OPEN ACCESS

Saudi Journal of Medical and Pharmaceutical Sciences
Abbreviated Key Title: Saudi J Med Pharm Sci
ISSN 2413-4929 (Print) | ISSN 2413-4910 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article | **Communicable Diseases Control**

Vector Bionomics of Anopheline Fauna in Malaria Endemic Areas (Three Sentinel Sites) of Bangladesh

Uddin, M. H[1*], Sohel, M. A[2], Islam, S[3], Rakibuzzaman, M[4], Sumon, S. I[5]

[1]Md Helal Uddin, Divisional Entomologist, Department of Communicable Diseases Control, Director General of Health Services, Dhaka, Bangladesh
[2]Dr. MM Aktaruzzaman Sohel, Assistant Director, PM Filariasis Elimination, STH, LD & National Kala-azar Elimination, CDC, DGHS, MOHFW, Dhaka, Bangladesh
[3]Dr. Md. Shafiqul Islam, Deputy Director, Communicable Disease Control, Directorate General of Health Services Mohakhali, Dhaka, Bangladesh
[4]Md. Rakibuzzaman, National Malaria Elimination and Aedes Transmitted Diseases Control Programme. CDC, DGHS, Mohakhali, Dhaka, Bangladesh
[5]Md. Sirajul Islam Sumon, Entomological Technician Communicable diseases control, Director General of Health Services, Mohakhali, Dhaka, Bangladesh

DOI: 10.36348/sjmps.2022.v09i01.004 | **Received:** 30.11.2022 | **Accepted:** 05.01.2023 | **Published:** 07.01.2023

***Corresponding author:** Uddin, M. H
Md Helal Uddin, Divisional Entomologist, Department of Communicable Diseases Control, Director General of Health Services, Dhaka, Bangladesh

Abstract

Background: The three Hill Tract Districts are highly malaria transmission areas in Bangladesh and intensified coverage of LLINs to reduce the number of malaria cases. Information of the bionomics of disease vectors and biting behavior is more essential to take appropriate vector control measures. The bionomics study was carried out after approximately 10 years back (2005-2006), if there any changes in vector behavior after introducing the long lasting insecticidal nets (LLINs) in malaria endemic areas. ***Method:*** Three sites were selected based on the number of last several years reported cases and malariogenic potentials including geographical condition, altitude, latitude, presence of vectors, availability of breeding sources, favorable temperature, humidity, rainfall and other possible risk factors. Mosquitoes were collected through the human and animal landing from outdoor and indoor, Pythrum Spray sheet collection, morning resting collection form human dwelling and cattle shed. ***Results:*** Mosquitoes were collected through the hand aspirator and Pyrethrum spray sheet collection during day and night time. A total of 8078 Anopheles mosquitoes, 20 specie were collected, out of that 3858 (47.76 %) are An. vagus is the most abundant followed by An. willmori 965 (11.95), An. nigerrimus 848 (10.50%), An. kochi 734 (9.09%), An. barbirostris 444 (5.50%), An. jamesii 367 (4.54 %), An. philippinensis 182 (2.25), A subpictus 163 (2.02%), An. annularis 135 (1.67%), the most virulent vector An baimaii 72(0.89), An culicifacies 51 (0.64%), An. minimus 26 (0.32%). ***Conclusion:*** The main malaria vectors A baimaii (=dirus) has been collected from 19.18 to 02.30 hrs and the pick biting period is identified 20.30 to 21.30 hrs and 21.30 to 22.30 The early biting of the An baimai indicate its behavioural changes. A vagus prevalence was higher among the collected anopheline populations in all three places.

Keywords: Anopheles mosquito; Vector Bionomics; biting period; host preference; *Anopheles baimaii; Anopheles vagus; Anopheles culicifacies*.

INTRODUCTION

Malaria is a public health problem in Bangladesh [1]. The disease is high endemic in the 13 border belt districts. These districts are in the east and north-east border facing international boundaries with the eastern states of India (Assam, Tripura and Meghalaya) and a small part of Myanmar [2]. The forested and hilly terrain has the geo-physical potentials for intense malaria transmission throughout the year [3]. Malaria focal outbreaks was reported every year from the eight epidemic prone districts previously lying in close proximity with the border areas, particularly due to the seasonal surge and tropical aggregation of labour forces to these areas. For the last few years there were hardly any reported outbreaks from malaria

endemic areas [4]. Anophelines were responsible for the transmission of malaria at the end of the nineteenth century; the discovery of DDT in 1940s was a major breakthrough in the control of vector- borne diseases [5]. Programme was largely successful and in some countries, it proved possible to interrupt or reduce the vector control activities. A programme started to reduce malaria incidence and prevalence introducing LLINs & ITNs from 2008, free of cost under the support of GFATM fund. After introducing the LLINs and ITNs, malaria transmission was reduced 50 to 60% or more in some upazilas in northern border belt areas or even in some upozila malaria cases were reduced up to pre-elimination indices [6].

Anophelines are one and only group of mosquitoes responsible for spreading malaria. For this early worker surveyed extensively for mosquitoes of the genus *Anopheles spp*. in India [7, 8] which covered areas of present-day Bangladesh. During Pakistani period, Entomologists again reviewed the anopheline records of the then West and East Pakistan [9]. Just before launching the Malaria Eradication Programme (MEP) in 1961, anopheline mosquitoes of the then 20 districts of Bangladesh were collected [10, 11]. There were 34 anopheline species recorded, out of these, seven species (spp.) are proven vector in Bangladesh. Among them, 4 spp. are primary vector namely *An. baimaii (dirus), An. philippinensis, An. minimus* and *An. sundaicus* and other three are *An. annularis, An. aconitus* and *An. vagus* are known as secondary vector (epidemic vector). In the 'Checklist of mosquitoes of Bangladesh, the last author exhaustedly reviewed all the works of earlier persons including himself [12]. There after a longitudinal cross sectional survey was conducted to collect information on anopheline mosquito fauna, their distribution and relative prevalence in 33 upazilas of 13 malaria endemic north eastern districts of Bangladesh, collection made from 2001 to 2009 yielded 29 species [13].

There is some sporadic entomological surveillance, but no in depth longitudinal entomological study to determine vectors behavior in changed ecological i.e.; deforestation, land utilization, Insecticidal Treated Nets (ITN) & introducing Long Lasting Insecticidal Nets (LLINs) and global warming whether any other mosquitoes are playing any role along with the old vectors or independently acting as vector [14, 15]. If so, we need to know the update bionomics of vectors and other anophelines, if any we are to know whether the existing vectors are behaving in the same manner or changing their habits in the changed ecological situation and global warming.

It is known that for taking any action against disease vectors, initially one should know about the mosquito fauna and their distribution in the country. Then they need to collect information on biology and bionomics of the mosquitoes. All such information will ultimately help to develop mosquito control strategy. There is apprehension that the present malaria control effort through use of long-lasting insecticidal nets (LLINs) may ultimately suffer due to non-availability of any base line information on mosquito fauna, their biology, bionomics and present vector status.

MATERIALS AND METHODS

Sites Selection:

The surveyed villages are selected based on the number of last several years reported cases and malariogenic potentials including geographical condition, altitude, latitude, presence of vectors, availability of breeding sources, favorable temperature, humidity, rainfall and other possible risk factors. The survey has conducted in the Rajbari and ShelerToya village of Lama Upazila under Bandarban Hill district, Jhorjhoripara and Moitribiharpara village of Rajashthali Upazila under Rangamati District, Gobidapur and Choitannagar village of Kalmakanda Upazila under Netrokona district.

Lama Upazila:

Lama is a hilly and forested zone. This upazila is bounded by Bandarban Sadar and Lohagara (Chittagong) upazila in the north, Naikhongchari and Alikadam upazila in the south, Ruma, Thanchi and Alikadam upazila in the east, Chakaria upazila in the west. There is 78488 populations in that upazila, among which 41693 are male and 36795 are female. The literacy rate is 30.4%. Male literacy rate is 36.4% and female is 23.5%. Main source of income is from agriculture 62.18%, commerce 10.82 and service 7.52%. The selected villages of this upazila are Rajbari and Sheler Toya.

Rajashthali:

Rajashthali is a hilly and forested zone. It is located between 22 17' and 22 26' north latitudes and between 92 06' and 92 22' east longitudes. This upazila is bounded on the north by Kaptai upazila on the East by Belaichari upazila, on the south by on the south by Bandar sadar and Roangchari upazila under Bandarban District and on the West by Rangunia upazila of Chittagong district. There is 26083 population in that upazila, among which 13595 are male and 12,488 are female. The literacy rate is 44.2%. Male literacy rate is 50.7% and female is 37.2%. The selected villages of this upazila are Rajbari and Sheler Toya.

Kalmakanda:

Kalmakanda is a foothill and plain boarder upazila with Meghalaya, India. The upazila occupies an area of 376.22 sq.km. It is located between 24°56´ and 25°11´ north latitudes and between 90°44´ and 90°58´ east longitudes. The upazila is bounded on the north by india, on the east by Dharmpasa upazila of Sunamganj zila, on the south by Barhatta and Netrokona sadar upazilas and on the west by Durgappur upazila. There is

2, 71,912 population in that upazila, among which 1,34,896 are male and 1,37,016 are female. The literacy rate is 36.6%. Male literacy rate is 37.9% and female is 35.3%. The selected villages of this upazila are Gobindapur and ChoitannoNagar.

Field sampling and processing of Mosquitoes: Human landing Collection:

Based on environmental situation and presence of Anopheles breeding sources Entomological Team has selected one human dwelling for human landing collection. Catches were made by four collectors; two collectors were seat in indoor and two were seat in outdoor for indoor and outdoor landing collection. Collectors were changed in every alternative hour for indoor and outdoor. Mosquitoes were caught through the exposed of leg and feet by hand aspirator and torch light. Mosquitoes were put into the paper cup and each paper cup was closed after one hour by double netting.

Indoor Resting Collection:

One collector was deputed to collect the Anopheles mosquitoes from indoor of human dwelling. Mosquitoes were collected for 15 minutes in each hour. Five minutes collection was continued in every 15 minutes interval. A total of 15 minutes collection was completed in each hour and paper cup was closed in each hour separately.

Cattle landing Collection:

One collector was collected the mosquitoes from the body of the cows by aspirator and torch light. A total of 15 minutes collection was made in each hour.

Pyrethrum Spray Sheet Collection:

Pyrethrum spray sheet collection was done in two house hold in each village. A total of four household were selected for each upazila for Spray sheet collection. X-pell and ACI Aerosol local brand (Allethrin and) were used as insecticide. Firstly, house was prepared for PSC and Pyretrum were sprayed for two to three minutes as per required. After spraying room were closed for 15 minutes and then collected the spray sheet. Mosquitoes were collected from the spray sheet by using hand sprayer and put into paper cup.

Laboratory Processing and Identification:

All mosquitoes collected from the field, bring to the field laboratory and give 10% glucose fed through the night. In the next morning the mosquitoes were killed by using chloroform and indentified through 20X and 30X hand lens.

RESULT

There were 20 different species of Anopheles mosquitoes collected in all, and 3858 (47.56%) of those were *An. vagus*, which is the most prevalent**.** Three sentinel sites were used to collect anopheline species throughout the year, but due to variations in temperature, humidity, rainfall, and other factors, the anopheline species densities changed. In all sites, Rajashthali (42.10%), Lama (57.24%), and Kolmakanda (40.16%) had the highest *An. vagus* densities. *An. baimii* gradually became more prevalent from February to May; the lading rate was greater in May. Due of the dense forest and ideal nesting grounds, the incidence is higher in Rajashthali, Rangamati. In three locations, *An. philippinensis* density was noticeably low in the study. The most virulent vector *An baimaii* was got more (66) in Rajashthali and very low (01) in Kolmakanda due their availability of habitats as this is known as dense forested mosquito. The prevalence was observed high for *An vagus* in May and August may be the early rain fall and short duration of winter season. In Kolmakanda, the density was determined in the month of February, March and July associated with the cultivation of irrigation and rainfall.

An. vagus was gathered from each of the three locations in our study and when compared to other places, Kolmakanda has a larger prevalence of *An vagus* in indoor resting than other mosquito-collecting areas.

Throughout the night, mosquitoes were gathered and the biting habits of *An. baimaii, An. philippinensis, An. vagus*, *An. maculates*, and *An. willmori* were observed. The peak biting time for *An. vagus* and *An. willmori* was reported to be early, usually between 18.30 and 19.30 hours. The most mosquitoes were captured in cases of *An baimaii* (=dairus) between 19.30 and 20.30 and 20.30 and 21.30. At 19.18, a bite from *An baimaii* was noticed for the first time. It was discovered that *An baimaii's* biting schedule had changed, possibly as a result of the distribution of LLINs and their hanging before bed.

Table-1: The percentage of collected Anopheline in three sites

Name	Percentage
An. vagus	47.76%
An. willmori	11.95%
An. nigerrimus	10.50
An. kochi	9.09%
An. jamesii	4.54%
An. philippinesis	2.25%
An. subpictus	2.02%
An. umbrosus	1.05%
An. baimaii	0.89%
An. culicifacies	0.64%
An. minimus	0.32%
An. maculatus	0.30%
An. hyrcanus	0.24%
An. karwari	0.19%
An. varuna	0.15%
An. pseudowillmori	0.09%
An. jeoporiensis	0.07%

Table-2: Monthly Prevalence of *Anopheles* species in Rajashthali, Rangamati District

	Rajosthali Upazilla, Rangamati - 2016											
Sl No	**Name of spp**	**Feb**	**March**	**April**	**May**	**June**	**July**	**August**	**Sep, oct, nov**	**Dec**	**Total**	**%**
1	*An.baimaii*	0	4	13	41	0	6	2	0	0	66	3.69
2	*An.minimus*	0	1	9	3	0	9	0	0	4	26	1.45
3	*An.philippinensis*	3	1	0	9	0	80	19	0	16	128	7.15
4	*An.annularis*	2	0	0	0	0	0	0	0	0	2	0.11
5	*An.vagus*	27	148	119	180	0	100	175	0	5	754	42.10
6	*An.maculatus*	5	1	3	0	0	0	1	0	1	11	0.61
7	*An.willmori*	60	45	20	34	0	142	43	0	8	352	19.65
8	*An.pseudowillmori*	0	2	4	0	0	0	0	0	0	6	0.34
9	*An.Jamesii*	16	4	2	44	0	118	52	0	12	248	13.85
10	*An.kochi*	30	11	0	7	0	12	9	0	10	79	4.41
11	*An.subpictus*	1	0	1	3	0	0	0	0	0	5	0.28
12	*An.karwari*	1	0	0	0	0	0	0	0	0	1	0.06
13	*An.jeyoporiensis*	17	3	1	7	0	15	4	0	11	58	3.24
14	*An.varuna*	3	0	0	0	0	0	1	0	0	4	0.22
15	*An.barbirostaris*	7	3	2	6	0	2	2	0	6	28	1.56
16	*An.nigerrimus*	0	1	3	2	0	1	0	0	0	7	0.39
17	*An.umbrosus*	3	7	1	0	0	0	0	0	0	11	0.61
18	*An.tessillatus*	0	0	1	0	0	0	0	0	0	1	0.06
19	*An.culicifacies*	0	0	0	4	0	0	0	0	0	4	0.22
Total	**19 Species**	175	231	179	340		485	308		73	**1791**	100

Table-3: Monthly Prevalence of Anopheles species in Lama, Bandarban District

	Lama Upazilla, Banderban – 2016											
Sl No	**Name of spp**	**Feb**	**March**	**April**	**May**	**June**	**July**	**August**	**Sep, oct, nov**	**Dec**	**Total**	**%**
	An.baimaii	0	0	1	1	0	0	1	0	2	5	0.15
	An.philippinensis	0	3	3	3	0	22	18	0	1	50	1.47
	An.annularis	0	0	0	1	0	0	0	0	0	1	0.03
	An.vagus	12	278	46	113	0	629	854	0	9	1941	57.24
	An.maculatus	5	1	0	3	0	0	1	0	0	10	0.29
	An.willmori	70	8	94	100	0	99	58	0	19	448	13.21
	An.pseudowillmori	0	0	0	0	0	0	1	0	0	1	0.03
	An.Jamesii	20	2	1	1	0	4	7	0	1	36	1.06
	An.kochi	8	2	0	0	0	2	25	0	31	68	2.01
	An.subpictus	0	11	19	24	0	42	17	0	1	114	3.36
	An.varuna	0	0	0	0	0	0	0	0	8	8	0.24
	An.barbirostaris	8	81	29	4	0	7	50	0	15	194	5.72
	An.nigerrimus	65	66	192	19	0	5	71	0	38	456	13.45
	An.umbrosus	0	4	1	1	0	6	12	0	2	26	0.77
	An.tessillatus	1	0	0	2	0	0	0	0	0	3	0.09
	An.culicifacies	0	0	25	5	0	0	0	0	0	30	0.88
Total	**16 Species**	189	456	590	617		816	1115		127	**3391**	

Table-4: Monthly Prevalence of Anopheles species in Kolmakanda, Netrokona District

	Kolmakanda upazilla, Netrokona 2016											
SI No	**Name of spp**	**Feb**	**March**	**April**	**May**	**June**	**July**	**August**	**Sep, oct, nov**	**Dec**	**Total**	**%**
1	*An.baimaii*	0	0	0	0	0	1	0	0	0	1	0.03
2	*An.philippinensis*	3	0	0	1	0	0	0	0	0	4	0.14
3	*An.annularis*	13	85	6	0	0	0	0	0	28	132	4.56
4	*An.vagus*	168	488	65	78	0	21	330	0	13	1163	40.16
5	*An.maculatus*	1	0	0	0	0	0	2	0	0	3	0.10
6	*An.willmori*	123	3	9	1	0	8	3	0	18	165	5.70
7	*An.pseudowillmori*	0	0	0	0	0	0	1	0	0	1	0.03
8	*An.Jamesii*	4	3	4	15	0	14	37	0	6	83	2.87
9	*An.kochi*	269	143	49	5	0	14	24	0	83	587	20.27
10	*An.subpictus*	0	7	7	4	0	0	26	0	0	44	1.52
11	*An.karwari*	0	0	1	4	0	8	2	0	0	15	0.52
12	*An.jeyoporiensis*	0	2	0	0	0	0	0	0	0	2	0.07
13	*An.barbirostaris*	106	19	22	34	0	9	24	0	8	222	7.67
14	*An.nigerrimus*	50	73	218	37	0	1	3	0	3	385	13.29
15	*An.umbrosus*	0	1	10	21	0	5	11	0	0	48	1.66
16	*An.tessillatus*	0	0	4	0	0	0	0	0	0	4	0.14
17	*An.culicifacies*	0	15	2	0	0	0	0	0	1	18	0.62
18	*An.hyrcanus*	0	0	19	0	0	0	0	0	0	19	0.66
Total	**18 Species**	737	839	416	200		81	463		160	**2896**	

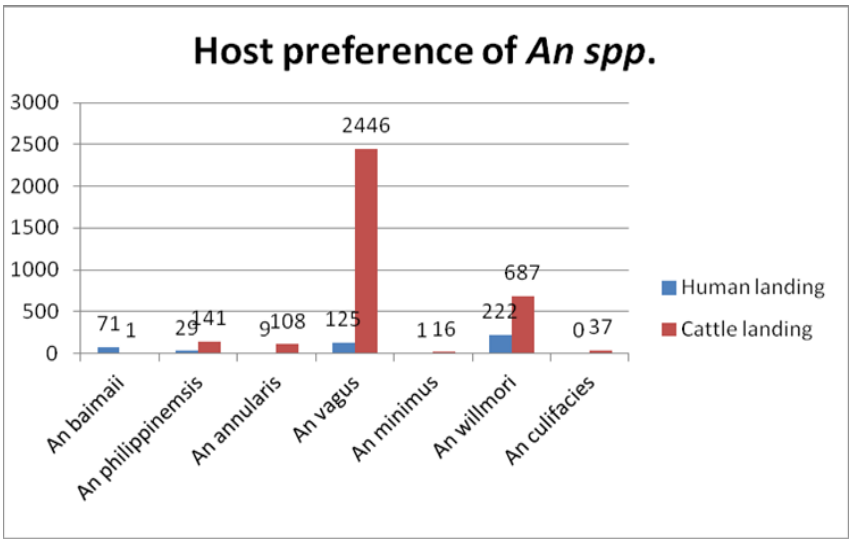

Fig-1: Host preference of *An baimaii* and other spp.

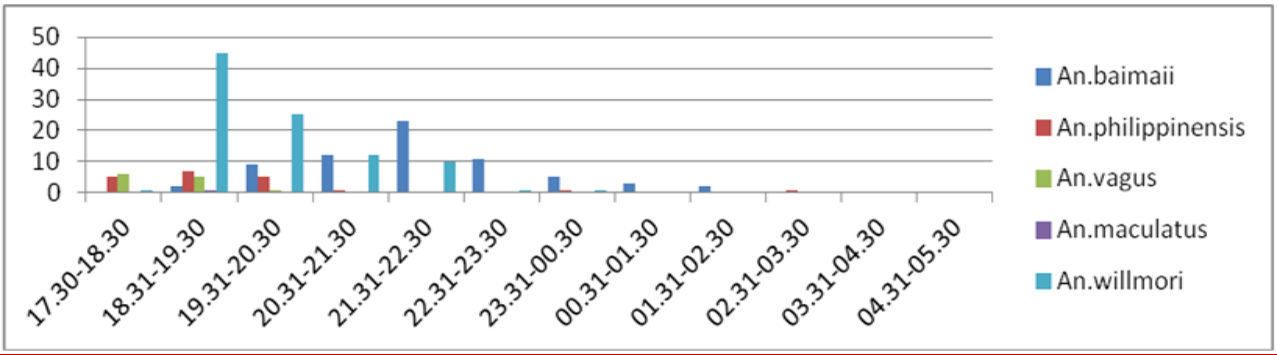

Fig-2: Biting behavior of *An. baimaii, An. vagus, An willmori* and *An. maculates in Rajashthali upazila, Rangamati.*

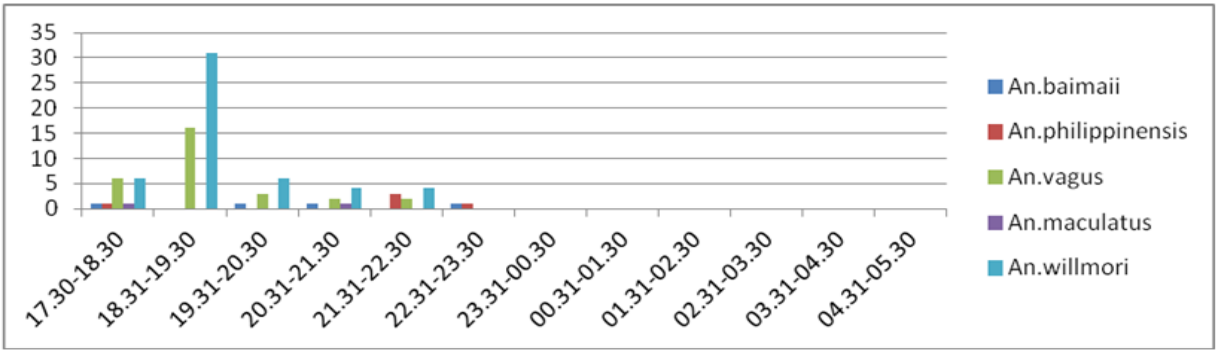

Fig-3: Biting behavior of *An.baimaii, An. vagus, An willmori* and *An. maculates in Lama upazila, Bandarban District*

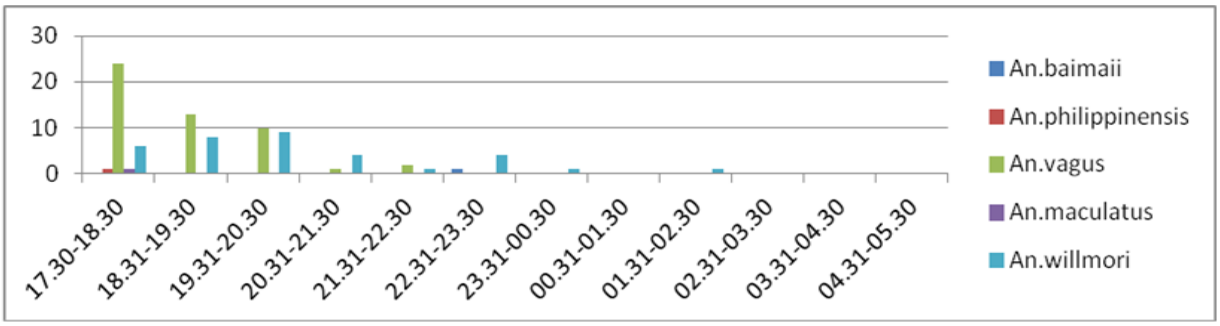

Fig-4: Biting behavior of *An.baimaii, An. vagus, An willmori* and *An. maculatus* in Kolmakanda upazila, Netrokona District

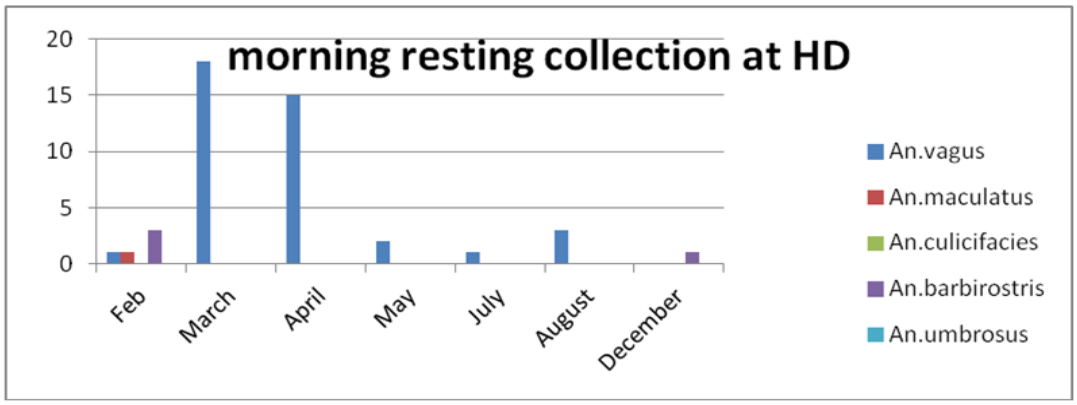

Fig-5: Resting behavior of *An. baimaii, An. vagus, An willmori* and *An. maculates in Rajashthali upazila, Rangamati*

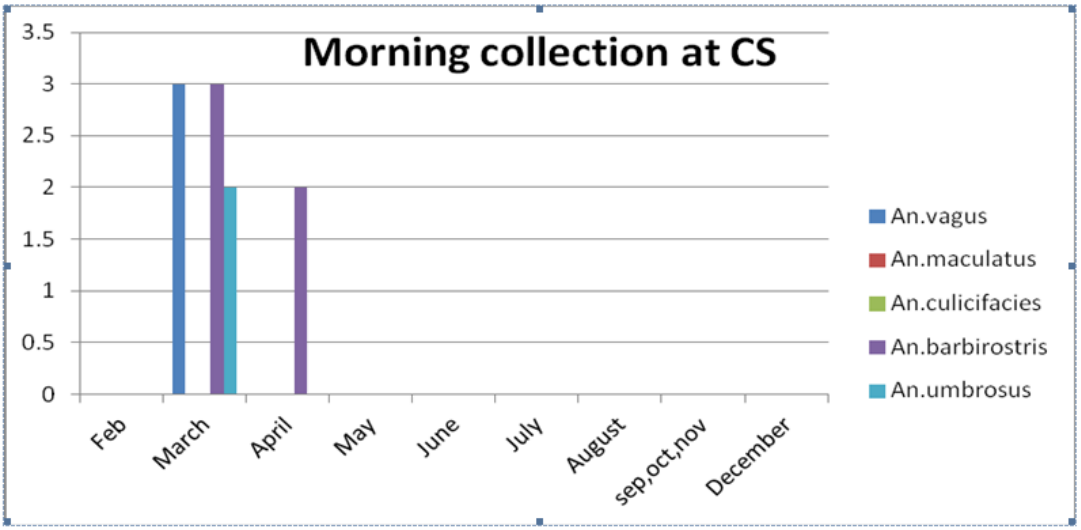

Fig-6: Resting behavior of *An. baimaii, An. vagus, An willmori* and *An. maculates in Rajashthali upazila, Rangamati*

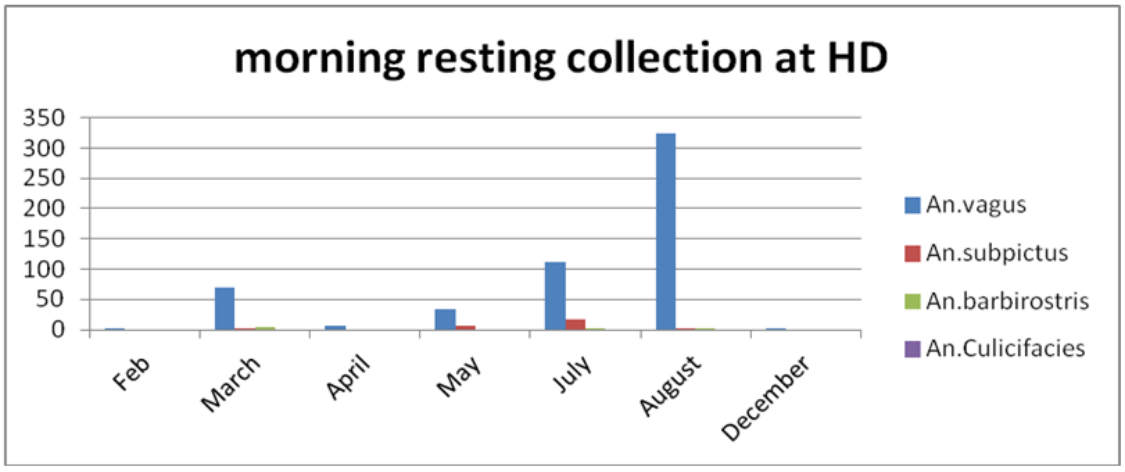

Fig-7: Resting behavior of *An.baimaii, An. vagus, An. willmori* and *An. maculates in Lama upazila, Bandarban District*

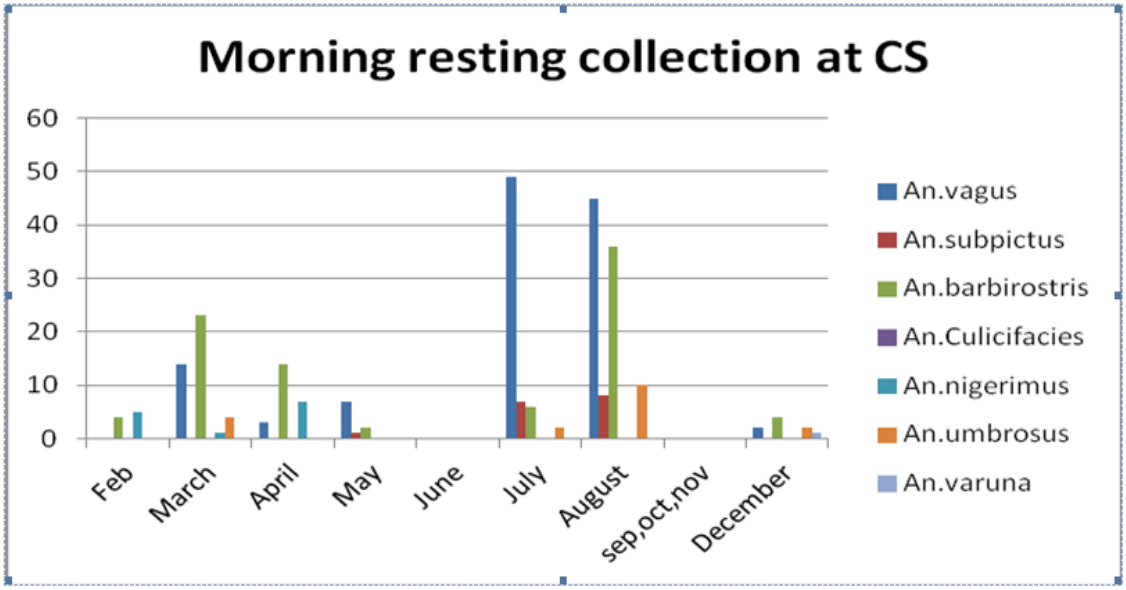

Fig-8: Resting behavior of *An.baimaii, An. vagus, An. willmori* and *An. maculates in Lama upazila, Bandarban District*

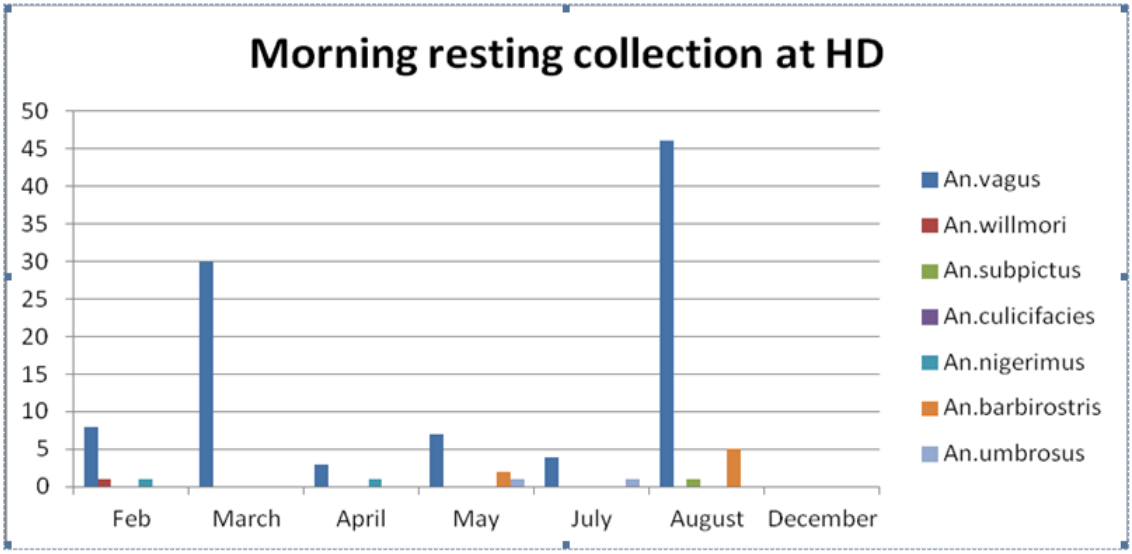

Fig-9: Resting behavior of *An.baimaii, An. vagus, An willmori* and *An. maculatus* in Kolmakanda upazila, Netrokona District

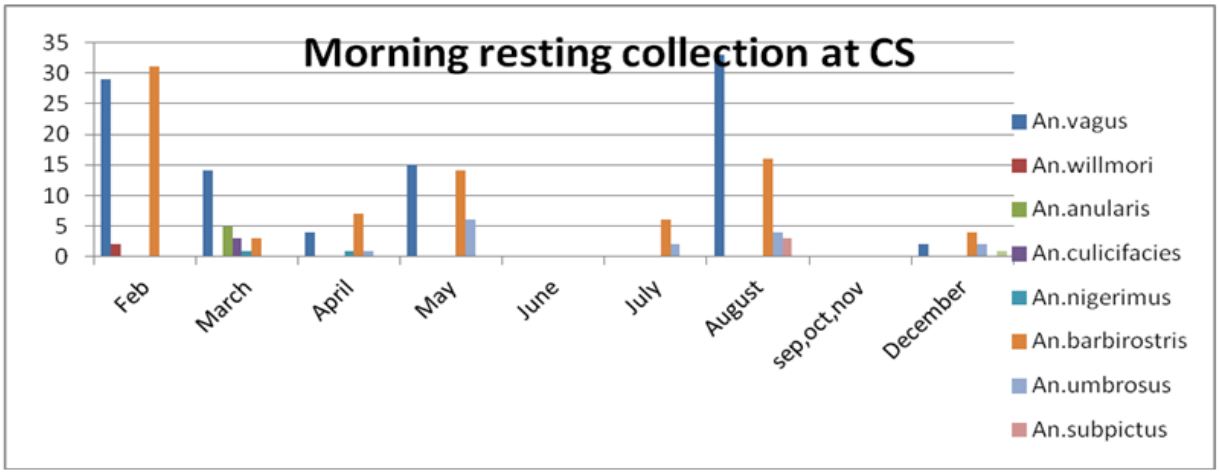

Fig-10: Resting behavior of *An.baimaii, An. vagus, An willmori* and *An. maculatus* in Kolmakanda upazila, Netrokona District

DISCUSSION

Vector/ Anopheline spp Prevalence/Abundance:

Entomological surveys were carried out in three malaria endemic area. A total of 8078 *Anopheles* mosquitoes, 20 specie were collected, out of that 3858 (47.76 %) are *An. vagus* is the most abundant followed by *An. willmori* 965 (11.95), *An. nigerrimus* 848 (10.50%), An. *kochi* 734 (9.09%), An. *barbirostris* 444 (5.50%), An. *jamesii* 367 (4.54 %), *An. philippinensis* 182 (2.25), A *subpictus* 163 (2.02%), An. *annularis* 135 (1.67%), the most virulent vector *A baimaii* 72(0.89), *A culicifacies* 51 (0.64%), *An. minimus* 26 (0.32%). The secondary vector *A vagus* prevalence is the highest, almost 50% of the total Anopheline species

Seasonal variation and vector Prevalence/Abundance:

Anopheline species were collected throughout the year in three sentinel sites but to varying of temperature, humidity, rainfall and some others factors, the density of anopheline species were varied. The density of *An vagus* was the highest in all sites Rajashthali 754(42.10%), Lama 1941 (57.24%) and Kolmakanda 1163 (40.16%), the suspected vector *An willmori* is the second highest prevalence 352 (19.65%) in Rajashthali and 488(13.21) in Lama due to availability their breeding sources. The highest number of *An. vagus* was recorded in July and August 629 & 854 respectively at Lama, Bandarban. The most virulent vector *A baimaii* was got more (66) in Rajashthali and very low (01) in Kolmakanda due their availability of habitats as this is known as dense forested mosquito. The prevalence was observed high for *A vagus* in May and August may be the early rain fall and short duration of winter season. In Kolmakanda, the density was determined in the month of February, March and July associated with the cultivation of irrigation and rainfall. Seasonal transmission pattern of malaria can varies even for geographical areas [16]. Experts in malaria prevention have surely continued to provide therapies in Africa that target indoor transmission. However, they accepted that significant funding for outdoor mosquito population control strategies is urgently required to maintain current levels of malaria control and further efforts toward malaria eradication [17-19].

Monthly outdoor human landing of *An. baimaii, An. philippinensis and An. vagus*:

Human landing collection for three sites, from February to May, the prevalence of *A baimii* is gradually increased and lading rate was higher in the month of May. There is only one *An. baimaii* was collected in Kolmakanda; Netrokona district may due to deforestation of the selected areas. The prevalence is higher in Rajashthali, Rangamati the presence of deep forest and its favourable breeding sites. *An. philippinensis* density was comparatively low in three sites. To drastically reduce indoor and outdoor resting vectors, integrated vector management (IVM) solutions with stakeholder involvement and community engagement are desirable [20].

Pyrethrum Spray Sheet collection

Pyrethrum Spray Sheet collection was done in three village during early in the morning. *An. vagus* was collected from all three places. The presence of *An vagus* in indoor resting in Kolmakanda is higher than other areas that relates to the total number of collected mosquitoes. *An. culicifacies*, the main malaria vector in west Bengal, India is re-emerging in the bordering districts and other areas also.

Host Preference

Mosquitoes were collected throughout the night from dusk to dawn by using human and cattle bait. In case of *A baimaii* 72 mosquitoes were collected, only one mosquito was collected from cattle shed on resting. These mosquitoes are highly anthropophillic. The another highly anthropophilic mosquito *An. minimus*, a total of 17 mosquitoes were collected, out of that 01 was collected from human bait and 16 were collected from cattle bait that indicate the mosquito are diverting from human to cattle, needs to further investigate. A good number of *An willmori* were collected from human bait. Compared to human bait,

cattle bait has a higher species variety [21]. It's possible that the widespread usage of IRS and ITNs for vector control has altered host-seeking behavior, changing the time or preferred location of host-seeking.

Resting behavior

The resting collection was made in the morning time to determine the resting behviour of the anopheline mosquitoes. In August there is high density of *A vagus* got in Lama, Bandarban and low in Rajshthali. The highest number (total eight species) of anopheles species was collected from cattle shed from Kolmakanda and lama and very few mainly *An vagus* was collected at morning resting collection human dwellin as well as cattle shed.

Biting behavior:

The biting behaviour of *An. baimaii, An. philippinensis, A vagus, an maculates and An. willmori* were observed and mosquitoes were collected throughout the night. It was observed that the peak biting period for An. vagus and *A willmori* was early within first 2 hours mostly 18.30–19.30 hrs. In case *A baimaii* (=*dairus*) the maximum number mosquitoes were collected during 19.30–20.30 and 20.30 to 21.30. The first bite for *An baimaii* was observed at 19.18. It was observed that the biting time for *A baimaii* has been changed, may be due to distribution of Long-Lasting Insecticidal Nets (LLINs) and hanging of LLIN before sleeping. In Earlier entomological study, it was observed that the biting period for *An. baimaii* was throughout the night but peak biting was 23.30 to 02.30 hrs. The density of *An willmori* was higher in Rajashthali & Lama due to their availability of breeding sources. Another study in Bangladesh [21] reported that diverse mosquito species have different biting habits at different times of the night. The amount of biting changes per month as well. After nightfall, Culex quinquefasciatus begins biting people; the density steadily rises until it reaches a peak between 2300 and 2400. [21] According to another study,in January, there was the lowest amount of outdoor biting. It began biting shortly after dusk and persisted through the night. The amount of biting was observed to increase to a peak at midnight and then progressively decline [22].

CONCLUSION

The current entomological study showed that the Primary and most virulent vector of malaria *An. baimaii* has changed their biting behaviour. The suspected vector An willmori also slightly chages their biting habit from 21.00 to 22.30 hrs to 18.30 to 19.30 hrs. The highly anthropophillic mosquito *An. minimus* were collected from cattle bait that indicate the species are converting to feed blood from human to animal. A good number of *An willmori* were collected by human landing that also indicates the mosquito species may playing the role in malaria transmission. The density of *An. vagus* is still higher in all three sentinel sites. *An. culicifacies*, the principal vector of west Bengal is re-emerging in the bordering upazila kolmakanda under Netrokona district and also other upazilas.

REFERENCE

1. Beier, J. C., Keating, J., Githure, J. I., Macdonald, M. B., Impoinvil, D. E., & Novak, R. J. (2008). Integrated vector management for malaria control. *Malaria journal*, *7*(1), 1-10.
2. Sarma, D. K., Mohapatra, P. K., Bhattacharyya, D. R., Chellappan, S., Karuppusamy, B., Barman, K., ... & Balabaskaran Nina, P. (2019). Malaria in North-East India: importance and implications in the era of elimination. *Microorganisms*, *7*(12), 673.
3. Alam, M. S., Khan, M. G. M., Chaudhury, N., Deloer, S., Nazib, F., Bangali, A. M., & Haque, R. (2010). Prevalence of anopheline species and their Plasmodium infection status in epidemic-prone border areas of Bangladesh. *Malaria journal*, *9*(1), 1-8.
4. World Health Organization. The technical basis for coordinated action against insecticide resistance: preserving the effectiveness of modern malaria vector control: meeting report.
5. Hiwat, H., Hardjopawiro, L. S., Takken, W., & Villegas, L. (2012). Novel strategies lead to pre-elimination of malaria in previously high-risk areas in Suriname, South America. *Malaria Journal*, *11*(1), 1-12.
6. Yang, G. G., Kim, D., Pham, A., & Paul, C. J. (2018). A meta-regression analysis of the effectiveness of mosquito nets for malaria control: the value of long-lasting insecticide nets. *International journal of environmental research and public health*, *15*(3), 546.
7. Covell, G. (1927). The Distribution of Anopheline Mosquitoes in India and Ceylon. *The Distribution of Anopheline Mosquitoes in India and Ceylon*, (5).
8. Christophers, S. R. (1933). The Fauna of British India, including Ceylon and Burma. Diptera. Vol. IV. Family Culicidae. Tribe Anophelini. The Fauna of British India, including Ceylon and Burma. Diptera. Vol. IV. Family Culicidae. Tribe Anophelini.
9. Quraishi, M. S., & Talibi, S. A. (1956). Anopheline mosquitoes of Pakistan, their distribution, ecology and relation to malaria. Govt of Pakistan Press, Karachi. *Health Bulletins*, *4*, 1-38.
10. Alam, M. S., Chakma, S., Khan, W. A., Glass, G. E., Mohon, A. N., Elahi, R., ... & Norris, D. E. (2012). Diversity of anopheline species and their Plasmodium infection status in rural Bandarban, Bangladesh. *Parasites & vectors*, *5*(1), 1-9.
11. Ahmedl, U. (1987). Checklist of the Mosquitos of Bangladesh. *Mosq Syst*, *19*.
12. Haque, U., Sunahara, T., Hashizume, M., Shields, T., Yamamoto, T., Haque, R., & Glass, G. E. (2011). Malaria prevalence, risk factors and spatial distribution in a hilly forest area of Bangladesh. *PLoS One*, *6*(4), e18908.

13. Okumu, F. O., & Moore, S. J. (2011). Combining indoor residual spraying and insecticide-treated nets for malaria control in Africa: a review of possible outcomes and an outline of suggestions for the future. *Malaria journal*, *10*(1), 1-13.
14. Alam, M. S., Chakma, S., Khan, W. A., Glass, G. E., Mohon, A. N., Elahi, R., ... & Norris, D. E. (2012). Diversity of anopheline species and their Plasmodium infection status in rural Bandarban, Bangladesh. *Parasites & vectors*, *5*(1), 1-9.
15. Okumu, F. O., & Moore, S. J. (2011). Combining indoor residual spraying and insecticide-treated nets for malaria control in Africa: a review of possible outcomes and an outline of suggestions for the future. *Malaria journal*, *10*(1), 1-13.
16. Briet, O. J. T. (2002). A simple method for calculating mosquito mortality rates, correcting for seasonal variations in recruitment. *Medical and Veterinary Entomology*, *16*(1), 22-27.
17. Govella, N. J., & Ferguson, H. (2012). Why use of interventions targeting outdoor biting mosquitoes will be necessary to achieve malaria elimination. *Frontiers in physiology*, *3*, 199.
18. Ferguson, H. M., Dornhaus, A., Beeche, A., Borgemeister, C., Gottlieb, M., Mulla, M. S., ... & Killeen, G. F. (2010). Ecology: a prerequisite for malaria elimination and eradication. *PLoS medicine*, *7*(8), e1000303.
19. Griffin, J. T., Hollingsworth, T. D., Okell, L. C., Churcher, T. S., White, M., Hinsley, W., ... & Ghani, A. C. (2010). Reducing Plasmodium falciparum malaria transmission in Africa: a model-based evaluation of intervention strategies. *PLoS medicine*, *7*(8), e1000324.
20. Mwangangi, J. M., Muturi, E. J., Muriu, S. M., Nzovu, J., Midega, J. T., & Mbogo, C. (2013). The role of Anopheles arabiensis and Anopheles coustani in indoor and outdoor malaria transmission in Taveta District, Kenya. *Parasites & vectors*, *6*(1), 1-9.
21. Bashar, K., Sarker, A., Asasuzzaman, M., Rahman, S., & Howlader, A. J. (2020). Host preference and nocturnal biting activity of mosquitoes collected in Dhaka, Bangladesh. *International Journal of Mosquito Research*, *7*(3), 1-8.
22. Ahmed, T., Maheswary, N. P., & Khan, N. I. (1986). Filariasis in Mirpur area of Dhaka city. *Bangladesh Medical Research Council Bulletin*, *12*(2), 83-94.