Lanka [28] with peak biting occurring earlier in winter than in summer months. *Anopheles subpictus* has been reported to bite mainly between 2000 and 2400 h [26, 28], slightly later than indicated in the present study. However, some biting activity towards dawn has also been reported during summer months in the Lahore area of Pakistan [28]. *Anopheles vagus* has been incriminated as malaria vectors where malaria outbreak took place in the plain land of Bangladesh [39]. The scientists termed them as 'Epidemic vector.' This is also more unlikely, but detailed studies are needed to see its role here. Other *Anopheles* species captured here are of no public health importance except some nuisance value. They are zoophilic species, i.e., prefer bite cattle. The feeding pattern of disease vectors varies widely and is dependent on climatic factors [40-41].

The risk of mosquito-borne disease transmission to humans depends greatly on the degree of human feeding by female mosquitoes, which would, in turn, be influenced by the abundance and distribution of other potentially attractive hosts. Concerning the biting rhythm, the degree of risk would vary with the peak biting time. Exophilic species active during the evening crepuscular period could potentially infect humans during the first 1-2 hr after sunset when people are still active outdoors in the rural farming community where this study was done. Species biting later in the night would encounter human hosts mainly within dwelling houses, and thus vector-host contact would largely be determined by the degree of endophily of the species population in the area.

Host preference

The expression of host preference (selection of host) by a mosquito in nature may depend on several extrinsic or intrinsic factors [42-43] is of which genetics is a major component. Many species express inherent traits in host preference, but this choice is readily mastered by physiological factors (hunger) and physical richness of available hosts [3] During our study, we found a significant difference (p<0.01) of the mosquito density in cattle bait and human bait catch.

In the present study, only one *Anopheles* species (*An. vagus*) was found in human bait indoor and cows bait. This species is known as an opportunistic feeder; they bite both humans and cattle when available [7]. Other *Anopheles* mosquito species (*An. barbirostris, An. hyrcanus gr., An. nigerrimus, An. peditaeniatus, An. subpictus, An. umbrosus* and *An. vagus*) were found to bite on cattle. These species are zoophilic and prefer to feed on bovine blood [7, 44].

A Large number of *Cx. quinquefasciatus* was captured during human landing indoor and cattle bait in the present study. The density of this species was lower in cattle bait than human bait indoor and outdoor. Ameen *et al*. [9] revealed that *Culex tritaeniorhynchus*, *Cx. gelidus*, and *Cx. quinquefasciatus* are the predominant cattle-biting species. Ornithophilic feeding behavior also was reported for *Cx. quinquefasciatus* populations in the city of Monterrey, northern Mexico [45] and Yucatan State, Mexico [46]. Though Ameen *et al*. [9] reported *Culex tritaeniorhynchus*, *Cx. gelidus* as a predominant cattle biter but we observed that a high proportion of this mosquito species took human blood. *Culex vishnui* mosquito was found to strongly prefer to feed on cattle in the present study. Mwandawiro *et al*. [47] reported that *Cx. tritaeniorhynchus, Cx. gelidus* and *Cx. vishnui* tended to return to the cow or the pig depending on which host they had previously been attracted to, or had already fed upon. Several authors [48-49] reported that *Anopheles barbirostris, Armigeres subalbatus,* and *Culex tritaeniorhynchus* mosquitoes preferred to feed on the human in their less active time. *Culex tritaeniorhynchus, Cx. gelidus and Cx. vishnui s. l.,* are the vector of JE in Bangladesh as well as the other countries of the world. The anthropophilic nature of this species will be playing an important role to transmit JE in this country.

Mansonia annulifera and *Ma. uniformis* were found to take blood from humans and cattle in the present study. Samuel *et al*. [50] reported high anthropophilic feeding rates *Ma. annulifera* collected from an endemic belt of Malayan filariasis, in India. In a recent outbreak of JE in Kerala, three isolations were made from *Ma. uniformis* and one from *Ma. Indiana* [51].

Host richness changed over the years and between areas and affected mosquito host choice. Though both innate host preference and host abundance affected feeding rates, the stimulus of either of these factors depended on the mosquito species [52]. Many *Culex* species have a chosen for feeding on birds. The availability of birds, yet, often varies throughout the year because of migration. When the accessibility of their preferred host declines, *Culex* species may shift to other hosts, including humans [52-54]. Many mosquitoes express an opportunistic trait of host choice, but that some species are indeed host-specific. The high degree of plasticity in host preference of *Cx. quinquefasciatus* suggests that, although inherent preferences may prevail locally, this species is exquisitely adjusted to obtaining blood under many different circumstances, where the most plenty of host species seems to be preferred. Consequently, to make accurate inferences about

the host preferences of a mosquito, it is necessary to take into attention the richness and availability of a particular host. The densities of potential hosts in the study area must be measured to obtain a better understanding of mosquito host preferences.

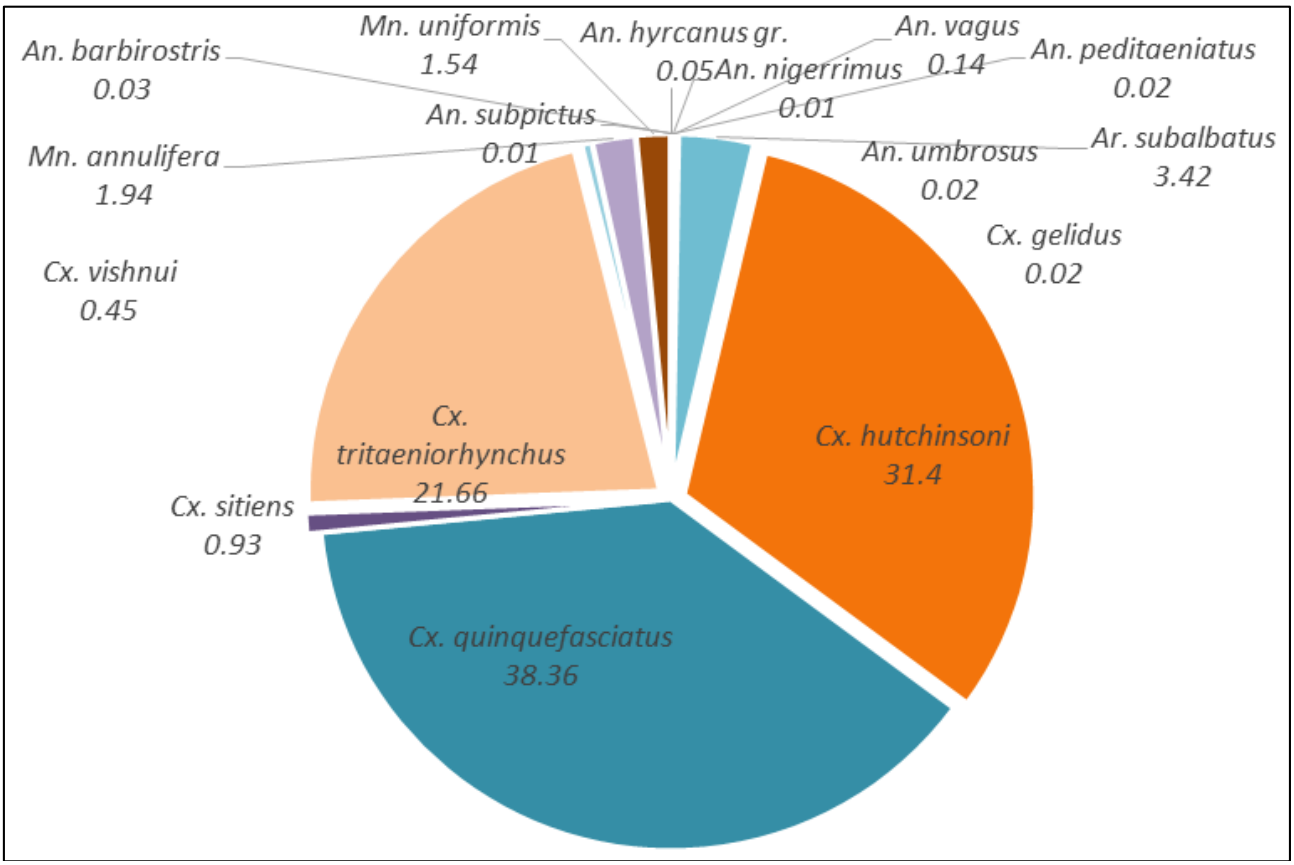

Fig 1: Proportion of mosquitoes collected from January to December 2011 in Dhaka, Bangladesh

Table 1: Species diversity and density of mosquitoes collected from January to December 2011in Dhaka, Bangladesh

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
An. barbirostris	-	-	-	2	1	1	-	-	-	-	-	-
An. hyrcanus	-	-	3	3	1	-	-	-	-	-	-	-
An. nigerrimus	-	-	1	1	-	-	-	-	-	-	-	-
An. peditaeniatus	3	-	-	-	-	-	-	-	-	-	-	-
An. subpictus	-	-	-	2	-	-	-	-	-	-	-	-
An. umbrosus	-	-	-	2	1	-	-	-	-	-	-	-
An. vagus	1	4	1	3	4	3	2	1	-	-	2	-
Ar. subalbatus	19	23	34	37	44	56	79	77	50	45	29	13
Cx. gelidus	1	-	-	-	-	-	-	-	-	-	-	2
Cx. hutchinsoni	173	327	378	415	464	522	585	549	419	362	278	172
Cx. quinquefasciatus	148	453	485	543	575	679	777	666	483	414	291	159
Cx. sitiens	9	8	10	17	16	13	15	13	13	8	6	9
Cx. tritaeniorhynchus	93	202	237	278	320	360	437	398	314	261	204	99
Cx. vishnui	-	4	5	10	12	11	8	6	6	3	1	-
Mn. annulifera	-	4	12	41	36	26	44	49	44	31	-	-
Mn. uniformis	-	1	20	25	21	21	27	48	36	28	-	-

Table 2: Hourly Human Bait Catch (HBC) in inside the house in Dhaka, Bangladesh during January to December 2011

SPECIES	18:0-19:0	19:0-20:0	20:0-21:0	21:0-22:0	22:0-23:0	23:0-24:0	0:0-1:0	1:0-2:0	2:0-3:0	3:0-4:0	4:0-5:0	5:0-6:0
An. vagus	-	1.00±0.00	-	-	-	-	-	-	-	-	-	-
Ar. subalbatus	2.25±0.75	-	-	-	-	-	-	-	-	-	-	-
Cx. gelidus	1.50±0.35	-	-	-	-	-	-	-	-	-	-	-
Cx. hutchinsoni	1.70±0.34	3.50±0.65	2.95±0.66	3.55±0.68	4.00±0.71	4.40±0.82	3.63±0.63	2.34±0.56	2.66±0.71	2.45±0.84	2.17±0.61	1.88±0.18
Cx. quinquefasciatus	2.50±0.41	3.77±0.80	3.13±0.95	4.10±0.87	3.20±0.84	4.29±0.79	3.04±0.73	3.45±1.02	3.05±0.82	2.59±0.69	1.00±±0.00	1.87±0.41
Cx. sitiens	-	-	-	-	-	1.00±0.00	-	-	-	-	1.39±0.29	-
Cx. tritaeniorhynchus	2.65±0.79	2.63±0.62	3.10±0.69	3.10±0.56	3.42±0.71	4.05±0.82	3.65±0.80	3.00±0.60	3.00±0.56	2.60±0.55	0.00±0.00	0.00±0.00
Mn. annulifera	-	-	2.47±0.59	2.50±0.53	2.33±0.31	2.53±0.56	1.86±0.19	-	-	-	-	-
Mn. uniformis	-	-	2.50±0.46	-	1.88±0.68	-	1.50±0.38	-	1.55±0.43	-	-	-

Table 3: Hourly Human Bait Catch (HBC) of mosquitoes (Mean±SE) in outside the house in Dhaka, Bangladesh during January to December 2011

Species	18:0-19:0	19:0-20:0	20:0-21:0	21:0-22:0	22:0-23:0	23:0-24:0	0:0-1:0	1:0-2:0	2:0-3:0	3:0-4:0	4:0-5:0	5:0-6:0
Ar. subalbatus	3.50±0.45	-	-	-	-	-	-	-	-	-	-	-
Cx. hutchinsoni	1.62±0.21	2.85±0.41	2.48±0.44	3.05±0.44	4.25±0.40	2.68±0.63	4.45±0.47	2.63±0.35	3.50±0.35	2.54±0.39	3.90±0.43	2.00±0.38
Cx. quinquefasciatus	2.46±0.38	3.85±0.28	4.15±0.44	3.05±0.62	4.55±0.39	6.09±0.56	3.00±0.44	4.70±0.83	4.30±0.44	3.30±0.37	3.64±0.38	2.79±0.48
Cx. tritaeniorhynchus	2.25±0.37	2.67±0.45	3.35±0.34	3.20±0.43	3.60±0.42	4.80±0.43	2.69±0.54	2.80±0.32	3.70±0.42	2.77±0.44	3.38±0.46	2.10±0.18
Mn. annulifera	-	1.86±0.28	2.14±0.26	1.57±0.17	-	-	2.29±0.26	-	-	-	-	-
Mn. uniformis	-	1.63±0.24	2.05±0.22	2.63±0.24	2.19±0.29	2.25±0.22	1.75±0.28	-	-	-	-	-

Table 4: Hourly Cattle Landing Catch (CLC) of mosquitoes (Mean± SE) in the cattle shed in Dhaka, Bangladesh during January to December 2011

Species	18:0-19:0	19:0-20:0	20:0-21:0	21:0-22:0	22:0-23:0	23:0-24:0	0:0-1:0	1:0-2:0	2:0-3:0	3:0-4:0	4:0-5:0	5:0-6:0
An. barbirostris	-	-	-	1.00±0.00	-	-	1.00±0.00	-	1.00±0.00	-	-	-
An. hyrcanus	-	1.00±0.00	-	1.00±0.00	-	-	-	-	-	1.00±0.00	-	-
An. nigerrimus	-	-	-	-	-	1.00±0.00	-	-	-	1.00±0.00	-	-
An. peditaeniatus	2.00±0.00	-	-	-	-	-	-	-	-	1.00±0.00	-	-
An. subpictus	-	-	1.00±0.00	-	1.00±0.00	-	-	-	-	-	-	-
An. umbrosus	-	-	1.00±0.00	-	1.00±0.00	1.00±0.00	-	-	-	-	-	-
An. vagus	1.00±0.00	-	1.00±0.00	1.00±0.00	1.00±0.00	1.00±0.00	1.00±0.00	-	-	-	-	-
Ar. subalbatus	2.80±0.25	-	-	-	-	-	-	-	-	-	-	-
Cx. hutchinsoni	2.00±0.24	2.69±0.46	3.15±0.54	3.15±0.48	2.08±0.31	3.75±0.63	2.87±0.55	2.55±0.33	2.42±0.31	2.63±0.33	3.06±0.49	2.00±0.27
Cx. quinquefasciatus	2.38±0.34	3.89±0.56	2.57±0.39	4.10±0.50	3.48±0.63	3.00±0.54	2.66±0.54	2.39±0.50	2.48±0.35	2.30±0.41	2.27±0.40	2.39±0.61
Cx. sitiens	-	-	-	2.00±0.00	-	-	1.00±0.00	1.00±0.00	-	-	-	-
Cx. tritaeniorhynchus	2.58±0.43	2.92±0.52	2.25±0.48	3.00±0.52	2.50±0.48	3.26±0.61	2.84±0.52	2.91±0.44	2.45±0.40	1.77±0.36	2.33±0.37	2.50±0.45
Cx. vishnui	-	-	1.67±0.35	-	1.43±0.17	-	-	1.89±0.37	1.30±0.15	-	1.75±0.16	1.00±0.00
Mn. annulifera	-	-	-	2.25±0.16	-	-	-	1.81±0.26	-	-	-	-

Table 5: Species diversity in Cattle bait catch and human bait catch and their significant difference

Species	Cattle Bait Catch		Human Bait Catch		Sig. value
	N	%	N	%	
An. barbirostris	3	0.04	-	-	-
An. hyrcanus	6	0.07	-	-	-
An. nigerrimus	2	0.02	-	-	-
An. peditaeniatus	3	0.04	-	-	-
An. subpictus	2	0.02	-	-	-
An. umbrosus	3	0.04	-	-	-
An. vagus	13	0.16	1	0.01	0.00
Ar. subalbatus	30	0.37	44	0.55	0.00
Cx. gelidus	-	-	3	0.04	-
Cx. hutchinsoni	710	8.86	1590	19.84	0.00
Cx. quinquefasciatus	949	11.84	2008	25.06	0.00
Cx. sitiens	8	0.10	34	0.42	0.00
Cx. tritaeniorhynchus	642	8.01	1390	17.34	0.00
Cx. vishnui	66	0.82	-	-	0.00
Mn. annulifera	38	0.47	246	3.07	0.00
Mn. uniformis	-	-	223	2.78	0.00
Total	2475	30.88	5539	69.12	0.00

Table 6: Species and number of mosquitoes captured using light traps in cattle shed and human house both outside and inside and their significant difference (Chi-square)

Species	Cattle shed				Outside house				Inside house			
	EN	LN	Total	p	EN	LN	Total	p	EN	LN	Total	p
An. vagus	3	3	6	-	-	-	-	-	-	-	-	-
Ar. subalbatus	229	0	229	0.00	-	-	-	-	-	-	-	-
Cx. hutchinsoni	288	310	598	0.01	127	200	327	NS	144	326	470	0.00
Cx. sitiens	-	-	-	-	0	38	38	0.00	303	342	645	0.01
Cx. quinquefasciatus	355	332	687	NS	157	96	253	0.00	0	35	35	0.00
Cx. tritaeniorhynchus	38	137	175	0.00	24	90	114	0.00	185	168	353	0.00
Total	913	782	1695	0.00	308	424	732	0.00	632	871	1503	0.00

Conclusion

Culex quinquefasciatus was the dominant species followed by *Cx. hutchinsoni*, and *Cx. tritaeniorhynchus*. The indoor biting activity of various mosquito species in different hours of night varied from each other. The majority of the mosquitoes species were seeking hosts between 24h00-03h00. The main filarial vector *Cx. quinquefasciatus* peak biting time was between 24h00-03h00. It seems advisable that during this

period (and throughout the night), people should be advised to take precautions like the use of appropriate repellents, and proper clothing as well as sleeping under a bed net to avoid vector-host contact. The species diversity was high in cattle bait as compared to a human bait. Widespread use of IRS and ITNs for vector control may have caused changes in host-seeking behavior, resulting in shifts in the time of or preferred site of host-seeking; these changes may affect the innate host choice when preferred hosts are scanty. The present study did not attempt to draw a definitive picture of the seasonal abundance of mosquitoes about these environmental variables. The direct causal link between these environmental factors and the mosquito biting preference in Bangladesh is of research interest. Comparative studies on the host preference, biting rhythms of the different sibling species about environmental factors could be important in elucidating the dynamics of disease transmission.

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