Project ID: 659

Competitive Research Grant

Sub-Project Completion Report

on

Assessment of the impact of climate change on arthropod vectors those transmitting vector borne diseases in Bangladesh

Project Duration

July 2017 to September 2018

Department Of Parasitology
Bangladesh Agricultural University
Mymensingh-2202

Submitted to
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Assessment of the impact of climate change on arthropod vectors those transmitting vector borne diseases in Bangladesh
Project Implementation Unit
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Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka – 1215
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Acknowledgement

The execution of CRG sub-project has successfully been completed by Department of Parasitology, Bangladesh Agricultural University using the research grant of USAID Trust Fund and GoB through Ministry of Agriculture. We would like to thanks to the World Bank for arranging the grant fund and supervising the CRGs by BARC. It is worthwhile to mention the cooperation and quick responses of PIU-BARC, NATP 2, in respect of field implementation of the sub-project in multiple sites. Preparing the project completion report required to contact a number of persons for collection of information and processing of research data. Without the help of those persons, the preparation of this document could not be made possible. All of them, who made it possible, deserve thanks. Our thanks are due to the Director PIU-BARC, NATP 2 and his team who have given their whole hearted support to prepare this document. We hope this publication would be helpful to the agricultural scientists of the country for designing their future research projects in order to technology generation which will help to predict future pattern of vectors and vector borne diseases (VBDs) and to develop sustainable vector and VBDs control programs in Bangladesh. It would also assist the policy makers for setting their future research directions.

Published in: September 2018

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Acronyms

Abbreviations	Full meaning
VBD	: Vector borne disease
BMD	: Bangladesh Meteorological Department
MoEFCC	: Ministry of Environment, Forests and Climate Change
GoB	: Government of Bangladesh
BDT	: Bangladesh Taka
WHO	: World Health Organization
IPCC	: International Panel for Climate Change
CCC	: Climate Change Cell
CDC	: Center for Disease Control
DNA	: Deoxyribo Nucleic Acid
RNA	: Ribo Nucleic Acid
SPSS	: Statistical Package for the Social Sciences
PCR	: Polymerase Chain Reaction
BAURES	: Bangladesh Agricultural University Research System
BARC	: Bangladesh Agricultural Research Council
CRG	: Competitive Research Grant
NATP	: National Agriculture Technology Program

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Executive Summary

Due to rising temperature and changing rainfall pattern, climate change is expected to have substantial effects on vector borne infectious diseases in developing countries like Bangladesh. This study was designed to recognize the trend of climate change, to identify the arthropod vectors with their seasonal distribution in Bangladesh, and to relate the effect of climate change on arthropod vectors in Bangladesh. Arthropods were collected from seven topographic zones (Gangetic aluvium, Brahmaputra alluvium, Tista silt basin, Madhupur tract, Barind tract, Coastal area and Hill tracts) of Bangladesh. Arthropods were identified under stereo microscope up to genus and species level. Molecular confirmation of some of the arthropod species was done by polymerase chain reaction (PCR). A total of 4789 ticks, 936 flies, 2096 lice, 17 fleas and 10997 mosquitoes were collected during July 2017 to June 2018. Among them five tick species, four lice species, four fly species, one flea species and thirteen mosquito species were identified. Fleas were collected only from Chokoria and Bandarban. The prevalence of the other four arthropod vectors (ticks, mosquitoes, lice and flies) were found in all the seven topographic zones studied but density for ticks was highest in Barind tracts (24%) followed by Coastal belt areas (18%) and Hill tracts areas (14.5%) with the lowest density in Madhupur tract areas (8.1%). Density for mosquitoes was highest in Coastal region (17.6%) with the lowest density in Madhupur hill tract areas (11.0%). The highest prevalence of lice was found in Tista silt basin (29.2%) and lowest in Barind tract (1.2%). Flies were found with the highest prevalence rate in Teesta silt basin (20.1%) and lowest in Madhupur hill tract (1.6%). Among the arthropod vectors identified, ticks and mosquitoes showed their pick in summer followed by monsoon. On the other hand, lice and flies were most prevalent in monsoon followed by summer. All the arthropods were found to have the lowest prevalence during winter. All the vectors had strong positive relation with temperature. Tick and mosquitoes had negative relation, whereas number of lice and flies showed positive relation with humidity. Almost all arthropods had a weak positive relation with the rainfall or precipitation. This information will help to predict the future pattern of vector borne disease occurrences due to climate change; and will help to develop early warning system and sustainable control measures against vectors and vector borne diseases in Bangladesh.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:**
   Assessment of the impact of climate change on arthropod vectors those transmitting vector borne diseases in Bangladesh

2. **Implementing organization:**
   Department of Parasitology, Faculty of Veterinary Science, Bangladesh Agricultural University

3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s):**

Principal Investigator:
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4. **Sub-project budget (Tk):**
   4.1 Total: 20,00,068 BDT
   4.2 Revised (if any): Not applicable

5. **Duration of the sub-project:**
   5.1 Start date (based on LoA signed) : 13 July, 2017
   5.2 End date : 30 September 2018

6. **Justification of undertaking the sub-project:**

Climate change is no longer a debate. The last century experienced a global average surface temperature increase by approximately 0.6°C and there is also change in the pattern of rainfall and humidity (WHO, 2003). Similar changes in the climate have also been experienced in Bangladesh (IPCC, 2007). The geographical location and geomorphological conditions of Bangladesh have made the country one of the most vulnerable ones to climate change (Sharmin, 2013). All the vector borne diseases (VBDs) are climate sensitive as the pathogens have to complete a part of their development in arthropod vectors (Patz et al, 2003). Arthropods are poikilothermic, so developmental period of their life cycle and development of pathogen in their body are affected by climatic conditions (Patzold and Seaman, 2006). Because of rising temperature and changing rainfall pattern, climate change is expected to have substantial effects on insect borne infectious diseases in developing countries like Bangladesh

(Alam, 2012). Global climate change can potentially increase the transmission of mosquito borne diseases such as dengue, chikunguniya, malaria, lymphatic filariasis, and dirofilariaisis in many parts of the world including Bangladesh (Ramasamy and Surendran, 2012; Rahman, 2014). In addition, leishmaniasis, stephanofilariasis and onchocerciasis are the major VBDs of Bangladesh transmitted by dipteran flies which will be affected by climate changes (Rahman, 2014). Dog flea/cat flea or dog lice acts as intermediate hosts of a tapeworm of dog, cat and human. Tick-borne diseases namely babesiosis, theileriasis and anaplasmosis are an increasing health burden in Bangladesh (Siddiki et al, 2010) and there is speculation that this is due to climate change affecting tick biology and disease transmission (Rahman, 2014). Prediction on VBDs is based on the effects of changing temperature, rainfall, and humidity on vector breeding and survival, the more rapid development of ingested pathogens in vectors and the more frequent blood feeds at moderately higher ambient temperatures (Patz et al, 2003). Higher temperature often changes in the abundance, the co-existence of vector species and distribution which cause the new emergence and spread of VBDs (Parham et al, 2015). Now the question is what proportion of this increased incidence of the diseases can be attributed to the effect climatic factors on vectors. To answer this question, at first it is necessary to determine the effect of climate variables (temperature, rainfall and humidity) on vector population. This information is required to mitigate the effects of climate change, including its potential impact on the global burden of vector-borne diseases and to develop sustainable control measures. Therefore this study was designed to assess the effect of climate variability on the presence, abundance and distribution of arthropod vectors those transmitting several important VBDs in Bangladesh.

7. Sub-project goal:

The ultimate goal of the project is to predict the future pattern of vector borne disease occurrences due to climate change; and to develop early warning system and sustainable control measures against vectors and VBD's in Bangladesh.

8. Sub-project objective (s):

i) To recognize the trend of climatic variables in Bangladesh by meteorological data
ii) To identify the arthropod vectors, and to determine their distribution in Bangladesh
iii) To assess the relationship between climate change and vectors in Bangladesh

9. **Implementing location (s):**

Department of Parasitology, Bangladesh Agricultural University

10. Methodology in brief:

10.1. To recognize the trend of climatic variables:

Approaches

The study was performed both at field and at laboratory. The arthropod samples were collected from field and were identified at the laboratory. The data were correlated with meteorological data and further analyzed to determine the impact of climate change on arthropod vectors.

Study area

The study areas were the major seven topographical zones viz. Gangetic Aluvium, Brahmaputra Alluvium, Tista Silt Basin, Madhupur Tract, Barind Tract, Coastal area and Hill Tract of Bangladesh. In the topographic zones, the sampling areas were selected in relation to the arthropod borne disease prevalence.

Collection of meteorological data

The meteorological data for 20 years (since 1998 to 2018) were collected from Bangladesh Meteorological Department (BMD) and from the Ministry of Environment, Forests and Climate Change (MoEFCC) of the Government of Bangladesh (GoB) to recognize the trend of climate change. The variables studied are maximum average temperature, average humidity and total annual rainfall. Simultaneously maximum, minimum and average temperature, average rainfall and average humidity of the seven topographical zones were collected to know the seasonal variation of the meteorological factors.

10.2. To determine the presence and distribution of arthropod vectors transmitting vector borne diseases:

Collection of arthropod vectors

The arthropod vectors were collected with appropriate collecting tools from different topographic zones. Insect net, CDC light trap and human bait were used to collect mosquitoes, sand flies and muscid flies from indoors and outdoors. Fleas and lice were collected by brush, forceps or manually from hosts and their beddings. Tick twister, forceps and some anesthetic agent were used to collect ticks from the animals.

Identification of arthropod vectors

Morphological identification of the arthropod vectors

All collected arthropods (mosquitoes, sand flies, muscid flies, fleas, lice and ticks) were studied first under stereomicroscope to identify up to genus level. Permanent slides of the arthropods were prepared, which were then examined under compound microscope to identify the species following the keys given by Barraud (1934), Bram (1967), Wall & Shearer (1997) and Soulsby (1982).

Molecular identification of the arthropods

DNA Extraction

DNA were extracted from freshly collected specimens (mosquitoes, sand flies, muscid flies, fleas, lice and ticks) or specimens stored in absolute alcohol using a commercial DNA Extraction Kit as instructed by the manufacturer. The DNA samples were evaluated quantitatively and qualitatively using spectrophotometer and agarose gel electrophoresis, respectively.

The primers

The primers targeting the ribosomal DNA (rDNA) genes as published (Table 1) were selected and used to generate fragments of DNA of the arthropods.

Polymerase Chain Reaction (PCR)

The extracted DNA was subjected to PCR using the set primers. The PCR were performed by a Thermocycler machine following the standard protocol.

Seasonal distribution of the arthropod

To study the effects of the seasons, the year was divided into summer or pre-monsoon (March-June), monsoon (July-October) and winter (November-February). The samples were collected from each topographical zone once in every two months of the year from July to June to cover a whole year. In each month 3 to 4 topographic zones were visited for arthropod collection.

Table 1: Primers used to generate fragments of DNA of the selected arthropods

Arhtropod	Genus/Species	Primers	Band size	References
Tick	Rhipicephalus Boophilus microplus (BM)	ITS2BMF -aggacacactgagcactgattc ITS2BMR -actgcgaagcactrgaccg	742 bp	Chitimia et al., 2009
Tick	Haemaphysalis bispinosa (HB)	ITS2HBF: cgagacttggtgtgaattgca ITS2HBR: tcccatacaccacatttcccg	1376 bp	Chitimia et al., 2009
Mosquito	Culex quinquefasciatus (CxQ)	ITS2CxQF: tgtgaactgcaggacacatgaa ITS2CxQR: atgcttaaattagggggtagtc	693 bp	Hettiaratchi et al., 2000
Mosquito	Anopheles quadrimaculatus (AnQ)	ITS2AnQF: gtgcgacacagctcgatg ITS2AnQR: ccg tag gag gctgcattt ta	321 bp	Cornel et al., 1996
Lice	Haematopinus quadripartusus (HQ)	16SHQF: ccggtttgaactcagatcatgt 16SHQR: ttacytwagggataacag	118 bp	Song et al., 2014
Fly	Stomoxys calcitrans (SC)	ITS2SCF: tgcttggactacatatggttga ITS2SCR: gtagtcccatatgagttgaggtt	376 bp	Bhakdeenuan et al., 2012

Calculation of density and distribution of the vectors:

Density of the species was calculated by the following formula: D= (l/L) x 100%.

Here, D= density, l= number of specimens of each vector species, L= number of all specimens.

The following density classes were accepted after Trojan (1992) with some modifications:
Satellite species (D < 1%), subdominant species (1< D <5%), dominant species (D > 5%)

Distribution of the species was calculated by the following formula: C= (n/N) x 100%
Here, C= Distribution, l= number of sites of the specimens, L= number of all sites

The following distribution classes were adopted from Dzieczkowski (1972):

C1= sporadic appearance (constancy 0- 20 %), C2= infrequent (20.1- 40%), C3= moderate (40.1 - 60%), C4= frequent (60.1- 80%), C5= constant (80.1-100%).

10.3. Assessment of the relationship between season, climate change and vectors in Bangladesh

Data of climate variables and vectors were analyzed with appropriate statistical analysis to relate the impact of climate change on disease vectors in Bangladesh.

Statistical analysis

Statistical analyses were done to correlate the climate variability (independent variable) with vector distribution (dependent variable). Statistical analyses were performed using JMP version 5.01 and SPSS version 16.0. Linear regression analyses were used to correlate the meteorological data (rainfall, temperature and humidity) with vector density and distribution.

11. Results and discussion:

11.1. Trend of climate change in Bangladesh:

From linear regression analysis it was found that maximum average temperature had increased during the 20 year time series from 1998 to 2018 though fluctuation of temperature was not sequential (Figure 1). Yearly average humidity had decreased from 1998 to 2018 (Figure 2). Rainfall did not follow any upward or downward trend in Bangladesh in last 20 years (Figure 3). The Intergovernmental Panel on Climate Change (IPCC) revealed an increase in world average temperature by 2100 within the range 1·4–5·8°C (IPCC, 2001).

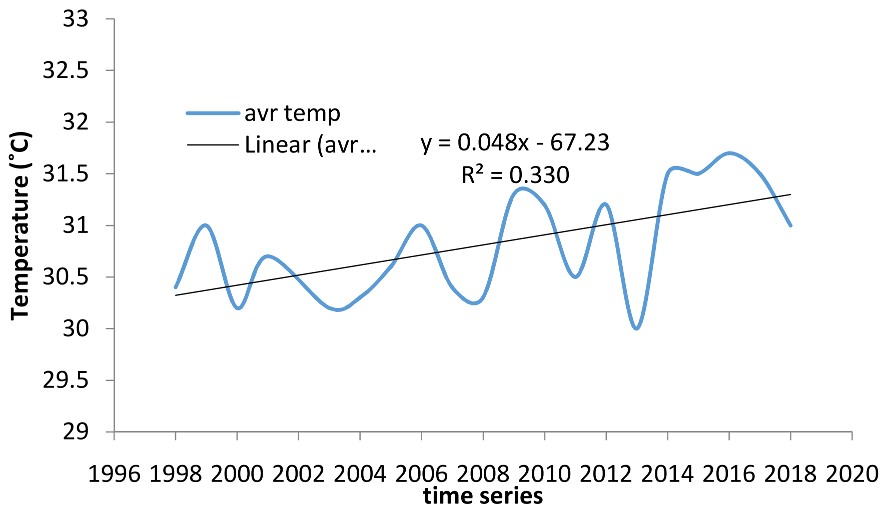


Figure 1: Linear relation between time series and maximum average temperature from 1998 to 2018

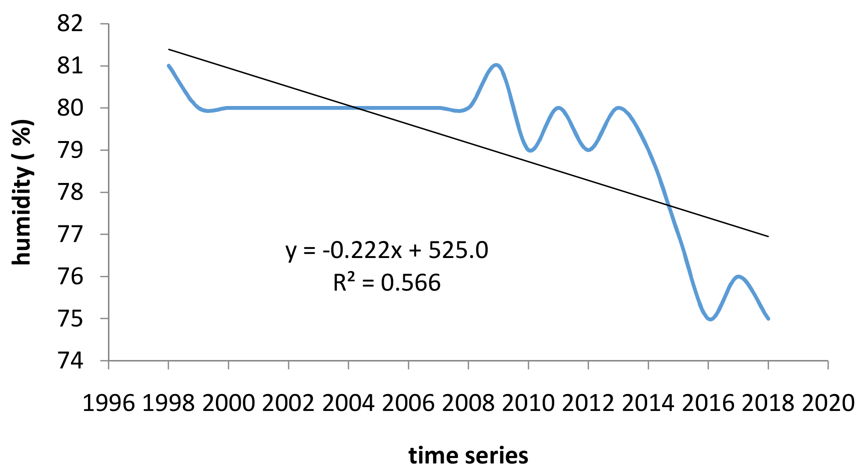


Figure 2: Linear relation between time series and average humidity from 1998 to 2018

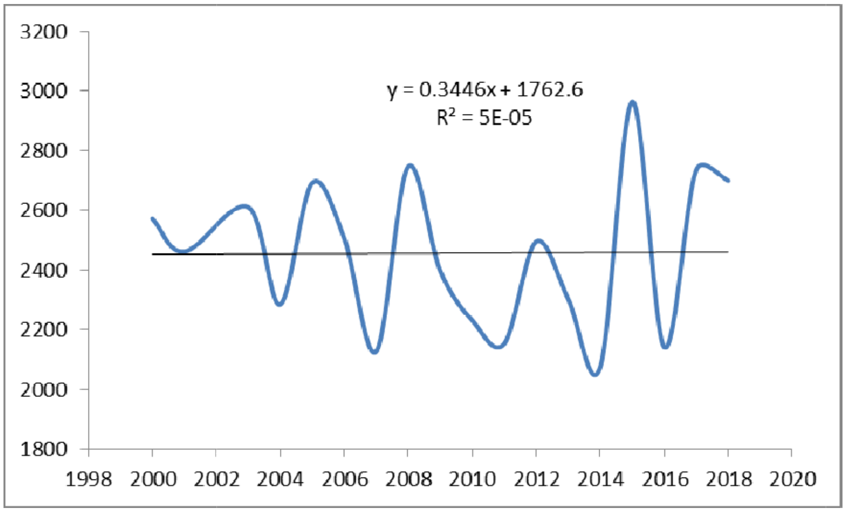


Figure 3: Linear relation between time series and total annual rainfall from 1998 to 2018

Seasonal variation of meteorological data

Monthly average temperature, humidity and outdoor rainfall of seven topographic zones of Bangladesh were collected from July 2017 to June 2018. The highest maximum temperature (38°C) was recorded in September 2017 in Lalmonirhat and lowest minimum temperature was recorded in January 2018 in Kushtia (8°C) (Figure 4). The humidity was found to be highest in September 2017 (87%) in Mymensingh and was the lowest (55%) in November in Kushtia (Figure 5). The highest rainfall (745 mm) was recorded in July 2017 in Chokoria and the lowest (2 mm) was recorded in December in Mymensingh, Madhupur and Lalmonirhat (Figure 6). No rainfall was recorded in January and February 2018.

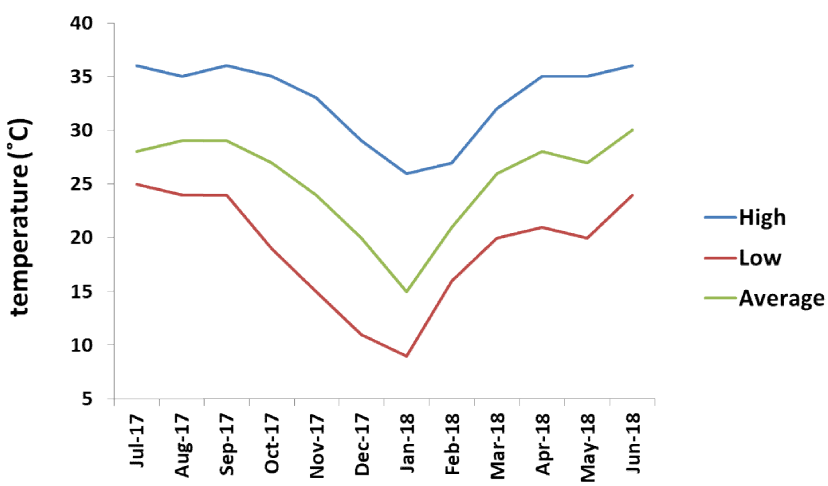


Figure 4: Graphical illustration of max, min. and average temperature from July 17 to June 18

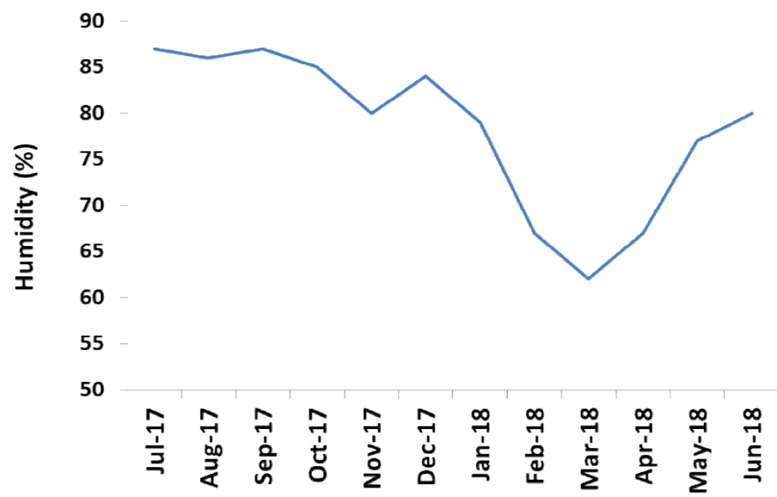


Figure 5: Graphical illustration of monthly humidity (%) from July 2017 to June 2018

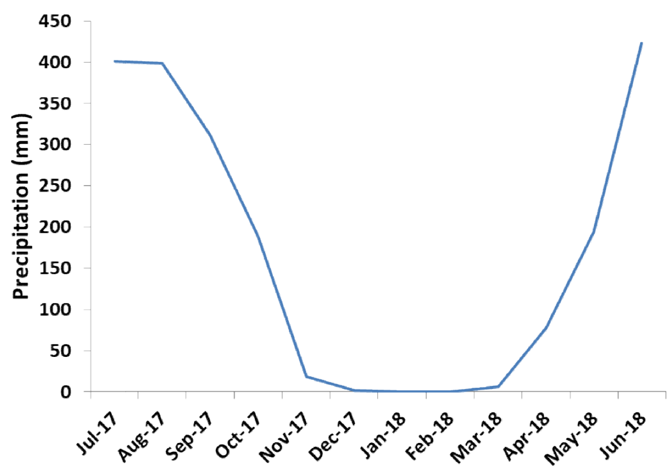


Figure 6: Graphical illustration of monthly average rainfall from July 2017 to June 2018

11.2. Identification of the arthropod vectors, and determination of their density and distribution

Ticks:

A total of 4789 ticks were collected from seven topographic zones of Bangladesh during the period of July 2017 to June 2018. Five species of ticks were identified (Figure 7). Only the two most dominant genera were confirmed with species e.g. *Rhipicephalus* (*Boophilus) microplus* and *Haemaphysalis bispinosa* by PCR (Figure 8). Among them, *Rhipicephalus* (*Boophilus) microplus* was the predominant species (68.9%), followed by other dominant species *Haemaphysalis* (29.4%), while *Rhipicephalus* sp. (1.4%) was the subdominant and *Hyalomma* sp. (0.3%) and *Amblyomma* sp. (0.2%) were the satellite species (Figure 9a). Considering the distribution of ticks throughout the country, *Boophilus microplus* (C=100%) and *Haemaphysalissp* (C=100%) were the constant species found in every places examined. *Rhipicephalus* sp. (C=57.1%) was a moderate species; and *Amblyomma* sp. (14.2%) and *Hyalomma* sp. (C=14.2%) were sporadic species which were restricted in Hill tract and Barind tract, respectively. Among the seven topographic zones, ticks were found in all the areas studied but density was highest in Barind tract (24%) and was the lowest in Madhupur hill tract (8.1%), as shown in Figure 9b. More than a dozen of tick species have so far been recorded from Bangladesh that are infesting cattle, goat, sheep, dog, wild mammals, birds, and lizards (Rahman and Mondal 1985). The cattle tick, *B. microplus* is predominant, followed by *Haemaphysalis bispinosa, Hyalomma truncatum and H. anatolicum*. Islam et al. (2006) investigated the distribution, host preference, and population density of ixodid ticks in Bangladesh and found that in three distinct topographic zones, viz. flood plains, hills, and steppe 'Barind,' five species of ixodid ticks were recorded namely, *B. microplus* (56.3%), *H. bispinosa* (11.3%), *R. sanguineus* (14.7%), *H. anatolicum anatolicum* (15.0%), and *Amblyomma testudinarium* (2.8%). The distribution of *H. anatolicum anatolicum* was restricted to the steppe 'Barind Tract' and *A. testudinarium* was found in the hilly regions only (Mondal et al. 1995) which is same as the present study.

During the 1 year study, the prevalence of ticks were highest in summer (53.2%) followed by Monsoon (27.9%) and were the lowest in winter (18.9%), as shown in Figure 10. Similar findings were reported by Ghosh e al., 2007. They found seasonal occurance of *B. microplus* to variy with the tick load; it was found that in the month of May, the tick load is increased because of the availability of favorable environmental conditions in April thus favoring embryonic development and increased larval activity for infestation of cattle. Heavy rainfall in June causes sharp decreases in tick load because of physical injury or the washing away of larvae. Rainfall in August creates suitable conditions for larval activity leading to a rise of load in September. Other possible factors for this bimodal peak could be loss of body vigor of cattle because of shortage of food and stress conditions in the winter and rainy season.

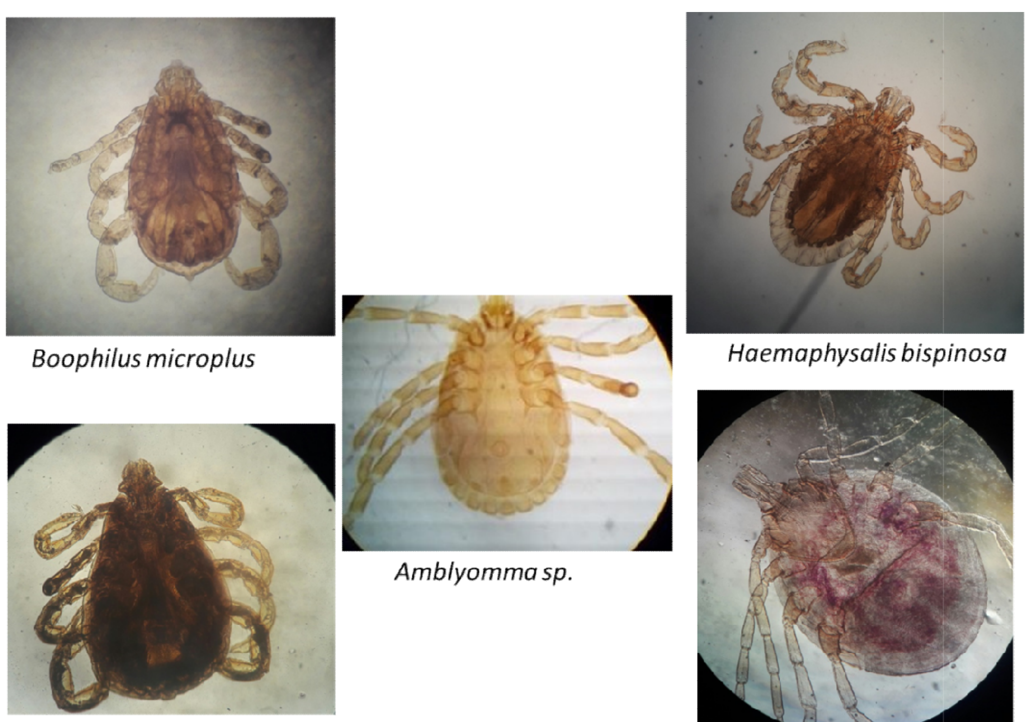


Figure 7: Identified tick species from seven topographic zones of Bangladesh

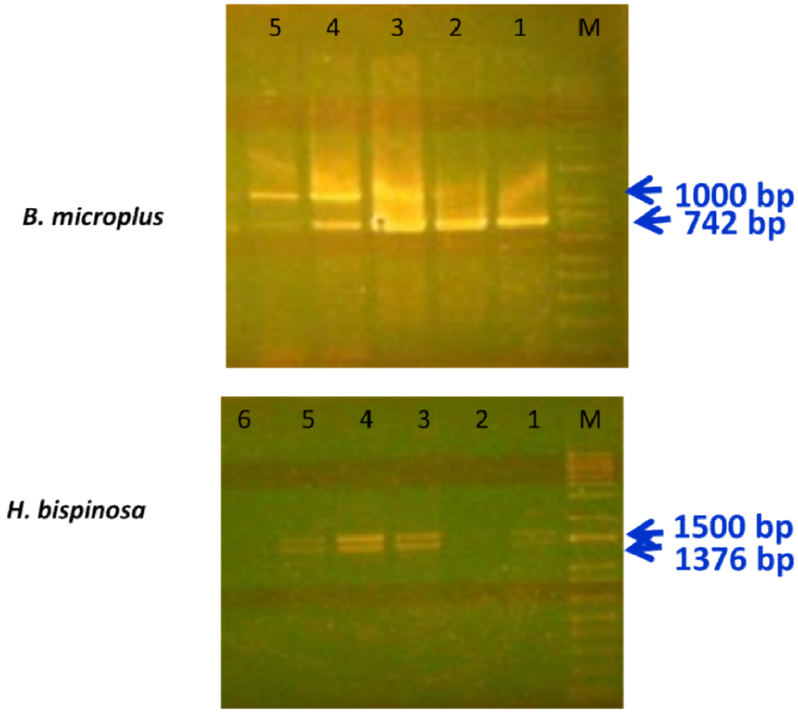


Figure 8: Agarose gel electrophoresis of amplified DNA from *B. microplus* and *H. bispinosa*
Lane 1, 2, 3, 4= B. microplus; M= marker and H. bispinosa= lane 1, 3, 4, 5; lane 6= negative control; M= marker

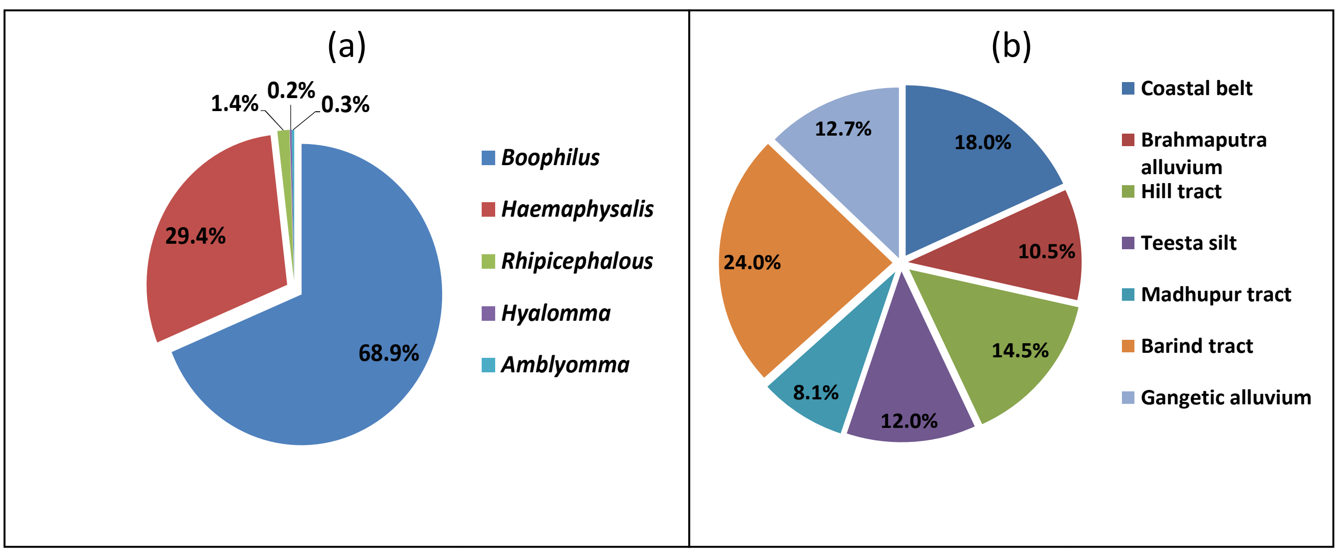


Figure 9: Density of different species of ticks (a); Density of ticks in 7 topographic zones (b)

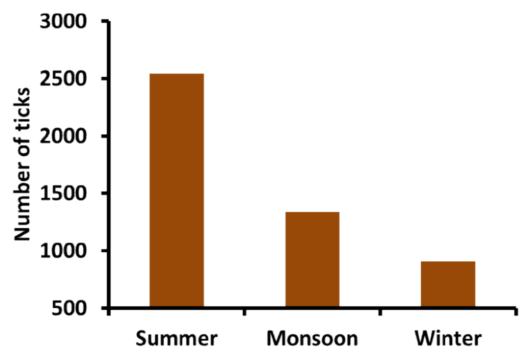
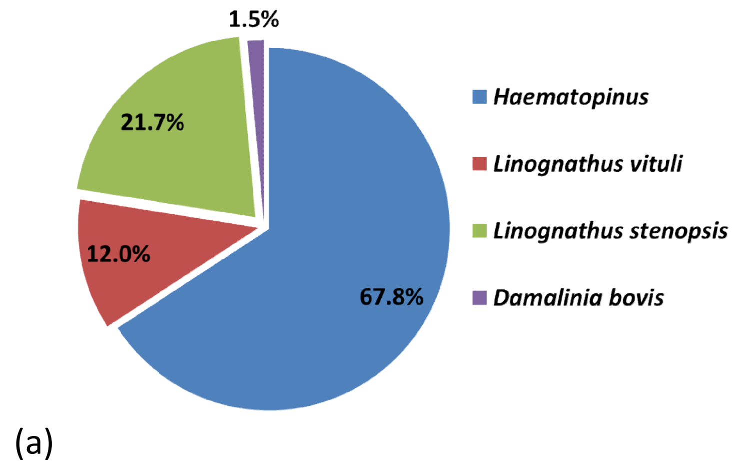


Figure 10: Seasonal prevalence of ticks

Lice:

Four lice species were identified out of 2096 samples those were collected from seven topographic zones (Figure 11). *Haematopinus* sp. was the predominant species with highest prevalence rate (67.8%). *Linognathus stenopsis* and *Linognathus vituli* were the other two dominant species (21.7% and 12.0%, respectively), whereas *Damaliniabovis (*1.5%) was the subdominant class (Figure 12a). *Haematopinus* sp. (C=85.7%) were the constant species found in 6 soil tracts while *Linognathus stenopsis* (C=71.4%) was a frequent species, *Linognathus vituli* and *Damalinia bovis* (28.6%) were the infrequent species. The highest prevalence of lice was found in Tista silt basin (29.2%) and was the lowest in Barind tract (1.2%), as shown in (Figure 12b). Bilkis et al (2013) found only single species *Haematopinus eurysternus* of lice from cattle of Bogura district and the prevalence rate was 23.2%. Musa et al. (2018) recorded one species of lice *Linognathus vituli* from cattle of Jessore with prevalence of 30%. This difference in result may be due to different collection procedure and geographical variation. The prevalence of lice were highest in monsoon (54.3 %) followed by summer (28.8%) and lowest in winter (16.9%), as shown in (Figure 13).

Figure 11: Identified lice species from seven topographic zones of Bangladesh



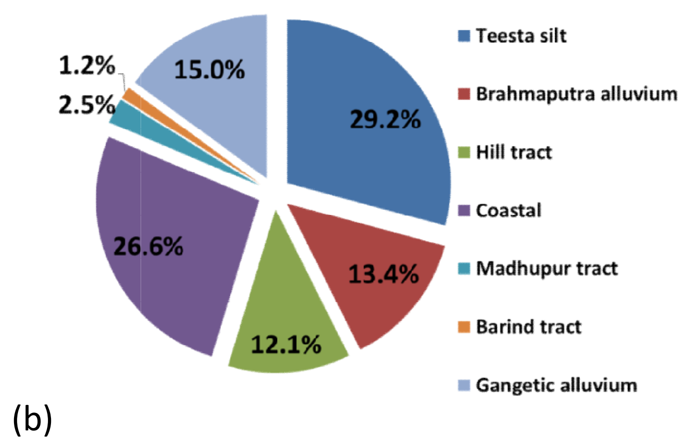


Figure 12: Density of different species of lice (a); Density of lice in 7 topographic zones (b)

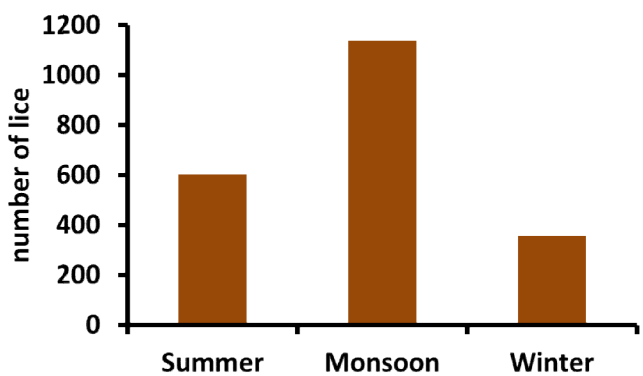


Figure 13: Seasonal prevalence of lice

Fly:

A total of 936 flies were collected of which four species were identified (Figure 14). Only *Stomoxys calcitrans* was amplified with the set primer (Figure 15). Among them, *Stomoxys calcitrans* was the predominant species (55.7%) followed by *Tabanus striatus* (26.4%) and *Pseudolynchiacanariensis* sp.

(14.9%), while *Phlebotomus* sp. (3.1%) were the subdominant species (Figure 16a). *Tabanus striatus* (C=85.7%) were the constant species found in 6 ecological zones and *Stomoxys calcitrans* (C=71.4%) was the frequent species. *Phlebotomus species* (sand flies) (14.2%) and *Pseudolynchiacanariensis* (C=14.2%) were sporadic species which were restricted in Brahmaputra alluvium and Barind tract, respectively. Among the seven topographic zones, flies were found most prevalent in Teesta silt basin (20.1%) and lowest number of flies was collected from animals in Madhupur hill tract (1.6%), as shown in (Figure 16b). Flies were found highest in Monsoon (46.9%) followed by summer (34.3%) and were the lowest in winter (18.8%) during the 12 month study (Figure 17). There is scarcity of published literature on the prevalence and seasonal density of flies.

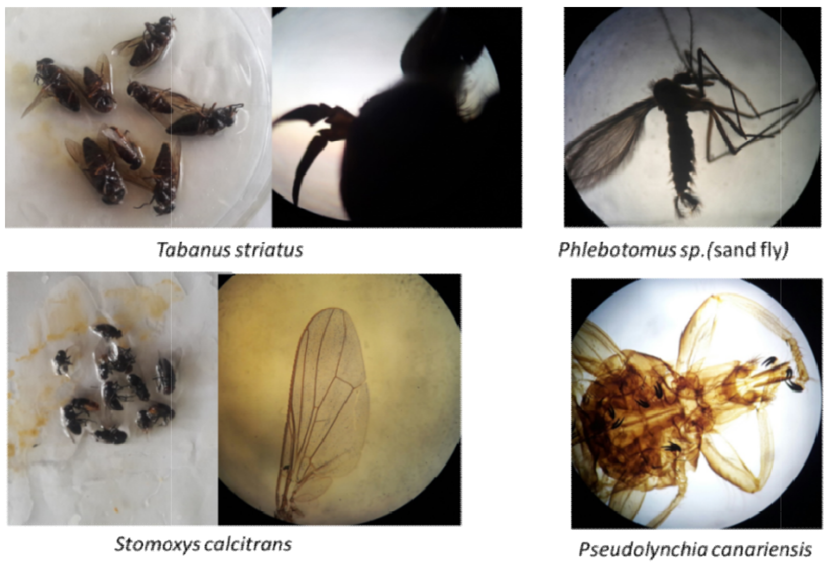


Figure 14: Identified fly species from seven topographic zones of Bangladesh

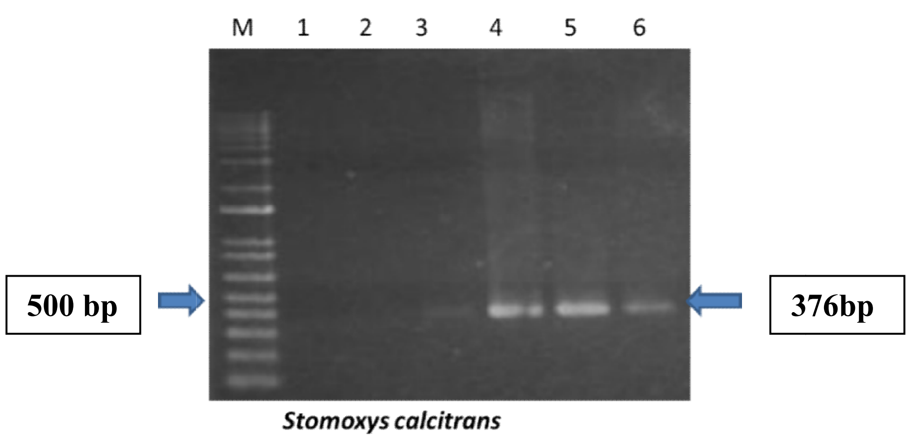
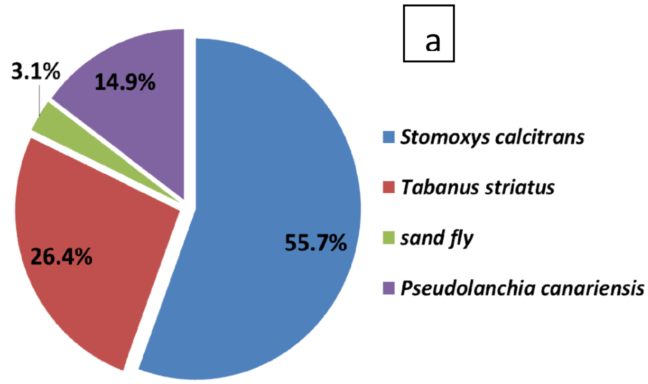


Figure 15: Agarose gel electrophoresis of amplified DNA from *S. calcitrans*
Positive samples lane= 3, 4, 5, 6; negative control= 1, 2 and M= marker



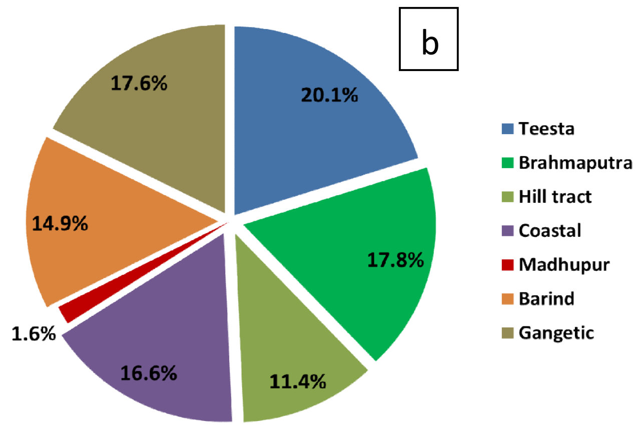


Figure 16: Density of different species of flies (a); Density of flies in 7 topographic zones (b)

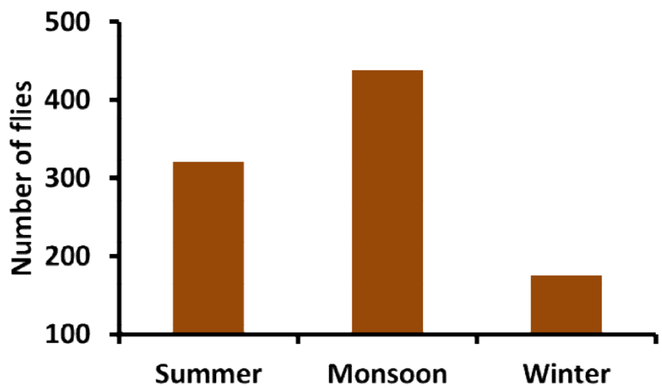
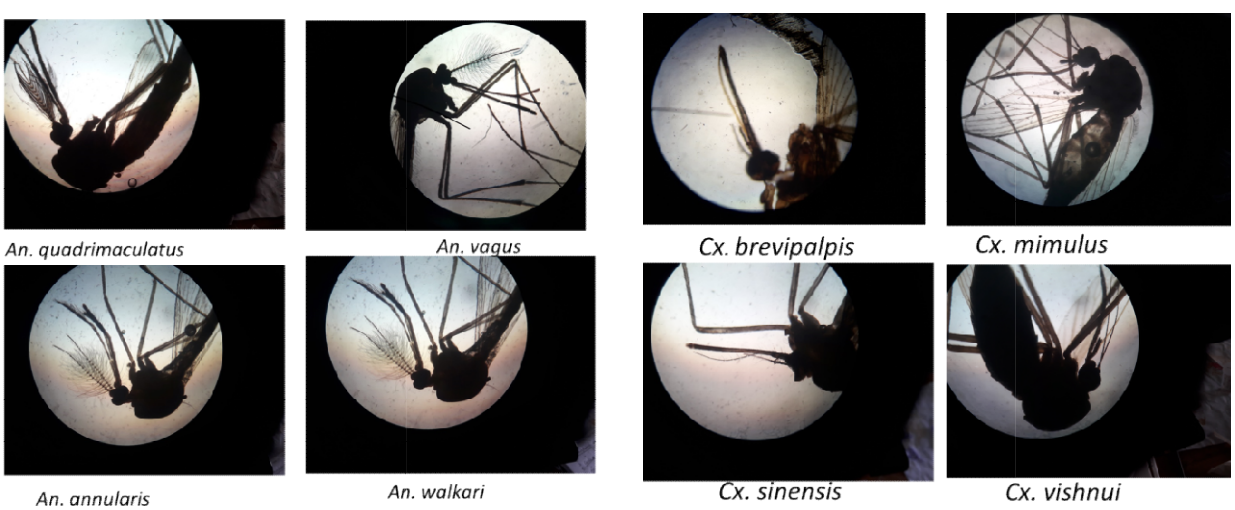


Figure 17: Seasonal prevalence of flies

Mosquitoes:

A total of 10997 adult mosquitoes were collected from different topographic zones of Bangladesh during the period of July 2017 to June 2018. All the collected mosquitoes were belonged to the family culicidae. Among the collected mosquitoes, thirteen species of three genera were identified (Figure 18). The identified three genera were *Anopheles, Culex* and *Aedes*. Species specific and regional densities of mosquitoes are shown in Figure 19a and 19b. Of the collected mosquitoes, *Culex* (70.0%) was dominating over *Anopheles* (29.2%) and *Aedes* (0.8%), and females (68.7%) were more prevalent than males (31.3%). Out of thirteen species, *Cx. quinquefasciatus* (41.2%) was the most predominant species followed by *An. quadrimaculatus* (20.3%), *Cx. fuscanus* (15.5%) and *An. vagus* (9.4%). Six mosquito species, viz. *Cx. tritaeniorhynchus* (4.1%), *An. walkari* (2.2%), *Cx. fuscocephala* (1.6%), *Cx. mimulus* (1.6%), *Ae. albopictus* (1.6%), *An. annularis* (1.5%) and *Cx. Sinensis* (1.4%), were the subdominant species; whereas *Cx. sinensis* (0.6%), *Cx. vishnui* (0.3%) and *Cx. brevipalpis* (0.1%) were the satellite species (Figure 19a). *Culex quenquifasciatus* and *An. quadrimaculatus* were the constant (C=100%) species found in every topographic zone while *Cx. brevipalpis* and *Ae. albopictus* were the sporadic species (C=14.2%) which was restricted only in coastal area and Brahmaputra alluvium of Bangladesh, respectively. Among seven topographic zones, mosquitoes were found in all areas studied but density was highest in Coastal region (17.6%) and was the lowest in Madhupur hill tract (11.0%), as shown in Figure 19b. Mosquito larval surveillance and adult mosquito prevalence and seasonal dynamics of mosquito species in BAU campus, its surrounding areas and in Mymensingh city have been studied recently (Akter et al., 2014, Farjana et al., 2015, Alam et al., 2015, and Farjana, 2017). Ten to thirteen species of mosquitoes have been reported in all those studies, which is similar to the present study. Due to dengue outbreaks, mosquito prevalence in Dhaka city has been studied by the different researchers (Ahmed et al, 2002, Bashar et al., 2005). They reported *Aedes aegypti* and *Aedes albopictus* from Dhaka city. We did not find *Aedes* species during 2017 but 2018 with less prevalence (0.8%). This may be due to that we selected rural areas in 7 topographic zones to collect our arthropods and *Aedes* mosquitoes normally breed in urban areas.

The mosquito density were highest in summer (48.7%) followed by monsoon (34.0%) and were the lowest in winter (17.3%) in this study (Figure 20) which do not conform with the previous study in Mymensingh (Farjana, 2017) where highest mosquito density was found during monsoon followed by summer and winter. This may be due to topographic difference of Mymensingh with other region.



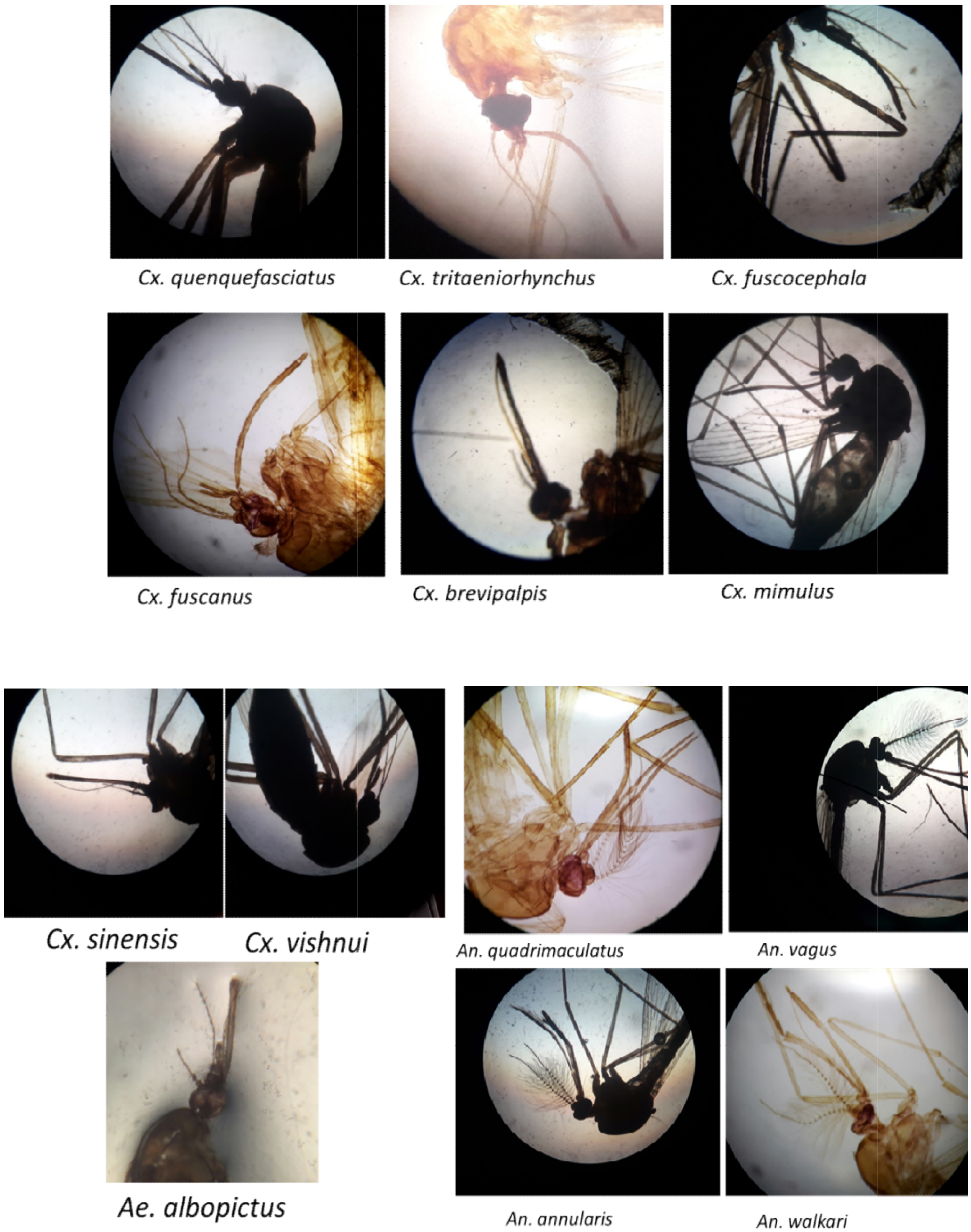
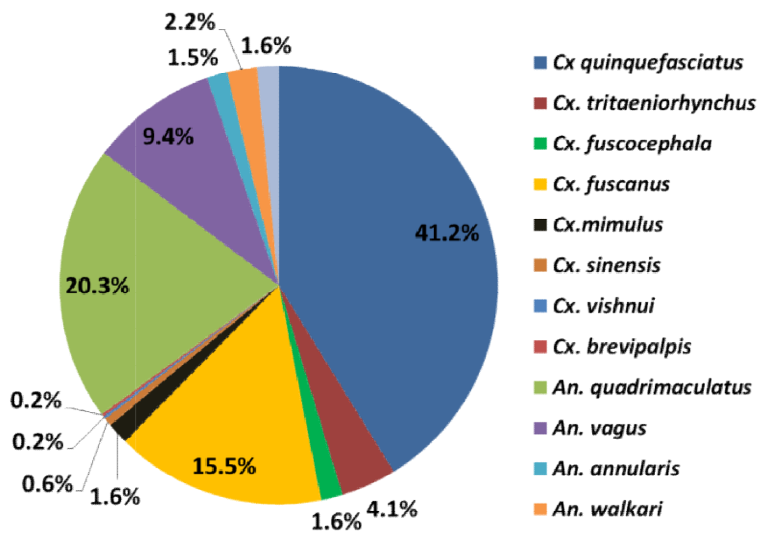
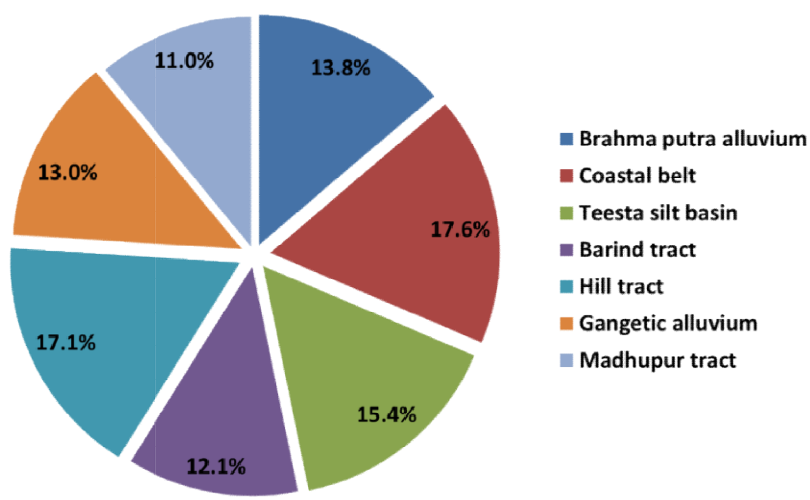


Figure 18: Identified mosquito species from seven topographic zones of Bangladesh



(a)



(b)

Figure 19: Species specific density of mosquitoes (a) and Regional density of mosquitoes (b)

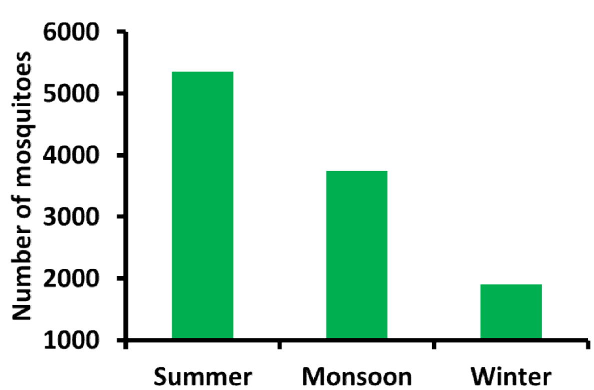


Figure 20: Seasonal prevalence of mosquitoes

Fleas:
A total of 17 fleas were collected from Chokoria and Bandarban during the period of July 2017 to June 2018. Only a single species *Ctenocephalides canis* was identified from goat (Figure 21).

Ctenocephalides canis

Figure 21: Identified flea species from Bandarban and Chokoria

11. 3. Relation of arthropods with meteorological factors (Temperature, humidity and rainfall):

All the arthropods had a very strong positive correlation with the average temperature of the year (Figure 22, 23, 24 and 25). Tick and mosquitoes had negative relation (Figure 22 and 25), whereas number of lice and flies showed positive relation with humidity (Figure 23 and 24). Almost all arthropods (tick, lice, flies and mosquitoes) had a weak positive relation with the rainfall or precipitation (Figure 22, 23, 24 and 25).

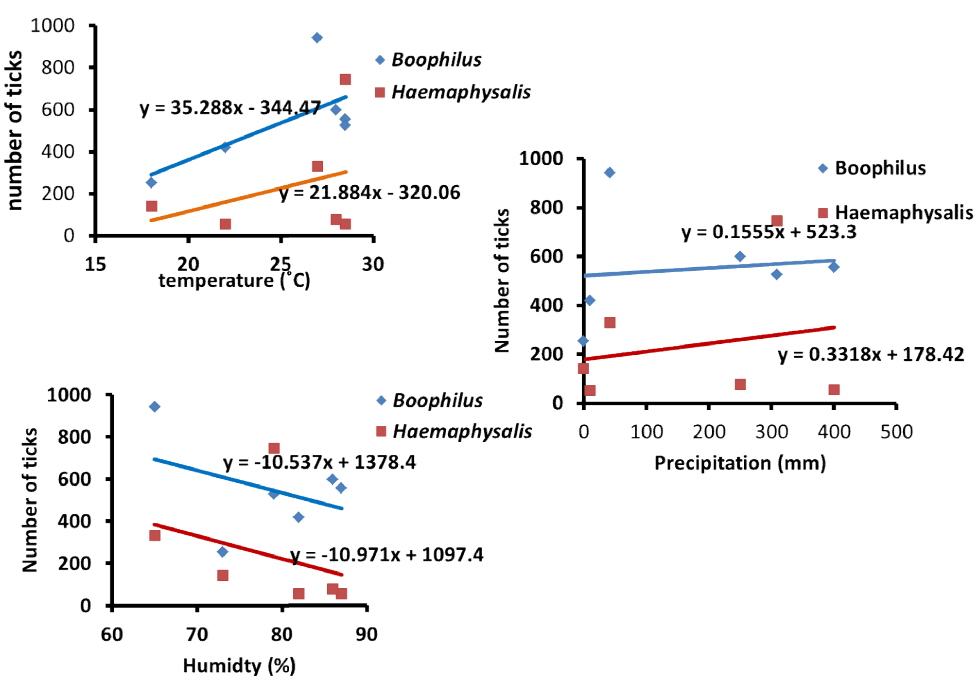


Figure 22: Linear relation of ticks with temperature, rainfall and humidity

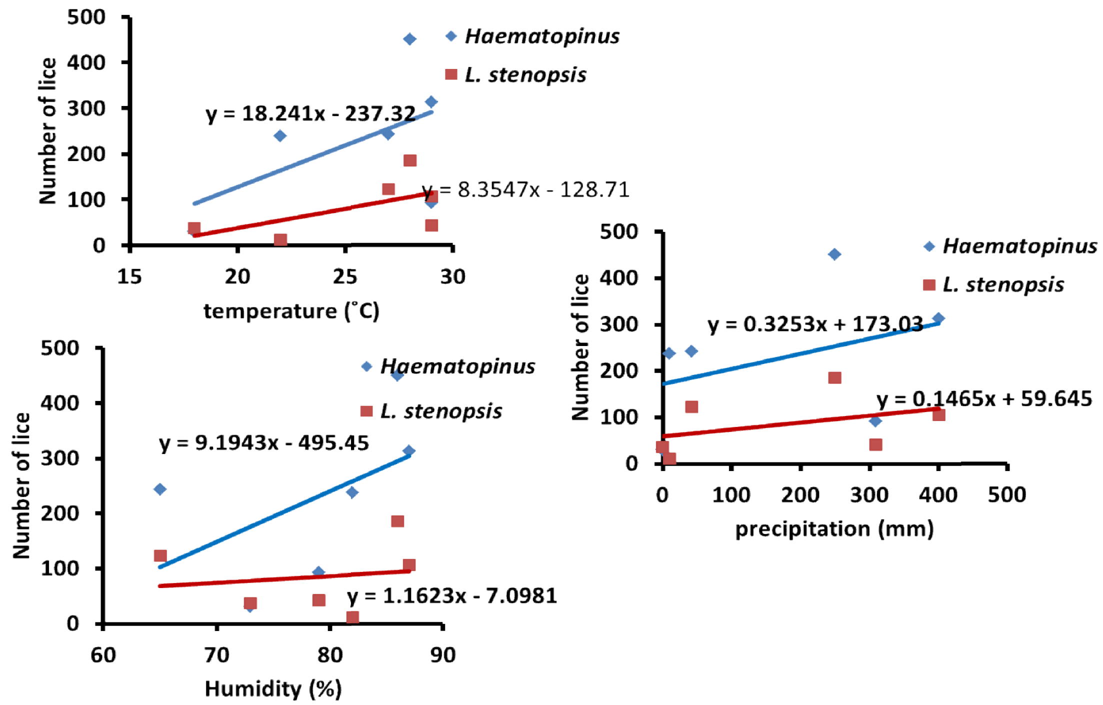


Figure 23: Linear relation of lice with temperature, rainfall and humidity

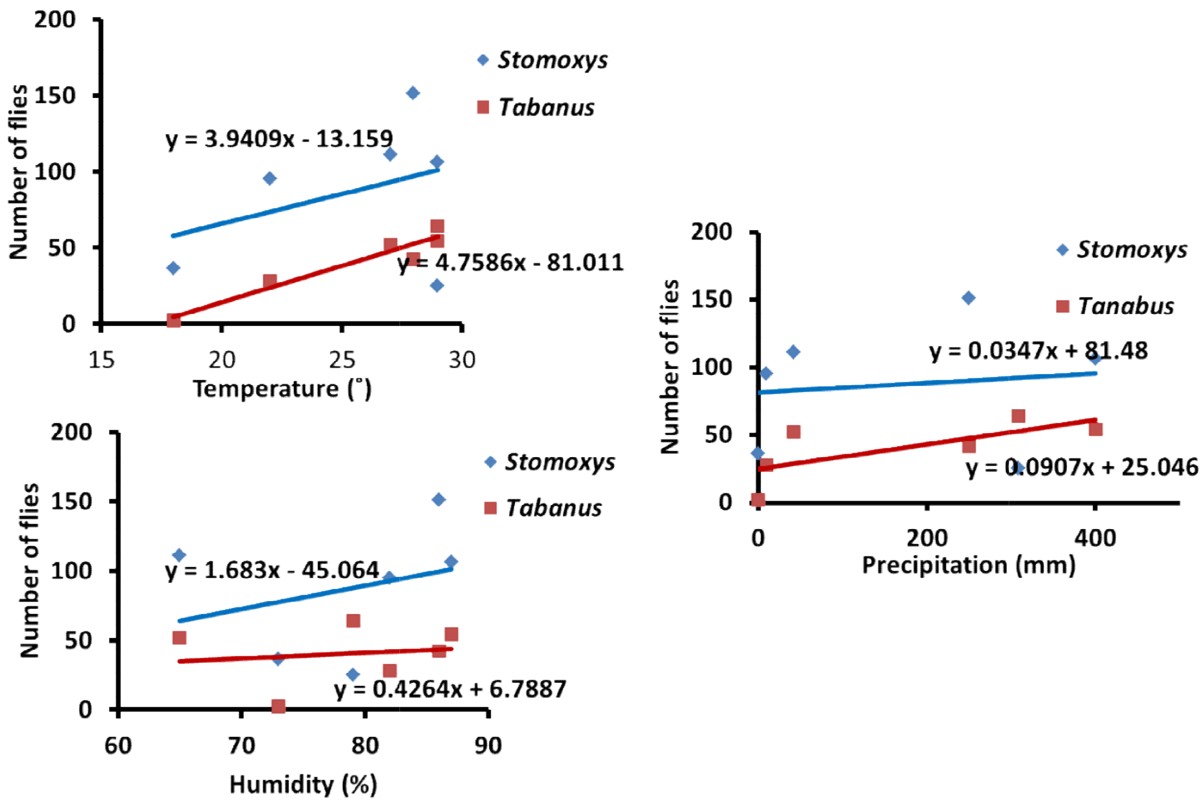


Figure 24: Linear relation of flies with temperature, rainfall and humidity

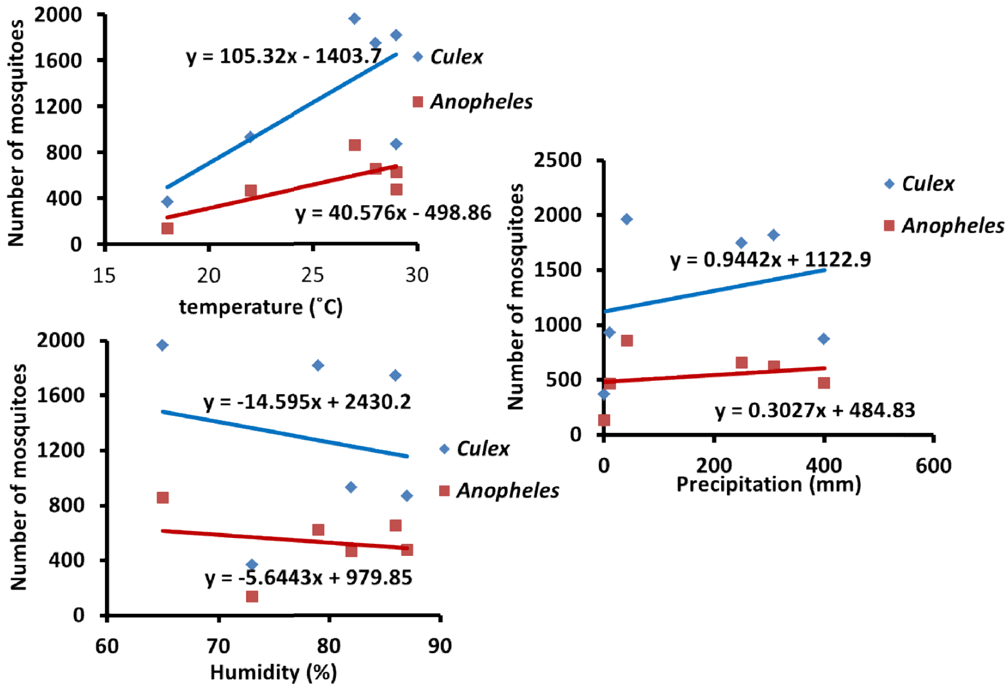


Figure 25: Linear relation of mosquitoes with temperature, rainfall and humidity

12. Research highlight/findings:

- Trend of climate change has been recognized in this study. Temperature showed increasing trend during last 20 years since 1998 to 2018. Humidity showed negative trend and rainfall did not follow increasing or decreasing trend during last 20 years.
- Five species of ticks, four species of lice, four species of flies, one species of fleas and 13 species of mosquitoes were identified.
- Among the seven topographic zones studied, the prevalence of arthropod vectors (ticks, mosquitoes, lice and flies) were found in all the areas but density for ticks was highest in Barind tracts (24%) followed by Coastal belt areas (18%) and Hill tracts areas (14.5%) with the lowest density in Madhupur tract areas (8.1%). Density for mosquitoes was highest in Coastal region (17.6%) with the lowest in Madhupur hill tract areas (11.0%). The highest prevalence of lice was found in Tista silt basin (29.2%) and lowest in Barind tract (1.2%). Flies were found with the highest prevalence rate in Teesta silt basin (20.1%) and lowest in Madhupur hill tract (1.6%)
- Two species of ticks and one species of flies were confirmed by PCR.
- Seasonal dynamics of arthropods were determined. Prevalence of all the arthropod species was found least in winter. Ticks and mosquitoes were most prevalent in summer while lice and flies were found highest in number during monsoon.
- Relationship of arthropods with meteorological factors was identified. All the arthropods had strong positive relation with temperature. Tick and mosquitoes had negative relation, whereas number of lice and flies showed positive relation with humidity. Almost all arthropods had a weak positive relation with the rainfall or precipitation.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	Completed
(a) Office equipment	-	-	-	-	
(b) Lab & field equipment	28.08.2017 08.10.2017	4,49,000 3,54,620	25.10.2017 09.4.2018	4,49,000 3,54,620	
(c) Other capital items	28.08.2017	84,700	9.4.2018	84,700	

2. Establishment/renovation facilities: Not applicable

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized: Not applicable

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop					

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	**6,03,636**	**6,03636**	**6,03,636**	**0**	**100%**	-
B. Field research/lab expenses and supplies	**8,80,150**	**8,80,150**	**8,80,150**	**0**	**100%**	-
C. Operating expenses	**2,29,582**	**2,25,582**	**2,29,582**	**-4000**	**98%**	fund not released
D. Vehicle hire and fuel, oil & maintenance	**1,15,000**	**1,15,000**	**1,15,000**	**0**	**100%**	-
E. Training/workshop/ seminar etc.	**--**					
F. Publications and printing	**75,000**	**15,000**	**15,000**	**-60,000**	**20%**	Fund not released
G. Miscellaneous	**12,000**	**12,000**	**12,000**	**0**	**100%**	-
H. Capital expenses	**84,700**	**84,700**	**84,700**	**0**	**100%**	-

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
1. Recognize the change of climate variables in Bangladesh by meteorological data.	-Collection of meteorological data for a time series of last 20 years	- Temperature showed increasing trend during last 20 years since 1998 to 2018. - Humidity showed negative trend. - Rainfall did not follow increasing or decreasing trend during last 20 years.	Trend of climate change in Bangladesh has been recognized.
2. Identify the arthropod vectors, and to determine their distribution in Bangladesh.	Collection, morphological and molecular identification of vector species e.g., ticks, lice, flies, fleas and mosquitoes. Calculation of density and distribution of vectors of 7 topographic zones of Bangladesh	- A total of 4589 ticks, 2096 lice, 936 flies, 17 fleas and 10997 mosquitoes were collected from seven topographic zones of Bangladesh during the period of July 2017 to June-2018. - Five species of ticks, four species of lice, four species of flies, one species of fleas and 13 species of mosquitoes were identified. - Among the seven topographic zones studied, the prevalence of arthropod vectors (ticks, mosquitoes, lice and flies) were found in all the areas but density for ticks was highest in Barind tracts (24%) followed by Coastal belt areas (18%) and Hill tracts areas (14.5%) with the lowest density in Madhupur tract areas (8.1%). Density for mosquitoes was highest in Coastal region (17.6%) with the lowest in Madhupur hill tract areas (11.0%). The highest prevalence of lice was found in Tista silt basin (29.2%) and lowest in Barind tract (1.2%). Flies were found with the highest prevalence rate in Teesta silt basin (20.1%) and lowest in Madhupur hill tract (1.6%) - Two species of ticks and one species of flies were confirmed by PCR.	The knowledge generated through this study will help policy makers in planning control measures of arthropod vectors towards controlling vector borne diseases in livestock.
3. Assess the relationship between climate change and vectors in Bangladesh.	Use of statistical analysis and regression model to find the relation of meteorological factors with the number of vector species	- Prevalence of all the arthropod species was found least in winter. Ticks and mosquitoes were most prevalent in summer while lice and flies were found highest in number during monsoon. - All the arthropods were found to have strong positive relation with temperature. Tick and mosquitoes had negative relation, whereas number of lice and flies showed positive relation with humidity. Almost all arthropods had a weak positive relation with the rainfall or precipitation.	

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	-	-	-
Journal publication	under preparation	-	-
Information development	-	-	-
Other publications, if any (Thesis)	-	1	Density and seasonal dynamics of arthropod vectors in Mymensingh
Conference paper		1	Title: Effect of meteorological factors on the density and distribution of ticks vectors in Bangladesh. Ento'19: Annual national Meeting and Symposium: arranged by the Royal Entomological Society

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

None

ii. **Generation of new knowledge that help in developing more technology in future**

The information generated through the project will help to predict the future pattern of vector born diseases (VBD) occurrences due to climate change; and to develop early warning system against VBDs.

iii. Technology transferred that help increased agricultural productivity and farmers' income

None

iv. Policy Support

The knowledge generated through this study will help policy makers in planning control measures of arthropod vectors towards controlling vector born diseases in livestock. The knowledge may also be used for the development of community awareness.

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring:

a) A meeting was arranged by director of BAURES to enhance the research activities

b) An oral presentation on the project activities in an Annual workshop arranged by BAURES

c) Annual report presentation on the project activities in a workshop arranged by BARC held on 24-25 April, 2018.

d) An oral presentation on a workshop arranged by BARC held on 22 September, 2018

ii) Field Monitoring:

a. A team visited on 4th March, 2018 to monitor the research progress
b. A team visited on 7th March 2017 to monitor the research activity

Output: Due to field monitoring, the research activity was enhanced

H. Lesson Learned/Challenges (if any)

i) This type of research related to climate change study needs longer time for fruitful results.

I. Challenges (if any)

a) It was not possible to do gene sequencing due to time constraints and fund shortage.
b) Quality of chemicals was not as good as it was expected.
c) The published primers could not amplify the DNA of some vector species.

Signature of the Principal Investigator
Date ……………………….
Seal

Counter signature of the Head of the organization/authorized representative
Date …………………………..
Seal

References

Ahmed, T.U., Hossain, M.I. and Banu, N.N. 2002.Surveillance of Dengue vector mosquito in Dhaka city. Consultants report: Dengue vector Surveillance Project, 2001-2002, Dhaka city corporation, Dhaka. pp. 1- 37.

Akter F, Farjana T, Islam T, Khanom TF, Islam KR, Alim A. 2014. Seasonal Distribution of Mosquitoes (Diptera: Culicidae) in Bangladesh Agricultural University (BAU) Campus, Mymensingh, Bangladesh. *Bangladesh Veterinary Journal*, 48 (1-4): 11-24.

Alam ABMM, 2012.Climate Change and Infectious Diseases: Global & Bangladesh perspective. *Journal of Shaheed Suhrawardy Medical College*, 3:1-2.

Alam N, Farjana T, Khanom TF, Labony SS, Islam KR, Ahmmed S and Mondal MMH. 2015. Prevalence of mosquito species (Diptera: Culicidae) in and around Bangladesh Agricultural University campus, Mymensingh*, Bangladesh. Progressive Agriculture*, 16(1): 12-18.

Barraud PJ, 1934. The fauna of British India, including Ceylon and Burma, Diptera, Family-Culicidae, Tribes-Megarhinini and Culicini. Taylor and Francis, London. 463.

Bashar K, Samsuzzaman M, Ullah MS, Iqbal MJH (2005). Surveillance of Dengue vectors mosquito in some rural areas of Bangladesh. *Pakistan Journal of Biological Sciences* 8: 1119-1122.

Bhakdeenuan P, Preativatanyou K, Payungpor S et al.2012. Identification of forensically important flesh fly (Diptera, Sarcophagidae) in Thailand based on the second internal transcribed spacer (ITS2) of ribosomal RNA gene.https://www.ncbi.nlm.nih.gov/nuccore/JQ811244.1

Bilkis, M., Mondal, M., Rony, S., Islam, M., & Begum, N. (2013). Host Determinant Based Prevalence of Ticks and Lice in Cattle (Bosindicus) at Bogra District of Bangladesh. *Progressive Agriculture*, *22*(1-2), 65-73.

Bram RM, 1967. Contribution to the mosquito fauna to South-East Asia, II. The genus Culex in Thailand (Diptera; Culicidae). 2(1):1-296.

Chitimia L, Lin RQ, Cosoroaba I et al (2009) Molecular characterization of hard and soft ticks from Romania by sequences of the internal transcribed spacers of ribosomal DNA. Parasitology Research, 105:907-

Cornel AJ, Porter CH and Collins FH.1996. Polymerase Chain Reaction Species Diagnostic Assay for *Anopheles quadrimaculatus* Cryptic Species (Diptera: Culicidae) Based on Ribosomal DNA ITS2 Sequences, *Journal of Medical Entomology*, 33(1): 109–116.

DziÍczkowski, A. 1972. Badaniailoúcioweúlimak Ûwbuczyn po³udniowo-zachodniej Polski. (Quantitative researches of the beech malacofauna in south-west of Poland). Studiumekologicznofaunistyczne. PraceKomisjiBiologicznej. 35: 243-332.

Farjana T, Ahmmed S, Khanom TF, Alam N and Begum N. 2015. Surveillance of mosquitoes larva at selected areas of Mymensingh District in Bangladesh. *Bangladesh Journal of Veterinary Medicine*. 13 (1): 79-88.

Farjana T. 2017. Seasonal dynamics of mosquito vectors in relation with meteorological factors like temperature, humidity and rainfall in Mymensingh city. unpublished data. project funded by MOST, MOST/MEDIS’-56/2017.

Ghosh S, Bansal GC, Gupta SC , Ray D et al, 2007.Status of tick distribution in Bangladesh, India and Pakistan. *Parasitology Research.* 10.1007/s00436-007-0684-7.

Hettiaratchi U, Munasinghe D, Chandrashekharan N and Karunanayeke EH. 2000. A polymerase chain reaction based method for the detection of Culexquinquefasciatus (Diptera: Culicidae). *Bulletin of Entomological Research*. 90:63-68.

Intergovernmental Panel on Climate Change (IPCC). 2001. Climate Change 2001: third assessment report, impacts, adaptations and vulnerability of climate change. Cambridge University Press, 2001.

IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R. K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, pp104.

Islam MK, Alim MA, Tsuji N, Mondal MMH (2006) An investigation into the distribution, host-preference and population density of Ixodid ticks affecting domestic animals in Bangladesh. *Tropical Animal Health Production* 38:485-490.

McMichael AJ, 2003. *Global climate change: will it affect vector-borne infectious diseases?* International Medical Journal. **33**: 554-555.

Mondal MMH, Islam MK, Kibria AKMG (1995) Ecological studies on Hyalomma anatolicum anatolicum in cattle of Barind area of Bangladesh. *Bangladesh Veterinary Journal* 29:63-66.

Musa S, Ahmed T and Khanum H 2018. Prevalence of Ectoparasites in Cattle (*Bos indicus*) of Jessore, Bangladesh. *Bangladesh Journal of Zoology*. 46 (2): 137-145.

Parham PE, Waldock J, Christophides GK, Michael E *et al.*, 2015. Climate change and vector-borne diseases of humans, *Philosophical Transactions of the Royal Society of Biological Sciences*, vol: 370:20140377.

Patz JA, Githeko AK, McCarty JP, Hussein S, Confalonieri U, and de Wet N2003. Climate change and infectious diseaes, In: Mc Michael AJ et al. eds. *Climate change and human health, Geneva:* WHO: pp103-132.

Patzold C and seaman A, 2006.Climate Change Effects on Insects and Pathogens, in *Climate Change and Agriculture: Promoting Practical and Profitable Responses, pp*6-16.

Rahman MH, Mondal MMH (1985) Tick fauna of Bangladesh. *Indian Journal of Parasitology* 9:145-149

Rahman, MJ. 2014. Climate change and vector borne disease in Bangladesh. A PhD thesis submitted to BRAC University Bangladesh. pp 1-64.

Ramasamy R and Shurendran, 2012. Global climate change and its potential impact on disease transmission by salinity-tolerant mosquito vectors in coastal zones, Frontiers Physiology, 3:198.

Sharmin S, 2013. Climate change and its impact on coastal areas of Bangladesh. *Asian Science and Technology*, 4(12): 015-020.

Siddiki AZ, MB Uddin, MB Hasan, MF Hossain, MM Rahman, BC Das, MS Sarker and MA Hossain, 2010. Coproscopic and haematological approaches to determine the prevalence of helminthiasis and protozoan diseases of red Chittagong cattle (RCC) breed in Bangladesh. *Pakistan Veterinary Journal*, 30: 1-6.

Song DS, Barker SC and Shao R (2014): Variation in mitochondrial minichromosome composition between blood-sucking lice of the genus *Haematopinus* that infest horses and pigs, Parasites and vectors, 7:7-144.

Soulsby EJL, 1982.Helminths, arthropods and protozoa of domesticated animals (7th edition): London: Baillière Tindall, pp 809.

Trojan, P. (1992). Analizastrukturyfauny. Memorabilia Zoologica, Warszawa, 47, 1–122.

Wall R and Shearer D, 1997. Veterinary Entomology, 1st edition, published by Chapman and Hall, 2-6 Boundary Row, London, pp. 43-135.

World Health Organization, 2003.Climate change and human health- risks and responses.