DIVERSITY OF INSECT AND MITE SPECIES IN CHILI ECOSYSTEM: RELATIONSHIP OF THE MAJOR PESTS WITH PREDATOR AND PLANT DAMAGE

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ABSTRACT

The study was carried out with *Capsicum frutescens* variety BARI Morich 2 to explore the abundance and diversity of insect and mite species harbored in chili ecosystem. The study also determined the relationship of the abundance of major insect and mite pests with predator and chili plant damage index. The chili plants were cultivated in the experimental field of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh and the data of the insect and mite populations were collected at weekly intervals from November 2017 to June 2018. In total 41 insects and one mite species were found in the chili ecosystem where 12 species depicted as pest (three major pests and nine minor pests), 12 species as predator, four species as pollinator and 14 species were found as casual visitor. Insects of the order Hemiptera showed the highest abundance and the ant depicted the top rank with 6.7% abundance of the harbored species. The pest and pollinator species occupied the highest and lowest ranks with 35.4% and 9.3% abundances, respectively. Predator insects revealed the highest diversity and the pollinator category was the most dominant group which has the highest evenness index. The insects of the casual visitor category showed the highest richness index. The population of whitefly was positively correlated with mite, and the abundances of thrips and mite showed significant positive correlation with plant damage index. The abundance of whitefly also showed significant positive correlation with the abundance of dragon fly but negatively associated with the abundance of pirate bug. The abundance of mite had significant negative correlation with the abundance of pirate bug and hover fly, but positively correlated with lady bird beetle. The results indicated that a diversified insect group prevailed in the chili ecosystem, and they had direct linkage with existing predators and plant damage.

Keywords: Abundance, *Capsicum frutescens*, diversity, pest, predator, pollinator.

ABSTRAK

Kajian ini dijalankan ke atas varieti cili, *Capsicum frutescens* BARI Morich 2 bagi mengkaji kepelbagaian dan kelimpahan spesies serangga dan hama yang terdapat di ekosistem cili. Selain itu, kajian ini juga dijalankan bagi menentukan hubungan di antara kelimpahan serangga major dan spesies hama perosak dengan pemangsa serta indeks kerosakannya. Pokok cili dikultivasi di ladang eksperimen Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh dan data serangga dari populasi hama dikumpulkan pada setiap minggu bermula November 2017 ke Jun 2018. Sejumlah 41 spesies serangga dan satu spesies hama didapati di ekosistem cili di mana 12 spesies dikenalpasti sebagai perosak (tiga perosak major dan sembilan minor, 12 spesies sebagai pemangsa, empat spesies pendebunga dan 14 spesies sebagai pelawat umum. Serangga dari order Hemiptera menunjukkan kelimpahan tertinggi dengan spesies semut tertinggi dengan 6.7% kelimpahan dari keseluruhan spesies. Spesies perosak dan pendebunga mewakili jumlah tertinggi dan peringkat terendah dengan 35.4% dan 9.3% kelimpahan, masing-masing. Serangga pemangsa menunjukkan kelimpahan tertinggi manakala pendebunga dikategorikan sebagai spesies paling dominan dengan nilai kesamarataan yang tertinggi. Serangga pelawat umum juga menunjukkan nilai indeks kekayaan yang paling tinggi. Populasi lalat putih menunjukkan korelasi positif dengan speseis hama, manakala kelimpahan thrips dan hama menunjukkan korelasi positif dengan indeks kerosakan tanaman. Kelimpahan lalat putih menunjukkan korelasi positif dengan spesies pepatung, korelasi secara negatif dengan kelimpahan *pirate bug* dan lalat *hover*, tetapi korelasi positif dengan spesies kumbang kura-kura. Hasil kajian menunjukkan wujudnya kepelbagaian kumpulan serangga yang terdapat di ekosistem cili dan ianya berhubungan langsung dengan speseis pemangsa dan kerosakkan tanaman.

Katakunci: Kelimpahan, *Capsicum frutescens,* kepelbagaian, perosak, pemangsa, pendebunga.

INTRODUCTION

The perennial crop chili *Capsicum frutescens* is cultivated world-wide and used primarily as spice or vegetable in various cuisines. Capsaicin, an alkaloid constituent of chili is responsible for its pungency (Kim & Ahn 2002; Sanatombi & Sharma 2008), and it has been used long in the preparation of medicine for treatment of pains (Ofori et al. 2015). The chili plants have a wide range of variability in morphology especially in architecture, height, branching, color, hairs and trichomes (Munshi & Behera 2000; Walsh & Hoot 2001; Carvalho et al. 2006). Chili flowers are solitary, white and possess a greenish white or greenish yellow corolla, and the flowers are insect-or self-pollinated (Berke 2000).

A number of insect and mite species harbor chili plantation and their abundance and diversity vary with the characteristics and growth stages of the chili varieties, season of the year and geographical locations. The harbored insect and mite species play role as pest, predator and pollinator, and some species forage as casual visitor. The number of insect and mite pests of chili is reported by several authors. Roopa & Kumar (2014) reported 10 species of arthropods belonging to eight different families and six orders attack chili plants in Karnata, India. Kaur & Sangha (2016) collected 41 species of arthropods in chili ecosystem at Ludhiana in Punjab, India. Of the collected insects,14 species were pest, 14 species were natural enemy, 12 species were casual visitor and 1 species was pollinator. Ofori et al. (2015) reported that 51 species of insects and two species of mites belonging to 27 families under nine orders harbored in the chili ecosystem in Ghana.

The pest species cause significant loss of the yield of chili both qualitatively and quantitatively measures. The predator species suppress the pest population, whereas pollinator species take part in transferring pollen from anther to stigma of the flowers and accelerate yield of the crop. Knowledge on abundance, diversity and activities of harbored insect and mite species with crop plant is the basic consideration of pest management strategy. Such information regarding chili ecosystem in Bangladesh is infrequent. Hence, there was a need to assess the diversity of insect and mite species associated with chili plants, and to find out relationship of the abundances of major pests with predators and plant damage index.

MATERIALS AND METHODS

Study Site and Condition

The study was conducted from November 2017 to June 2018 in the field and laboratory of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh. The study site ($25^0$25' N and $89^0$5' E) is surrounded by sal tree (*Shorea robusta* Gaertn.) forest, and have an annual mean maximum and minimum temperatures, relative humidity, and rainfall of 36.0°C, 12.7°C, 65.8 %, and 2376 mm, respectively (Amin et al. 2015).

Cultivation of Chili Varieties

The study was done with chili *Capsicum frutescens* variety BARI Morich 2. Forty days old seedlings were transplanted on 21 December 2017 in the experimental plot (8 m × 8 m) and the seedlings were grown without pesticide application. Experimental plot contained 5 rows, and each row had 10 plants. Manures and Fertilizers were applied according to the Fertilizer Recommendation Guide (FRG 2012) (N = 32, P = 16, K = 25, and S = 3 $kg \cdot ha^{-1}$, and cow dung = 5 and poultry manure = 2 $t \cdot ha^{-1}$).

Abundance of Insect and Mite

Data on the abundances of the insect and mite species harbored in chili ecosystem were recorded weekly in five consecutive weeks during the fruiting stage of the plants. The mobile insects were captured using a sweep net. Sweeping was done from 09:00 to 11:00 h of the day, and each sample consisted of 30 sweeps. The captured insects were kept in polythene bags and brought to the Entomology Laboratory for identification and counting. Abundances of the sedentary or sessile insects except the tiny sucking pests were counted on the whole plant basis. On every observation day, five plants were randomly selected from the experimental plot and the plants were approached slowly without disturbing the harbored insects. The number of immature and adult insects of different species associated with the plants were recorded. Five young shoots (each contained three leaves) of the selected plants were also observed using a 10X magnifying hand lens and the numbers of thrips, aphid, jassid, white fly and mealy bug per shoot were counted. To collect data on the abundance of mite, one young shoot (apical two leaves) from each selected plant was plucked. Five shoots were plucked on every observation day and kept fresh in polythene bags and brought to the laboratory, and the number of mites per shoot was counted using a stereo microscope (BOE3200, BOECO, Hamburg, Germany). The counted insects and mite were categorized as pest, predator, pollinator, or casual visitor group (not detected) on the basis of their behavior and feeding. Occurrences of the species in different taxonomic orders and different categories were calculated into percentage.

Assessment of Plant Damage Index (PDI)

Plant damage index (PDI) was determined on the basis of scoring scale 0-9 (Bhutia et al. 2015). At the first harvesting day of chili fruit, fifteen plants were randomly selected and graded individually into six categories (0 = normal leaf, 1 = curling of 1–10% leaves, 3 curling of 11-25% leaves, 5 = curling of 26–50% leaves, 7 curling of 50-75% leaves, 9 = curling of > 75% leaves). PDI (%) was calculated with the following formula:

$$\text{PDI (\%)} = \frac{\Sigma \text{ Numerical ratings}}{\text{Highest grade of rating } \times \text{Total number of plants examined}} \times 100$$

Data Analysis

Whittaker abundance-rank curve (Whittaker 1972) was used to compare the abundances of the harbored species, and to compare the abundances of the species among the categories of pest, predator, pollinator and casual visitor. Correlation matrices of the abundances of the major pests of chili with predators and plant damage index (PDI) were calculated following Principal Component Analysis. Shannon-Weaver diversity index (Shannon & Weaver 1963), Pielou's evenness index (Pielou 1966), Margalef's richness index (Margalef l958), and Berger-Parker dominance index (Berger & Parker 1970) were calculated for pest, predator, pollinator and casual visitor categories. The indices were computed using the following formulae:

Shannon-Weaver diversity index (H'):

$$H' = -\sum_{i=1}^{S} (Pi)\,(ln\ Pi)$$

Where,
S = The total number of species
Pi = The relative abundance of each species.

Margalef's species richness index (D^{mg}) is:

$$D^{mg} = \frac{S-1}{\ln N}$$

Where,
S = Total number of species.
N = Total number of individual in the sample.

Pielou's evenness index (J´):

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

Where,
H´ is the number derived from the Shannon diversity index.
S = Total number of species.

Berger-Parker dominance index (D^{BP}):

$$D_{BP} = \frac{N_{max}}{N}$$

Where,
N_{max} = The total number of individuals in the most abundant species.
N = The total number of individuals in the sample.

RESULTS

A total of 41 insects and one mite species were recorded in the chili ecosystem. Amongst the harbored arthropods, two insects and one mite species were found as major pest, 12 insect species as minor pest, 12 insect species as predator, 4 insect species as pollinator and 14 insect species were found as casual visitor (Table 1). The major pest species belongs to the order Acari, Thysanoptera and Hemiptera. The minor pest species occupies in the orders of Orthoptera, Isoptera, Hemiptera and Lepidoptera. The predator species belongs to the orders Dictyoptera, Odonata, Hemiptera, Coleoptera, Diptera and Neuroptera. The pollinator species are allied to the orders of Lepidoptera and Hymenoptera. The casual visitors occupy in the orders of Orthoptera, Hemiptera, Coleoptera, Lepidoptera, Hymenoptera and Diptera.

Table 1. Encountered insect and mite species and their harbored categories in chili ecosystem at Gazipur in Bangladesh during November 2017 to June 2018

Category	Species
Major pest	Mite, *Polyphagotarsonemus latus* (Acari: Tarsonemidae)
	Thrips, *Scirtothrips dorsalis* (Thysanoptera: Thripidae)
	Whitefly, *Bemisia tabaci* (Hemiptera: Aleyrodidae)
Minor pest	Field cricket, *Brachytrypes portentosus* (Orthoptera: Gryllidae)
	Mole cricket, *Gryllotalpa gryllotalpa* (Orthoptera: Gryllotalpidae)
	Termite, *Odontotermes obesus* (Isoptera: Termitidae)
	Aphid, *Aphis gossypii* (Hemiptera: Aphididae)
	Jassid, *Amrasca devastans* (Hemiptera: Cicadellidae)
	Mealy bug, *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae)
	Fruit borer, *Helicoverpa armigera* (Lepidoptera: Noctuidae)
	Tobacco caterpillar, *Spodoptera litura* (Lepidoptera: Noctuidae)
	Cut worm, *Agrotis ipsilon* (Lepidoptera: Noctuidae)
Predator	Praying mantid, *Mantis religiosa* (Dictyoptera: Mantidae)
	Dragonfly, *Orthetrum glaucum* (Odonata: Libellulidae)
	Damselfly, *Coenagrion resolutum* (Odonata: Coenagrionidae)
	Pirate bug, *Orius sp*. (Hemiptera: Anthocoridae)
	Mirid bug, *Rhabdomiris striatellus* (Hemiptera: Miridae)
	Zigzag beetle, *Menochilus sexmaculatus* (Coleoptera: Coccinellidae)
	Ladybird, *Coccinella septempunctata* (Coleoptera: Coccinellidae)

	Rove beetle, *Paederus fuscipes* (Coleoptera: Staphylinidae) Robber fly, *Zosteria* sp. (Diptera: Asilidae) Hover fly, *Eristalis* sp. (Diptera: Syrphidae) Syrphid fly, *Syrphid* sp. (Diptera: Syrphidae) Green lace wing, *Chrysoperla carnea* (Neuroptera: Chrysopidae)
Pollinator	Lime butterfly, *Papilio demoleus* (Lepidoptera : Papilionidae) Honey bee, *Apis florae* (Hymenoptera: Apidae) Carpenter bee, *Xylo copaviolacea* (Hymenoptera: Apidae) Sweat bee, *Halictus* sp. (Hymenoptera: Halictidae)
Casual visitor	Green grasshopper, *Attractomorpha acutipennis* (Orthoptera: Acrididae) Leafhopper, *Macrostele squadrilineatus* (Hemiptera: Cicadellidae) Green sting bug, *Nezara viridula* (Hemiptera: Pentatomidae) Painted bug, *Bagrada hilaris* (Hemiptera: Pentatomidae) Squash bug, *Anasa tristis* (Hemiptera: Scutelleridae) Red pumpkin beetle, *Aulacophora foveicollis* (Coleoptera: Chrysomelidae) Epilachna beetle, *Epilachna dodecastigma* (Coleoptera: Coccinellidae) Flea beetle, *Phyllotreta cruciferae* (Coleoptera: Chrysomelidae) Cabbage butterfly, *Pieris brassicae* (Lepidoptera: Pieridae) Sulphur butterfly, *Phoebis sennae* (Lepidoptera: Pieridae) Bean pod borer, *Maruca vitrata* (Lepidoptera: Crambidae) Rice skipper, *Pelopidas mathias* (Lepidoptera: Hesperiidae) Ant, *Camponotus compressus* (Hymenoptera: Formicidae) House fly, *Musca domestica* (Diptera: Muscidae)

Results showed that Hemiptera occupied the highest abundance (27.1%) followed by Coleoptera (16.3%), and the lowest abundance (1.4%) was found in Dictyoptera and Orthoptera (Figure 1). The rank abundance of the harbored insect and mite species showed that the ant occupied the highest rank with 6.7% abundance, followed by aphid and lady bird beetle showing 6.2% abundance in both the cases (Figure 2). Rice skipper depicted the lowest rank with 0.5% abundance. Field cricket, mole cricket and grasshopper also exerted the same level of abundance.

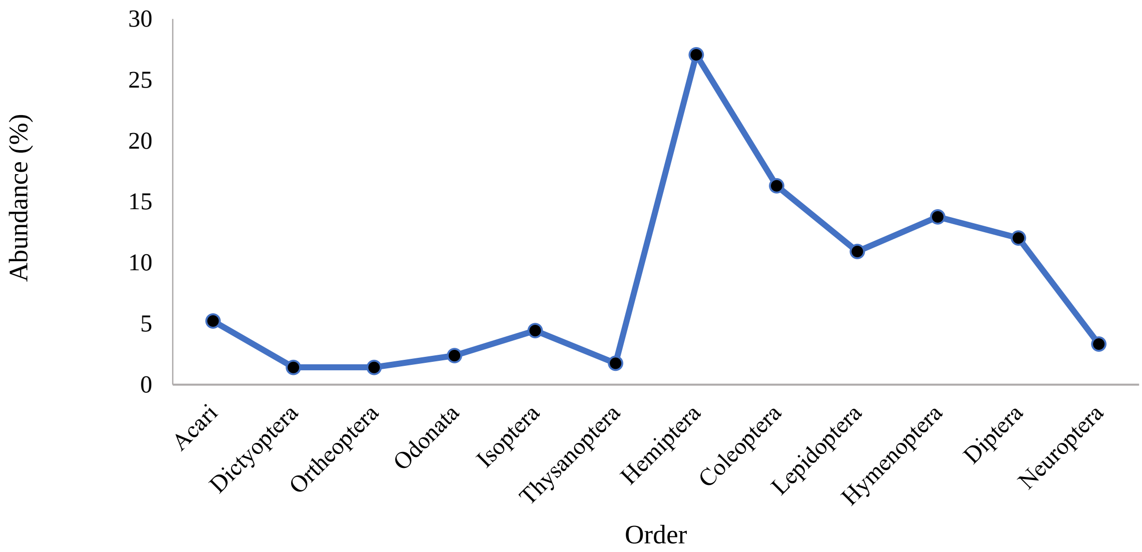

Figure 1. Relative abundance (%) of the insects and mites of different orders associated with chili ecosystem at Gazipur in Bangladesh during November 2017 to June 2018

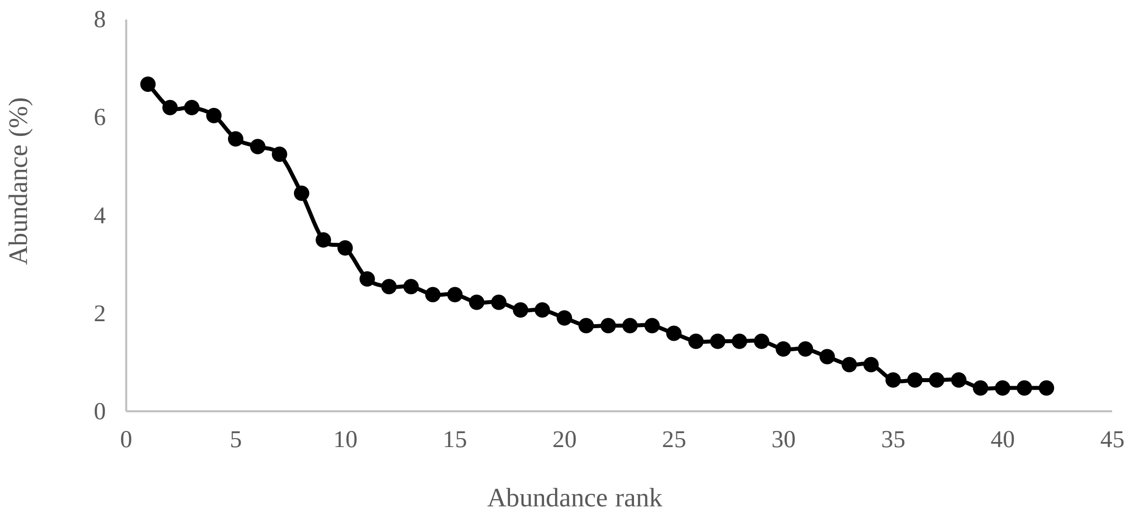

Figure 2. Rank abundance curve of the encountered insect and mite species of chili ecosystem at Gazipur in Bangladesh during November 2017 to June 2018.

Rank abundance of the pest, predator, pollinator and casual visitor presented in figure 3 showed that the highest rank was found in pollinator species with abundance of 37.9% followed by casual visitor and predator species with abundances of 24.3% and 22.4%, respectively. The lowest rank was found in pest species with maximum abundance of 17.4%.

Diversity, evenness, richness and dominance of the different categories of harbored species are presented in table 2. Results showed that the diversity, evenness, richness and dominance of the categories ranged from 1.33 to 2.34, 0.54 to 0.97, 1.71 to 4.56 and 0.17 to 0.38, respectively. Predator category showed the highest diversity, whereas pollinator was the most dominant group which had the highest evenness index. The casual visitor category depicted the highest richness index. Table 3 showed the correlation matrix of the major pest population and plant damage index. Abundance of thrips showed significantly positive correlation with the population of mite, and plant damage index. Relationships of the population of whitefly with mite, and plant damage index were positive but insignificant. Mite population was positively correlated with plant damage index.

Table 2. Diversity indices of different categories of insect and mite species which were encountered in the chili ecosystem at Gazipur in Bangladesh during November 2017 to June 2018

Category	**Diversity (H´)**	**Evenness (J´)**	**Richness (D^{mg})**	**Dominance (D_{BP})**
Pest	1.33	0.54	3.22	0.17
Predator	2.34	0.94	3.50	0.22
Pollinator	1.34	0.97	1.71	0.38
Casual visitor	2.24	0.92	4.56	0.24

Shannon diversity index (H´), Pielous evenness index, Margalef''s richness, Berger-Parker dominance index

Table 3. Correlation matrix of the major pests of chili and plant damage index

Parameter	**White fly**	**Mite**	**Plant damage index (PDI)**
Thrips	0.166^{NS}	0.560*	0.475*
White fly		0.046^{NS}	0.324^{NS}
Mite			0.572**

NS = Non-significant, * = Significant, ** = Highly significant, $p < 0.05$.

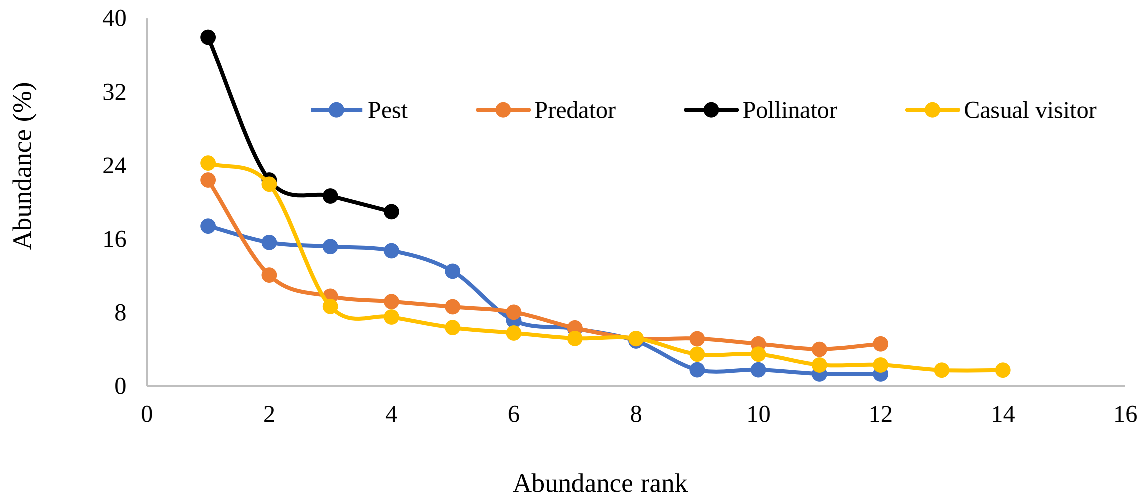

Figure 3. Comparison of the abundance of pest, predator, pollinator and casual visitor insect and mite species which were encountered in the chili ecosystem at Gazipur in Bangladesh during November 2017 to June 2018

Correlation matrices of the major pests of chili and harbored predator insects are shown in table 4. The abundance of mirid bug showed significantly positive correlation with the abundance of damselfly. The abundance of ladybird beetle had significant but negative association with the abundance of pirate bug and rove beetle. Praying mantid had significant negative impact on the abundance of hover fly. The abundance of whitefly depicted significantly positive correlation with the abundance of dragon fly but negative association with the abundance of pirate bug. The abundance of pirate bug and hover fly had significantly negative impact on the abundance of mite while the abundance of lady bird beetle was positively correlated with the mite abundance.

Table 4. Correlation matrix of the major pests of chili and harbored predator insects

	Praying mantid	Dragon fly	Damsel fly	Pirate bug	Mirid bug	Zigzag beetle	Lady bird beetle	Rove beetle	Robber fly	Hover fly	Syrphid fly	Lace wing
Dragon fly	0.420^{NS}											
Damsel fly	0.163^{NS}	-0.185^{NS}										
Pirate bug	0.026^{NS}	-0.327^{NS}	0.161^{NS}									
Mirid bug	-0.030^{NS}	0.063^{NS}	0.508*	0.082^{NS}								
Zigzag beetle	0.077^{NS}	0.132^{NS}	0.314^{NS}	-0.211^{NS}	-0.088^{NS}							
Lady bird beetle	0.119^{NS}	0.370^{NS}	-0.247^{NS}	-0.670**	0.238^{NS}	0.161^{NS}						
Rove beetle	-0.036^{NS}	-0.207^{NS}	0.195^{NS}	0.345^{NS}	-0.113^{NS}	-0.106^{NS}	-0.670**					
Robber fly	-0.290^{NS}	-0.093^{NS}	0.274^{NS}	0.182^{NS}	0.255^{NS}	0.457*	-0.059^{NS}	-0.112^{NS}				
Hover fly	-0.523*	-0.339^{NS}	-0.128^{NS}	0.122^{NS}	-0.040^{NS}	0.290^{NS}	-0.124^{NS}	0.192^{NS}	0.429^{NS}			
Syrphid fly	-0.008^{NS}	0.335^{NS}	0.129^{NS}	0.334^{NS}	0.096^{NS}	0.230^{NS}	-0.209^{NS}	0.115^{NS}	0.391^{NS}	0.117^{NS}		
Lace wing	0.301^{NS}	0.430^{NS}	0.342^{NS}	-0.018^{NS}	0.020^{NS}	0.163^{NS}	-0.167^{NS}	-0.037^{NS}	-0.030^{NS}	-0.426^{NS}	0.005^{NS}	
Thrips	0.374^{NS}	0.292^{NS}	-0.287^{NS}	-0.255^{NS}	0.00 0^{NS}	-0.240^{NS}	0.329^{NS}	-0.176^{NS}	-0.325^{NS}	-0.403^{NS}	-0.261^{NS}	-0.350^{NS}
Whitefly	0.083^{NS}	0.518*	-0.319^{NS}	-0.452*	0.259^{NS}	-0.334^{NS}	0.365^{NS}	-0.312^{NS}	-0.192^{NS}	-0.385^{NS}	-0.264^{NS}	0.141^{NS}
Mite	0.180^{NS}	0.396^{NS}	0.130^{NS}	-0.490*	0.396^{NS}	-0.170^{NS}	0.438*	-0.219^{NS}	-0.343^{NS}	-0.639**	-236^{NS}	0.202^{NS}

NS= Non-significant, * = Significant, ** = Highly significant, $p< 0.05$

DISCUSSION

Different varieties of chili are cultivated in Bangladesh throughout the year and the hot and humid weather of the country favors reproduction, growth and development of insect and mite species. This study is the first to report the abundance and diversity of insect and mite species harbored in chili ecosystem of Bangladesh. In the present study, we found 41 species of insect and one species of mite in the chili ecosystem. The results are in conformity with Hossain et al. (2019) who recorded more than 50 insect and 2 mite pests harboring on chili crops in Malaysia. Sucking pests are becoming serious obstacle of crop production in Bangladesh. This study showed that two species of insects i.e. whitefly and thrips, and one species of mite existed as the major pest of chili, and they are sucking pests. Tan et al. (2016) reported thrips as a major pest of chili and identified a number of total 4 species of thrips infesting *Capsicum annuum* in Malaysia. Saad et al. (2015) reported whitefly as a recently arisen devastating pest of chili in Malaysia.

This study depicts that the insects in the order Hemiptera had the highest abundance which shows harmony with Islam et al. (2019) who reported that the Hemiptera occupied the highest abundance (31%) in an ornamental ecosystem of Bangladesh. The results of the current study showed that the ant occupied the top rank-abundance among the harbored species. This finding concurred with the report of Nancy et al. (2018) who found the top rank of ant *Camponotus compressus* among the abundant arthropod species of a sweet gourd field in Bangladesh. The current study shows that the chili ecosystem played role as a habitat for diverse community of arthropod species. The pollinators found in the study were in the orders of Lepidoptera and Hymenoptera which is in accordance with the findings of Amin et al. (2015) who found 8 pollinator species belonged to Lepidoptera, Hymenoptera and Diptera in a mango-based agroforestry in Bangladesh.

The diversity indices of the present study show that the insect and mite species found in chili ecosystem occupied a diverse community and the pollinators are dominant category and they have the highest evenness index. It occurred due to the higher abundance of honeybee during longer flowering stage of the chili plants.

According to the findings, plant damage index was significantly and positively associated with the abundance of thrips and mite. The relative abundance of insect pests varies depending on the presence of their predators because the predator insects directly feed on them and are responsible to reduce their population (Kindlmann & Dixon 2002). The findings of the present study revealed that the abundance of mite had significantly negative association with the presence of pirate bug and hover fly. The abundance of white fly had also significant negative correlation with the presence of pirate bug. The abundance of white fly was positively associated with the abundance of dragonfly while the abundance of mite was positively correlated with the abundance of ladybird beetle. It might happen in the case when the individuals of predators show response to the abundance of their prey and increase their population. The result is in accordance with the findings of Fok et al. (2014) who observed a strong positive relationship with the abundances of predators and thrips in onion agro-ecosystem. Rahman et al. (2010) found different species of ladybird beetle as a predator against aphid in *Capsicum annuum* ecosystem in Malaysia.

Ambient weather conditions, host plant characteristics and crop cultivation practices affect the abundance and diversity of insect and mite species (Afroz et al. 2019a; Afroz et al. 2019b; Amin et al. 2019). Increasing temperature and CO_2 favor reproduction of herbivore insects and accelerate their population growth. Indiscriminate use of pesticides causes death of predator and pollinator species, and results in secondary pest outbreak. So, abundance and diversity of insects and mites in chili ecosystem have enough possibility of variation with geographical locations, climatic conditions, season of the year, and availability and characteristics of the plants. Moreover, the presence and activity of predators associated to chili plant has a great influence on regulating the abundance of insect and mite species on this host.

CONCLUSION

The results of the study revealed that the mite, thrips and whitefly were found as the major pests of chili in Bangladesh and their populations exerted positive relationship with plant damage index. Predator and casual visitor species revealed the highest diversity and richness indices, respectively. Pollinator species depicted the highest evenness and dominance indices.

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