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Diversity and seasonal prevalence of mosquito fauna in Gushkara, West Bengal, India

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Abstract
Mosquitoes are potential vectors of some of the serious diseases causing parasites and pathogens of humans and animals. Analysis of mosquito diversity and prevalence in any area is often a prerequisite component in disease and mosquito management. The present study was conducted at the Gushkara municipal area of Purba Bardhaman district in West Bengal, India to gather systematic first-hand information on mosquitoes. Indoor-resting adult mosquitoes were collected and identified systematically using standard methods. Monthly and seasonal Relative Abundance (RA), Per Man Hour Density (PMHD), and House Index (HI) of different species were calculated from the accumulated data. In five genera, eight species of mosquitoes were encountered in the study area namely *Aedes albopictus*, *Anopheles annularis*, *Anopheles barbirostris*, *Anopheles subpictus*, *Armigeres subalbatus*, *Culex quinquefasciatus*, *Culex vishnui* (group) and *Mansonia annulifera*. The RA, PMHD, and HI were highest for *Ar. subalbatus* (56.14, 17.63, and 81.94) followed by *Cx. quinquefasciatus* (20.31, 6.38, and 61.11) and *An. subpictus* (9.89, 3.10, and 35.76). In the case of some species, there was notable monthly variation throughout the year but seasonal variation was not prominent in most species. About ninety percent of the surveyed human habitations were found to be invaded by at least one mosquito. All the species collected in the study area were reported as potential vectors in many other areas but in the present study, fortunately, the vectorial role of any of the species was not established. But with favourable microclimatic changes, any of them can be turned into potential vectors in the area and become a serious threat to public health. The epidemiological significance of mosquito diversity in the area should not be overlooked.

Keywords: diversity, mosquito, vector, mosquito-borne disease, Gushkara

Introduction
Mosquitoes are one of the deadliest animals in the world and can be designated as the public enemy no. 1 [1]. The notorious creature appeared on earth nearly 250 million years ago, today distributed almost throughout the world and established itself as the most important single family of insects that distress humans and other animals. Belonging to the family Culicidae under the order Diptera, mosquitoes possess more than 3619 species in 113 genera [2].

The term 'Mosquito' is believed to be derived from the Sanskrit term 'Masak' and in another opinion may be from the Spanish terms 'Mosca' & 'Ito'. The mosquitoes are mentioned as 'Macca' in Atharva Veda (1500 years B.C.) [3]. Adult females of most mosquito species are ectoparasites and feed on the blood of various vertebrates by piercing the skin. Blood protein is essential for the production of their eggs. With a negligible blood loss of the victim, the mosquito bite often causes an irritating rash from the saliva. But the real danger lies when the mosquitoes act as a vector for different diseases, transmitting pathogens/parasites during a blood meal. Vector species of mosquitos transmit hundreds of extremely harmful diseases including malaria, dengue, chikungunya, zika, yellow fever, filariasis, etc. Millions of people get affected and die by mosquito-transmitted diseases every year [4]. Mosquitoes are also a threat to other animals including livestock.

Globally, in terms of mosquito biodiversity India is ranked fifth [5]. 404 species of mosquitoes under 50 genera are recorded from India [6], and among them, about 31 species are recognized for transmitting various mosquito-borne diseases in humans [7]. Different species were reported to be vectors of different human diseases in different areas. Several research conducted on the environment-friendly control of the vectors [8, 9]. An acquaintance of mosquito fauna of any area will be useful to combat mosquito-borne diseases in that area and to formulate a control strategy. The species diversity of mosquitoes was studied in different areas [10-12]. But there has been a lack of such information from the Gushkara region of Purba Bardhaman district in West Bengal, India, and hence the present study was conducted to inspect the mosquito diversity from that area. This could be the first study of its kind from the area.

Materials and Methods
Study area
Gushkara is a municipal city in Purba Bardhaman district in West Bengal, India (23.50°N - 87.75°E). It stretched into an area of about 21 sq. KM with a population of more than 36 thousand. It is the business and marketing center for the local and the peoples of surrounding areas of several Kilometres. It is also a major gateway of transportation to several regions of the state. Thousands of people from different other villages and towns visit this city every day for various purposes. Nearly 3-4 thousand students came to Gushkara Mahavidyalaya to study. The typical tropical climatic condition of the city and several waterbodies with organic pollution may suit mosquito breeding and survival [13].

Sampling and Preservation
Adult mosquitoes were collected during 2018-19 by hand collection method, recommended by World Health Organization [14] and followed by many researchers with minor modifications [15-19]. Indoor resting mosquitoes were

collected from 24 human habitations (rooms) once a month in the morning (0600 - 0800 hours IST) for 10 minutes in each room by one collector. When identification was not done immediately after the collection, the mosquitoes were kept in cages with a 2% sucrose diet and the dead mosquitoes were preserved in 70% alcohol in plastic vials.

Identification

Mosquitoes were identified under a hand-lens or simple microscope using standard identification keys [3, 6].

Statistical Analysis

From the accumulated data Relative Abundance (RA), Per Man Hour Density (PMHD), and House Index (HI) of different species were calculated. Statistical analysis was done using MS Excel.

$$RA = \frac{\text{Total No. of Individual Species}}{\text{Total No. of All Species Population}} \times 100$$

$$PMHD = \frac{\text{Total No. of Individual Species}}{\text{Total Hour of Collection}}$$

$$HI = \frac{\text{No. of Positive House}}{\text{Total No. of House Surveyed}} \times 100$$

Table 1: Month-wise number of diverse mosquitoes caught at Gushkara, West Bengal, India

Species	Months												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Aedes albopictus			2	7	5	3	9	5	4	10	4	2	51
Anopheles annularis	1		2	1			1	2		1	3	2	13
Anopheles barbirostris	2	1	6	5	4	3	4	4	2	6	3	6	46
Anopheles subpictus	6	9	15	13	11	13	16	10	13	21	10	12	149
Armigeres subalbatus	65	66	69	59	66	70	84	88	57	77	70	75	846
Culex quinquefasciatus	14	17	25	37	30	20	18	19	42	42	28	14	306
Culex vishnui (group)	2	3	5	4	8	8	6	16	15	4	4	3	78
Mansonia annulifera	1		2	1		4	2	1	5		2		18
Total	91	96	126	127	124	121	140	145	138	161	124	114	1507

Table 2: Month-wise Relative Abundance (RA) of different species of mosquitoes in Gushkara

Species	Months												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Aedes albopictus	0.00	0.00	1.59	5.51	4.03	2.48	6.43	3.45	2.90	6.21	3.23	1.75	3.38
Anopheles annularis	1.10	0.00	1.59	0.79	0.00	0.00	0.71	1.38	0.00	0.62	2.42	1.75	0.86
Anopheles barbirostris	2.20	1.04	4.76	3.94	3.23	2.48	2.86	2.76	1.45	3.73	2.42	5.26	3.05
Anopheles subpictus	6.59	9.38	11.90	10.24	8.87	10.74	11.43	6.90	9.42	13.04	8.06	10.53	9.89
Armigeres subalbatus	71.43	68.75	54.76	46.46	53.23	57.85	60.00	60.69	41.30	47.83	56.45	65.79	56.14
Culex quinquefasciatus	15.38	17.71	19.84	29.13	24.19	16.53	12.86	13.10	30.43	26.09	22.58	12.28	20.31
Culex vishnui (group)	2.20	3.13	3.97	3.15	6.45	6.61	4.29	11.03	10.87	2.48	3.23	2.63	5.18
Mansonia annulifera	1.10	0.00	1.59	0.79	0.00	3.31	1.43	0.69	3.62	0.00	1.61	0.00	1.19
Overall	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 3: Month-wise Per Man Hour Density (PMHD) of different species of mosquitoes in Gushkara

Species	Months												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Aedes albopictus	0.00	0.00	0.50	1.75	1.25	0.75	2.25	1.25	1.00	2.50	1.00	0.50	1.06
Anopheles annularis	0.25	0.00	0.50	0.25	0.00	0.00	0.25	0.50	0.00	0.25	0.75	0.50	0.27
Anopheles barbirostris	0.50	0.25	1.50	1.25	1.00	0.75	1.00	1.00	0.50	1.50	0.75	1.50	0.96
Anopheles subpictus	1.50	2.25	3.75	3.25	2.75	3.25	4.00	2.50	3.25	5.25	2.50	3.00	3.10
Armigeres subalbatus	16.25	16.50	17.25	14.75	16.50	17.50	21.00	22.00	14.25	19.25	17.50	18.75	17.63
Culex quinquefasciatus	3.50	4.25	6.25	9.25	7.50	5.00	4.50	4.75	10.50	10.50	7.00	3.50	6.38
Culex vishnui (group)	0.50	0.75	1.25	1.00	2.00	2.00	1.50	4.00	3.75	1.00	1.00	0.75	1.63
Mansonia annulifera	0.25	0.00	0.50	0.25	0.00	1.00	0.50	0.25	1.25	0.00	0.50	0.00	0.38
All Species	22.75	24.00	31.50	31.75	31.00	30.25	35.00	36.25	34.50	40.25	31.00	28.50	31.40

Table 4: Month-wise House Index (HI) of different species of mosquitoes in Gushkara

Species	Months												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Aedes albopictus	0.00	0.00	8.33	20.83	12.50	12.50	25.00	16.67	16.67	29.17	12.50	4.17	13.19
Anopheles annularis	4.17	0.00	8.33	4.17	0.00	0.00	4.17	4.17	0.00	4.17	12.50	8.33	4.17
Anopheles barbirostris	8.33	4.17	16.67	16.67	8.33	8.33	16.67	12.50	8.33	16.67	12.50	20.83	12.50
Anopheles subpictus	16.67	25.00	45.83	37.50	29.17	37.50	45.83	33.33	33.33	62.50	25.00	37.50	35.76
Armigeres subalbatus	70.83	75.00	83.33	83.33	79.17	91.67	95.83	100	58.33	83.33	75.00	87.50	81.94
Culex quinquefasciatus	41.67	50.00	66.67	75.00	62.50	62.50	50.00	58.33	79.17	83.33	66.67	37.50	61.11
Culex vishnui (group)	8.33	8.33	20.83	12.50	20.83	25.00	16.67	45.83	41.67	16.67	8.33	8.33	19.44
Mansonia annulifera	4.17	0.00	4.17	4.17	0.00	16.67	4.17	4.17	20.83	0.00	8.33	0.00	5.56
All Species	75.00	79.17	91.67	95.83	91.67	87.50	91.67	100	100	100	83.33	83.33	89.93

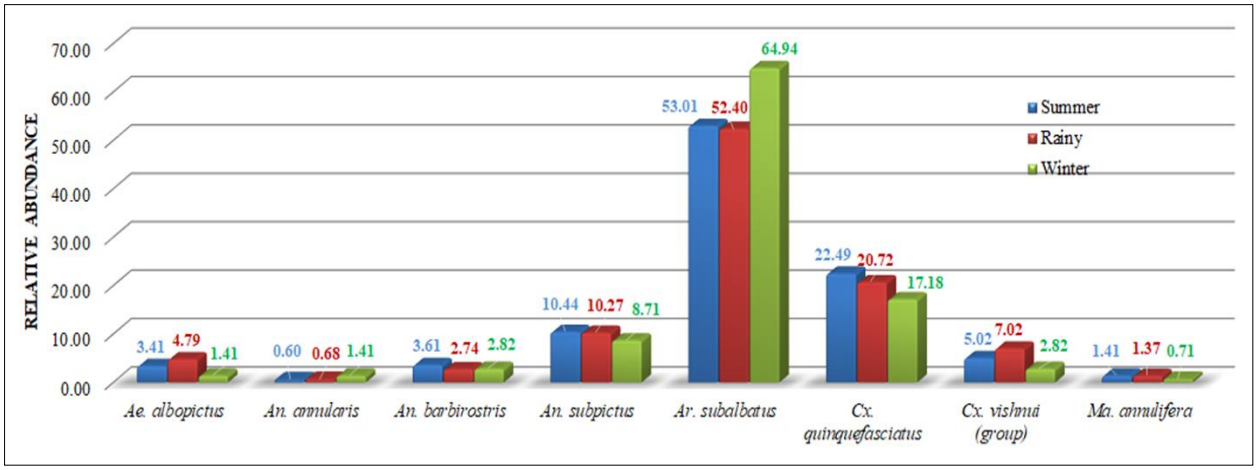

Fig 1: Seasonal variation of Relative Abundance (RA) of different species of mosquitoes in Gushkara

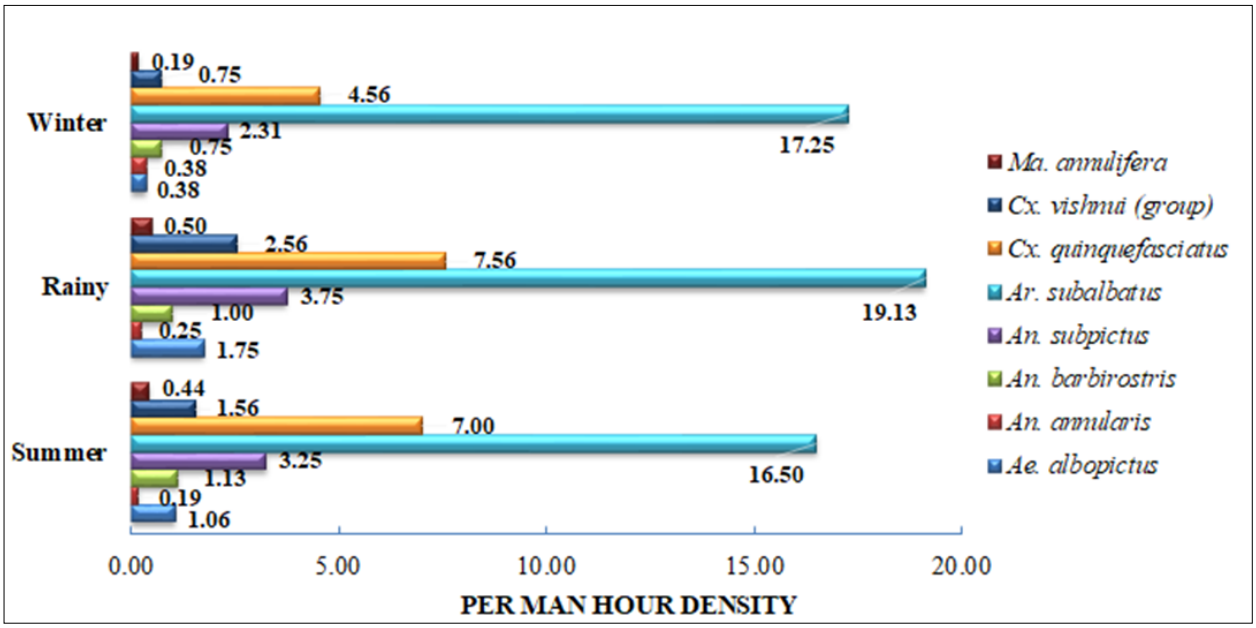

Fig 2: Seasonal variation of Per Man Hour Density (PMHD) of different species of mosquitoes in Gushkara

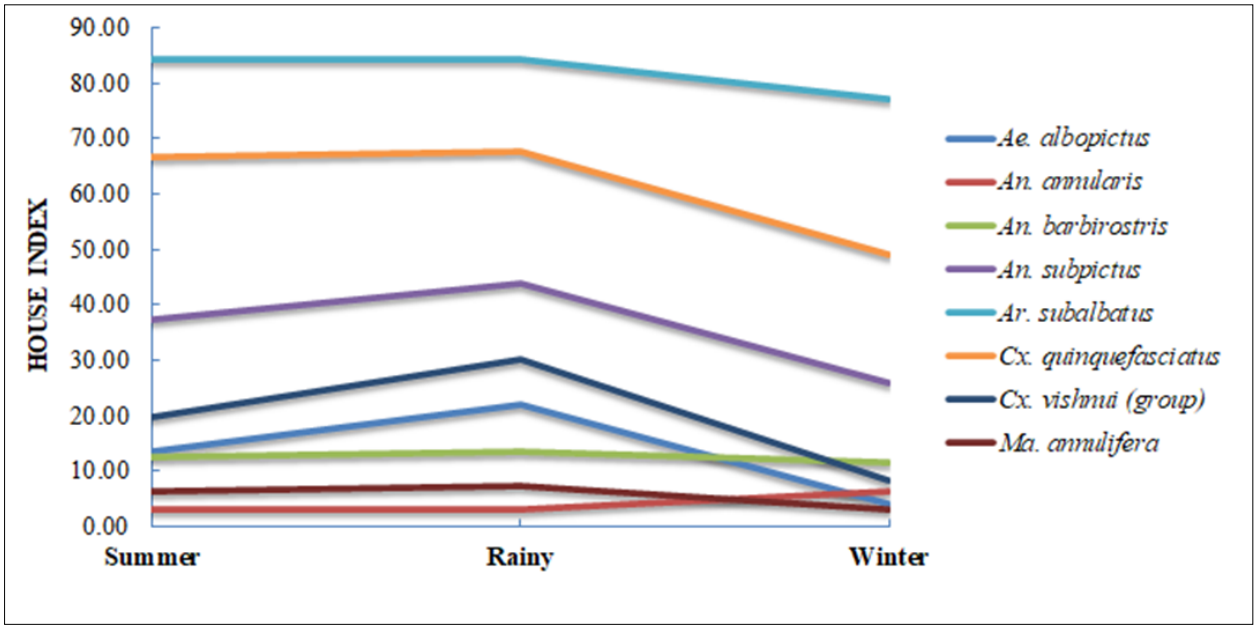

Fig 3: Seasonal variation of House Index (HI) of different species of mosquitoes in Gushkara

Results and Discussion

During the study period, a total of 1507 adult female indoor resting mosquitoes were collected from Gushkara of Purba Bardhaman district in West Bengal, India. Table 1-4 shows the month-wise diversity, RA, PMHD, and HI of mosquitoes in the area. Eight species of mosquitoes in five genera were caught: *Aedes albopictus*, *Anopheles annularis*, *Anopheles barbirostris*, *Anopheles subpictus*, *Armigeres subalbatus*, *Culex quinquefasciatus*, *Culex vishnui* (group) and *Mansonia annulifera*. The highest number collected was *Ar. subalbatus*, distantly followed by *Cx. quinquefasciatus* and *An. subpictus* (Table 1).

In terms of RA, *Ar. subalbatus* maintains the highest rank (56.14) throughout the year with the highest abundance in January (71.43) and the lowest in September (41.30). The second most abundant mosquito in the area was *Cx. quinquefasciatus* (20.31), with a peak in September (30.43) and a low in December (12.28). The third abundant mosquito was *An. subpictus* (9.89), with a peak in October (13.04) and a low in January (6.59) (Table 2). The difference in abundance between these three species was statistically significant ($P < 0.05$). The lowest abundant mosquitoes were *An. annularis* (0.86) and *Ma. annulifera* (1.19) with zero catch during some months.

Vector density in any area is usually measured by PMHD. During the study year on average 31.40 indoor resting mosquitoes were collected in one hour by one insect collector in the study area. PMHD of *Ar. subalbatus* was found to vary from 22.00 to 14.25 in different months with an average of 17.63. The density of *Cx. quinquefasciatus* during the year was 6.38, also maintaining a healthy density throughout the year, ranges 3.50 - 10.50 in different months. PMHD other species were recorded as 3.10 of *An. subpictus* (ranges 1.50 - 5.25), 1.63 of *Cx. vishnui* group (ranges 0.50 - 4.00), 1.06 of *Ae. albopictus* (ranges 0.00 - 2.50), 0.96 of *An. barbirostris* (ranges 0.25 - 1.50), 0.38 of *Ma. Annulifera* (ranges 0.00 - 1.25), and 0.27 of *An. annularis* (ranges 0.00 - 0.75) (Table 3).

HI is another important parameter that reveals the frequency of human shelters invaded by the vectors which may be directly related to the risk of vector-borne disease transmission in any area. Nearly 90% of the surveyed human habitations were found to be invaded by at least one mosquito. Higher HI was noticed for *Ar. subalbatus* 81.84 (58.33 - 100), followed by *Cx. quinquefasciatus* 61.11 (37.50 - 83.33), and *An. subpictus* 35.76 (16.67 - 62.50) with a statistically significant difference between them ($P < 0.05$). HI for other species was on the lower side as their RA and PMHD were also low (Table 4).

When the seasonal prevalence was analyzed, the highest number of mosquitoes were caught during the rainy season 584 (38.75%) followed by the summer 498 (33.05%), and the winter season 425 (28.20%). RA of 4 species *An. barbirostris*, *An. subpictus*, *Cx. quinquefasciatus*, and *Ma. annulifera* was comparatively higher in the summer; while in the case of *Ae. albopictus* and *Cx. vishnui* group it was higher during rainy; and in the case of *An. annularis* and *Ar. subalbatus* in the winter season (Figure 1). PMHD of 6 species out of 8 were higher in the rainy season with no significant seasonal variations (Figure 2). HI in the case of 7 species out of 8 was higher in the rainy season with marked seasonal variation in most cases (Figure 3).

Ae. albopictus (3.38% of the total catch in the study area) is known to transmit dengue and chikungunya in West Bengal. With these diseases, this vector also transmits yellow fever, zika, etc. in other parts of the world. West Bengal is a dengue-endemic state and *Ae. albopictus* plays the role of a secondary vector in rural and suburban areas [20]. *An. annularis* (0.86% of the total catch in the study area) is reported to transmit malaria in some areas of West Bengal and some other areas [21, 22]. *An. barbirostris* (3.05% of the total catch in the study area) is considered an important vector of malaria and brugian filariasis in a few parts of the world [23] but information on its role as a vector in West Bengal is scanty. *An. subpictus* (9.89% of the total catch in the study area) is incriminated as a vector of the malarial parasite in many parts of the world including West Bengal [23, 24]. *Ar. subalbatus* (56.14% of the total catch in the study area) has been reported to be a potential vector for filariasis, zika, and Japanese encephalitis, etc. in different areas of the world [25], but information on its potential as a vector in West Bengal is scanty [16]. *Cx. quinquefasciatus* (20.31% of the total catch in the study area) is an established vector for bancroftian filariasis in West Bengal [17, 26]. This species is also a potential vector of many arboviral, protozoic, and nematode diseases in other parts of the world [27]. *Cx. vishnui* (group) (5.18% of the total catch in the study area) is the primary vector of Japanese encephalitis in several areas of the world including West Bengal [28]. There are shreds of evidence of transmission of the West Nile virus through this species [29]. *Ma. annulifera* (1.19% of the total catch in the study area) was reported to be a vector of lymphatic filariasis in West Bengal and other places [30, 31].

No incidence of human parasites was noted in the mosquitoes caught during the study.

Conclusions

Mosquitoes becoming one of the biggest challenges to mankind. Every year millions of people suffer from the consequences of mosquito-borne diseases. To combat vector mosquitoes, public awareness and information on the mosquito population and their breeding habitats in any area is a prerequisite [10, 32, 33]. But the community perception of mosquitoes and mosquito-borne diseases is often very poor and as a result, the burden of vector-borne diseases is enhanced sometimes [34, 35]. In the present study area, 8 species of mosquitoes were recognized and all of them were reported as potential vectors in other areas including 6 species already documented as medically important in different districts of West Bengal. Monthly variation was notable in the case of some species but seasonal variation was not prominent, indicating a steady state of mosquito population in the area. Hopefully, the vectorial role of any of the species is not established in the present study. But any of them can turn into a potential vector in slight favourable microclimatic changes. Therefore, the epidemiological significance of the mosquito diversity in Gushkara area should not be overlooked.

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