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ABUNDANCE AND DIVERSITY OF INSECT PESTS ATTACKING MAIZE (*ZEA MAYS*) IN SYLHET DISTRICT OF BANGLADESH

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ABSTRACT

Maize (*Zea mays*), a globally significant crop, is increasingly cultivated in Sylhet district of Bangladesh, but faces challenges due to various insect pests. This study aimed to record the abundance and diversity of insect pests of maize field in Sylhet district. Field studies were conducted at Jalalabad Union of Sylhet Sadar Upazila under Sylhet district, from January to May 2022. Results revealed that various insect pests and natural enemies were found in the maize field viz., cutworm, fall armyworm, tachinid fly, non-biting midge, ladybird beetle, honey bee, and grasshopper. Among these insect pests, non-biting midge (*Chironomus* sp.) (51%) and fall armyworm (*Spodoptera frugiperda*) (16%) were identified as the most prevalent. Insect pests and natural enemies varied by functional diversity with 51% categorized as neutral, 30% as pests, 10% as predators, 5% as parasitoids and 4% as pollinators. The abundance and diversity of insect pests belongs to five different orders which include Diptera (56%), Lepidoptera (24%), Coleoptera (10%), Orthoptera (6%), and Hymenoptera (4%). The Shannon-Wiener Diversity Index was 1.74, indicating a stable community structure, and Pielou's Evenness Index was 0.275, suggesting moderate species distribution uniformity. Insect abundance differed across maize growth stages, with certain pests prevalent in specific stages: cutworm was found during the seedling stage; non-biting midge and ladybird beetle were observed from seedling to harvest; fall armyworm, tachinid fly, and grasshopper were present in both vegetative and reproductive stages; and honey bee appeared during the reproductive stage. Temperature and relative humidity were found to have distinct effects on insect populations, with correlations varying among different species. Temperature was positively correlated with non-biting midge (r = 0.86), fall armyworm (r = 0.54), and tachinid fly (r = 0.39), while negative correlations were observed with ladybird beetle (r = -0.05) and grasshopper (r = -0.31). In terms of relative humidity, positive correlations were identified for fall armyworm (r = 0.14), ladybird beetle (r = 0.31), grasshopper (r = 0.64), and tachinid fly (r = 0.07), whereas non-biting midge showed a negative correlation (r = -0.12). These findings would be helpful for implementing IPM program to manage these pests effectively and ensure sustainable maize cultivation.

Keywords: Maize insects, insect diversity, abundance, IPM, Sylhet, Correlation, Temperature, Humidity

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INTRODUCTION

Maize (*Zea mays*), belongs to the Poaceae family, and is the third most important staple food all over the world followed after wheat and rice (Singh and Jaglan 2018). Among the top three cereals, maize is capable of producing the highest grain yield per unit area, and considered the highest human consumption food all over the world (Wotia and Omukunda 2021). About 200 million people in underdeveloped nations directly consume maize as a primary food (Nuss and Tanumihardjo 2010). In terms of caloric and protein intake, this grain is the staple diet in underdeveloped nations, accounting for 61% of consumption in Mesoamerica, 45% in Eastern and Southern Africa, 29% in the Andean region, and 25% in West and Central Africa (Shiferaw *et al.* 2011). In the warmer parts of the world, maize is typically grown for grain, whereas in the cooler regions, it is grown for silage (Millner *et al.* 2005). Due to its higher genetic output potential and wider range of adaptability among cereal crops, it is referred to as the "Queen of Cereals" in popular culture (Chloupek and Hrstkova 2005). Maize has huge demand in international market for its nutritional values like carbohydrate, protein, fat (oil) and it is also used for beverage, animal feed, poultry feed (Arifie *et al.* 2019). The primary way that maize is eaten in developed nations as second-cycle food, such as meat, eggs, and dairy products (Sofi *et al.* 2009).

In Bangladesh, maize is considered as cash crop and the third grain crop followed after rice and wheat (Biswas *et al.* 2022). The major maize producing districts of Bangladesh are Dinajpur, Chuadanga, Thakurgaon, Lalmonirhat, Rajshahi, Kushtia, Rangpur and Bogura (Biswas *et al.* 2022). At present total cultivated land areas of maize is about 398,309.66 hectares and total annual production is about 3713793.1 MT (BBS 2023). Compared to the production area of maize, yield is not being obtained as expected (Ayalew and Sekar 2016). To overcome the yield loss farmers are using the hybrid varieties. However, it has been claimed that hybrid maize is extremely vulnerable to insect pest

attacks, both in the field and during storage (Almekinders *et al.* 2021). Maize crop is infested by numerous insect-pests in its different growth stages (Tefera *et al.* 2016). Paini *et al.* (2016) reported more than 1300 species of insect-pest and pathogens in maize crop. The major insect-pests of maize at emergence stage are: cutworm (*Agrotis* spp.), maize stem borer (*Chilo partellus*), pink stem borer (*Sesamia inferens*), cotton bollworm (*Helicoverpa armigera*) etc. At tasseling stage: white grub beetle (*Holotrichia longipennis*), miaze leafhopper (*Dalbulus maidis*) etc, at reproductive stage: grass hopper (*Oxya japonica*), Flea beetle (*Chaetocnema pulicaria*), wireworm (*Agriotes* spp.) (Arifie *et al.* 2019). The fall armyworm (S*podoptera frugiperda*) which is native to the tropical and subtropical region of America has recently become major and serious pest in maize all over the world (Sisay *et al.* 2018). Recently it has spread even in Bangladesh, causing major loss to economically cultivated maize crop (Early *et al.* 2018).

Sylhet, the north-eastern district of Bangladesh, is very new in maize cultivation. The department of Agricultural Extension under Ministry of Agriculture is supporting the farmers of Sylhet district to grow maize crop in winter as most of the land of Sylhet district remain fallow during the winter season. Accordingly, farmers have started to grow maize as a new crop in this region. However, various insect pest infestation in different growth stages of maize made them reluctant to grow this crop in this region. Farmers of this area are not familiar with the insect pest of maize. For the sustainable cultivation of maize crop in Sylhet integrated pest management (IPM) of maize crop is necessary. For establishing IPM, pest list with their abundance is prerequisite (Deguine *et al.* 2021). As the maize farmers of Sylhet district are not acquainted with the insect pest of maize and their abundance in maize field, this research was aimed to enlist the available insect pests and natural enemies of maize with their abundance in relation to maize crop growth stages.

MATERIALS AND METHODS

The field experiment was conducted on abundance of insect pests in maize (*Zea mays*) at Palpur village, Jalalabad Union, Sylhet district, during the period from January to May 2022. Geographically, the study area is situated between 24°53' and 25°01' north latitude and between 91°42' and 91°52' east longitude (Banglapedia 2021) (Fig. 1).

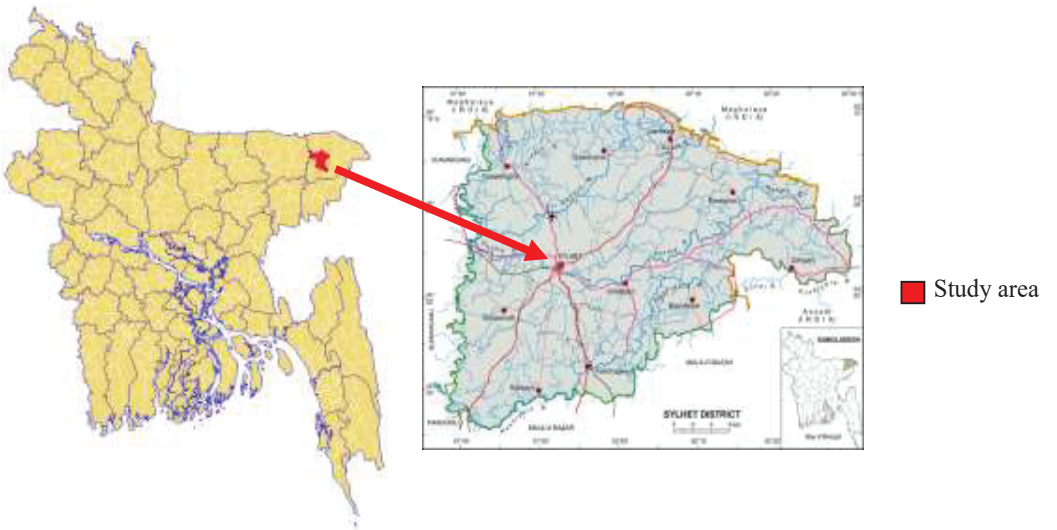


Fig. 1. Map showing the experimental site at Jalalabad Union of Sylhet District.

The experimental site was selected near the Surma riverside. The site has a tropical monsoon climate with the extreme unsteady rainfall condition. But during the experimental period of January to April, 2022, scanty rainfall prevailed during cropping season. The temperature ranged from 12°C to 34.4°C and the relative humidity ranged from 55% to 89% during the period. The plot was thoroughly prepared through multiple plowings using a power tiller to ensure well-tilled soil. After tilling, the field was left undisturbed for 3 days. Weeds and unwanted stubbles were carefully removed manually.

Different kinds of fertilizer and manure: Urea (360 kg ha-1), TSP (150 kg ha-1), MoP (250 kg ha-1), and cow-dung (10 tons ha-1), were applied by broadcasting method to the experimental site. Half of the urea as well as other fertilizers and cow dung were applied in the time of the final land preparation, and the rest of

the urea was used after 28 days of seed sowing. The experiment was arranged in a randomized complete block design (RCBD) with eight replications. Each treated plot measured 6m × 5m and there were total 8 plots. The distance between plots was 1 meter, with a row spacing of 75-90 cm. Each subplot contained 9 rows, with 13 plants per row. The maize Supershine F1 variety was collected from the local market of Sylhet and sown for this study. The seeds were soaked for 3 hours prior to planting. The germination rate was 85-90%. Germination occurred within 5 to 7 days under optimal conditions. The dribbling method was used for planting, where seeds were manually sown to a uniform depth 6 cm.

After seedling establishment, several intercultural operations were performed, including irrigation, weeding, and gap filling, to promote better growth and development. Watering was carried out three times, with the timing and amount carefully adjusted to support seedling growth and maintain soil moisture. During gap filling, damaged seedlings were replaced with healthy ones, and surplus seedlings were transplanted along the borders. Weeding was done 2 times during the growing season, with the first weeding done 15–20 days after planting and the second around 30–40 days after planting, before the silking stage. Finally, spading was conducted to keep the land weed-free.

Data collection: Data collection began on February 11, 2022, after 15 days of sowing and continued until harvest. Data was recorded six times from 9 randomly selected plants per plot across eight plots, with observations taken at intervals of 14 days between 10 am and 12 pm. The purpose of the study was to understand the abundance, and diversity of insect pests and natural enemies throughout the maize crop's lifecycle. The insects were collected using handpicking and net sweeping methods to capture individuals across different growth stages i.e., seedling, vegetative, and reproductive.

The seedling stage was defined as the period from emergence to 4 weeks of plant growth, followed by the vegetative stage, which ended with the appearance of silking, and finally the reproductive stage, which lasted until harvest. During each growth stage, data was recorded to identify the diversity and abundance of insect's

present, as well as their functional roles (e.g., pests, predators, pollinators, or neutral). Diversity indices such as the Shannon-Wiener diversity index (H) and Pielou's evenness index (J) were used to analyze species diversity and distribution patterns in the community. Abiotic factors, specifically relative humidity and temperature, were also recorded at each data collection interval with the help of digital hygrometer that was placed in the field, as these factors significantly influence insect populations. Relationships between these abiotic parameters and the abundance of different insect species were explored to determine their effects.

Data analysis: Statistical analysis was performed to evaluate the relative abundance, Shannon-Wiener diversity index (H), and Pielou's evenness index (J) of insect species. The Shannon-Wiener diversity index and Pielou's evenness index results were described in the paragraphs, providing a comparative view of species richness and distribution uniformity across different plots. Insect composition was visually represented using a pie chart, depicting the relative abundance of each insect category, enhancing understanding of the predominant species within the study area. The relationship between temperature, humidity, and their combined impact on insect abundance was analyzed using correlation and regression techniques. Microsoft Excel 2007 was used for all other calculations.

Relative Abundance (%): The relative abundance of insect species was alculated to show the distribution of insects across different genera, families, and orders. It was computed using the formula:

Relative abundance (%) = (n/N) * 100

Where,

n= Number of each individual
N= Total number of individuals

This formula provided insights into the proportional representation of each species relative to the total insect population.

Shannon-Wiener Diversity Index (H): The Shannon-Wiener diversity index (H) was used to quantify species diversity, taking into account both species richness and

the evenness of species distribution. It was calculated using the following formula:

$$H' = -\sum(Pi \times InPi)$$

Where:

- Pi = Proportion of individuals of the ith species, Pi=ni/Pi
- ni = Number of individuals of the ith species
- N = Total number of individuals
- ln = Natural logarithm
- ∑ = Summation across all species

This index provided an understanding of both the richness and evenness of species present in the ecosystem.

After calculating the diversity index, it was matched with the general interpretation of the diversity index (Reflinaldon and Hamid 2023) (Table 1).

Table 1. General interpretation of Shannon Diversity Index values (Reflinaldon and Hamid 2023)

Diversity Index	Community Structure Condition	Category
H' ≥ 2.41	Very Stable	Excellent
1.8 ≤ H' < 2.41	More Stable	Good
1.21 ≤ H' < 1.8	Stable	Medium
0.61 ≤ H' < 1.21	Stable Enough	Bad
H' < 0.6	Unstable	Very Bad

Pielou's Evenness Index (J): Pielou's evenness index (J) was used to measure how evenly individuals are distributed across different species in the community. It was calculated using the following formula:

$$J = \frac{H}{Hmax}$$

Where:

- H = Shannon-Wiener diversity index
- Hmax=ln(n), with n being the total number of species

Pielou's index indicated the uniformity in the species distribution, with values closer to 1 representing more even distributions across species. These diversity metrics, combined with relative abundance data, allowed for a comprehensive analysis of insect community structure and ecological dynamics within the study area.

RESULTS

The study identified a variety of insect species of maize in Sylhet, Bangladesh, including both insect pests and beneficial insects. Insect pests like cutworms (*Agrotis* spp.), fall armyworms (*Spodoptera frugiperda*), and grasshoppers (*Tettigonia viridissima*) were found. Conversely, beneficial insects such as tachinid flies (*Lixophaga* sp.), ladybird beetles (*Coccinella* spp.) contribute to natural pest control. Honeybees (*Apis mellifera*) help in pollination. These insects' pests are from five different orders *viz*., Lepidoptera, Diptera, Coleoptera, Hymenoptera, and Orthoptera (Table 2).

Table 2. Biodiversity of insect species of maize in Sylhet district, Bangladesh

Sl No.	Common name	Scientific name	Family	Order
1	Cutworm	*Agrotis* spp.	Noctuidae	Lepidoptera
2	Fall armyworm	*Spodoptera frugiperda*	Noctuidae	Lepidoptera
3	Tachinid fly	*Lixophaga* sp.	Tachinidae	Diptera
4	Non-biting midge	*Chironomus* sp.	Chironomidae	Diptera
5	Ladybird beetle	*Coccinella* spp.	Coccinellidae	Coleoptera
6	Honeybee	*Apis mellifera*	Apidae	Hymenoptera
7	Grasshopper	*Tettigonia viridissima*	Tettigoniidae	Orthoptera

The relative abundance of various insect species found in the study area. The data reveals that non-biting midge were the most dominant species, making up 51% of the total insect population of maize. Fall armyworms were the second most abundant species, accounting for 16%, followed by cutworms and ladybird beetles, both at 9%. Grasshoppers contributed 6% of the population. Among natural enemies, ladybird beetles were the most prevalent (9%), whereas tachinid fly and honey bee represented 5% and 4%, respectively (Table 3).

Table 3. Relative abundance of insect species of maize in Sylhet, Bangladesh

Sl. No.	Species	Relative abundance
1	Cutworm	9%
2	Fall armyworm	16%
3	Tachinid fly	5%
4	Non-biting midge	51%
5	Grasshopper	6%
6	Ladybird beetle	9%
7	Honey bee	4%

The higher the value of H', the more the diversity of species in the community and vice-versa. The Shanon-wiener diversity index (H') was calculated 1.74 indicating that community structure was stable and moderately diversified by different species in the community (Table 1). Pielou's index indicated the uniformity in the species distribution, with values closer to 1 representing more even distributions across species. The estimated value of J was 0.275 delineating that there was a moderate degree of evenness of species found in study area. Nearly half (51%) of the total insect population was categorized as neutral, largely due to the substantial presence of non-biting midge. Pollinator i.e., honey bee contributed 4% to maize crop pollination. Pests like Cutworm, Fall armyworm, and Grasshopper made up a significant portion, at 30%, causing considerable damage to maize plants, while predator i.e. Ladybird beetle represented 10%, and parasitoid, Tachinid fly presenting 5% having a relatively minor role as beneficial insects (Fig. 2).

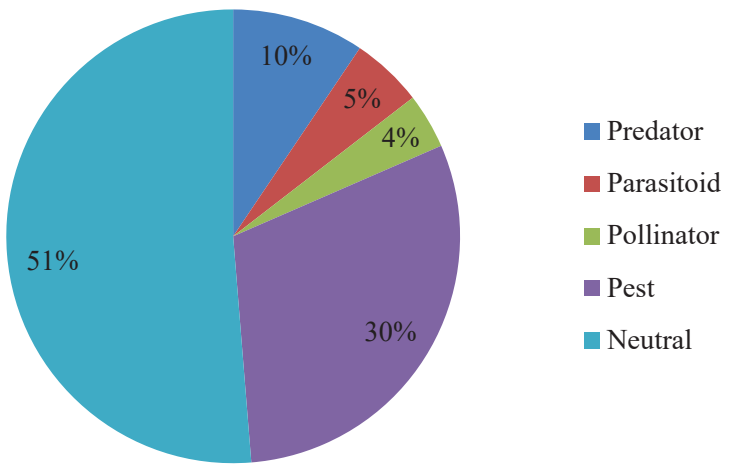


Fig. 2. Functional diversity of maize insect species in Sylhet

The dipteran insects were widely distributed throughout the maize field, comprising more than half (56%) of the total insect population. Lepidoptera and Coleoptera were also significant, constituting 24% and 10%, respectively. The remaining orders; Orthoptera, and Hymenoptera collectively accounted for 10%, with less significance compared to the abundance of other orders (Fig. 3).

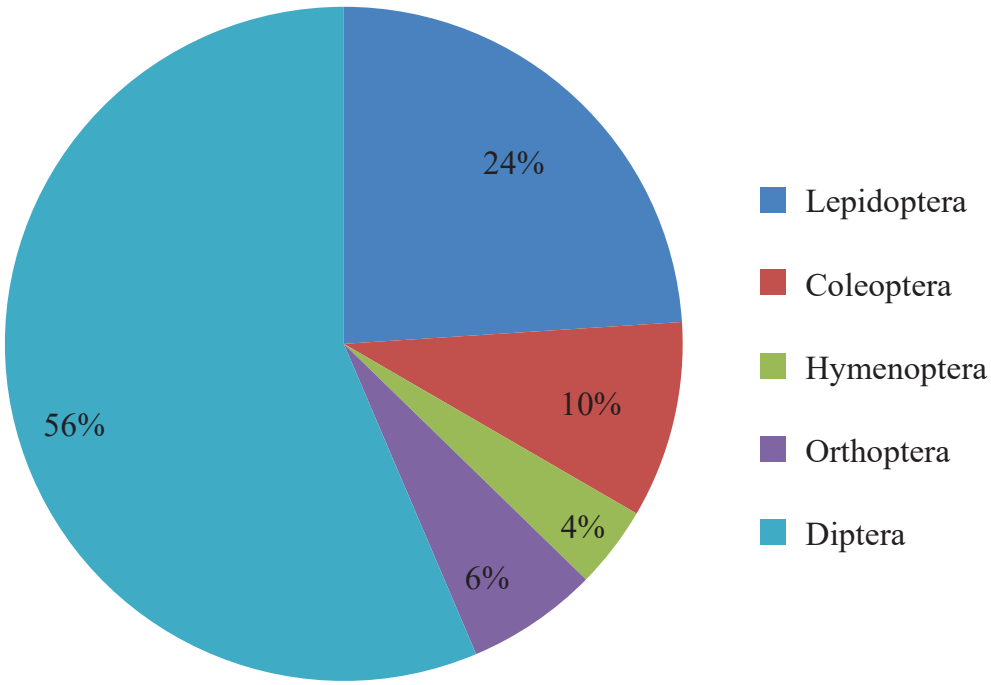


Fig. 3. Order wise distribution of maize insect species in Sylhet

Insect populations of maize crop varied with maize growth stages. Cutworm and non-biting midge were most abundant in the vegetative stage, with cutworm decreasing at the reproductive stage. Ladybird beetles and fall armyworms showed higher numbers at the vegetative stage. Tachinid flies, grasshoppers, and honeybees had low numbers, with slight increases in the reproductive stage (Fig. 4).

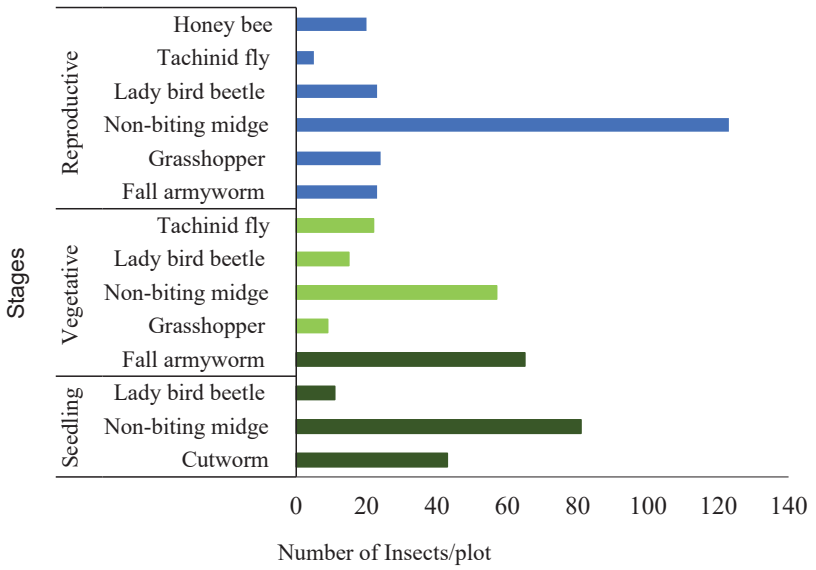


Fig. 4. Prevalence of insect species at different stages of maize

Temperature has a positive correlation with non-biting midge (r=0.86) and fall armyworm (r= 0.54), respectively. In contrast, temperature has a negative correlation with grasshopper (-0.31) (Fig. 5). This graph suggests that non-biting midge and fall armyworm population increase with the increase of temperature. Whereas, grasshopper population decreases with increasing temperature.

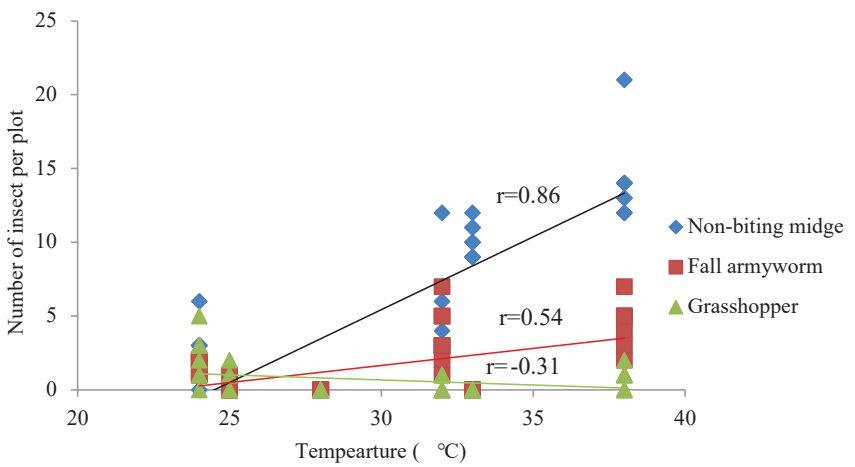


Fig. 5. Effect of temperature on pest population (Non-biting midge, Fall armyworm, Grasshopper) of maize in Sylhet

In case of natural enemies, temperature showed a positive correlation with the tachinid fly (r = 0.39), exhibiting that its population increases considerably with rising temperatures. In contrast, the lady bird beetle had a very weak negative correlation (r = -0.05), suggesting that its population rarely depends upon temperature (Fig. 6).

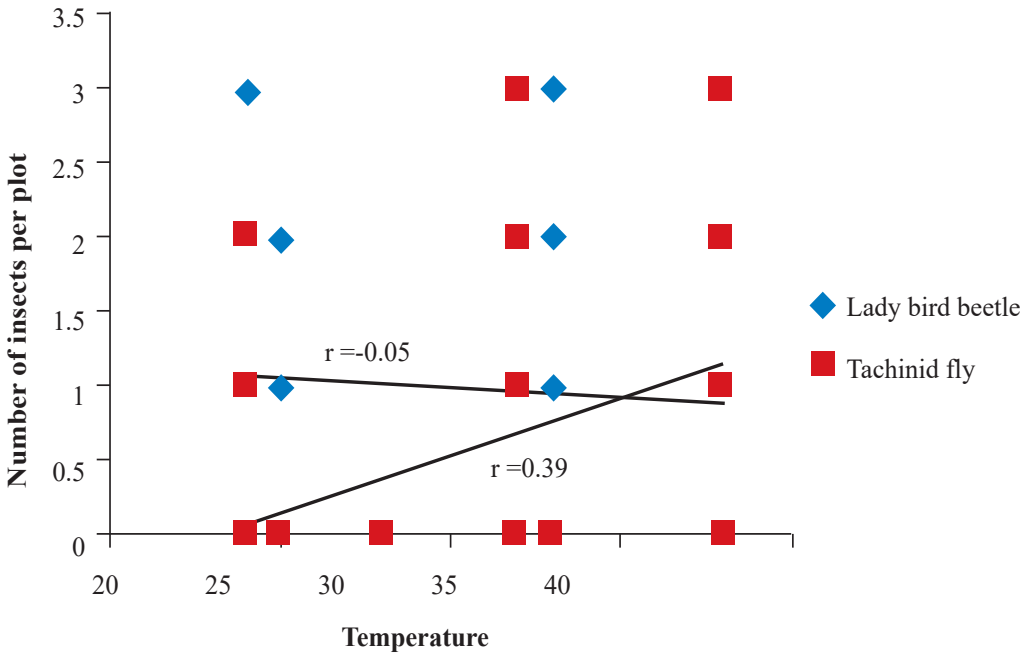


Fig. 6. Effect of temperature on natural enemies' population (Ladybird beetle, Tachinid fly) of maize in Sylhet

The correlation between grasshoppers and relative humidity was found strong (r= 0.64), indicating that relative humidity has a significant effect on increasing grasshopper populations. The fall armyworm had a weak positive correlation with relative humidity (r= 0.14), suggesting that their numbers are not affected much with higher humidity levels. In contrast, non-biting midge exhibited a negative correlation with relative humidity (r = -0.12), indicating it doesn't affect much in their population as humidity increases or decreases (Fig. 7).

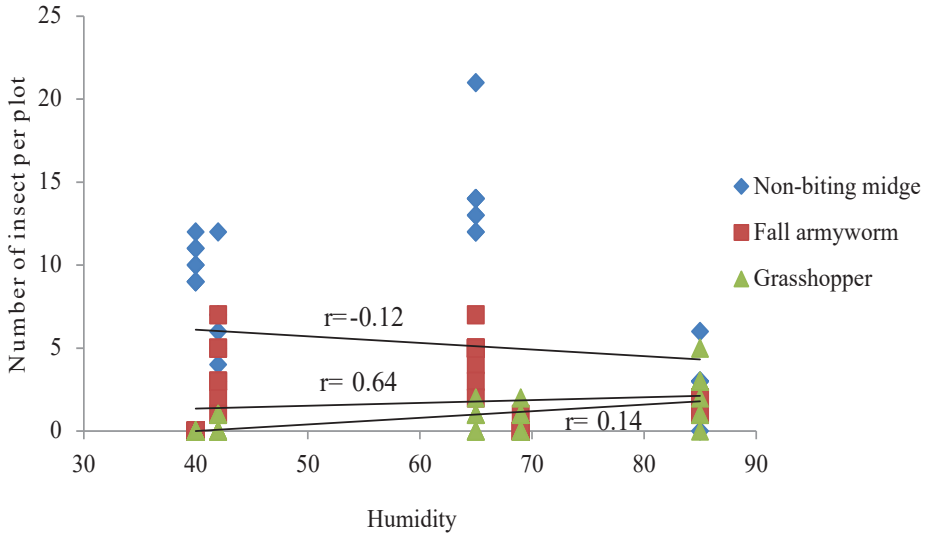


Fig. 7. Effect of relative humidity on the pests population of maize in Sylhet

The relation of relative humidity with both lady bird beetles and tachinid flies has a positive slope (r = 0.31), (r= 0.07), respectively. These results signify that lady bird beetle has a stronger relation with relative humidity than tachinid fly (Fig. 8).

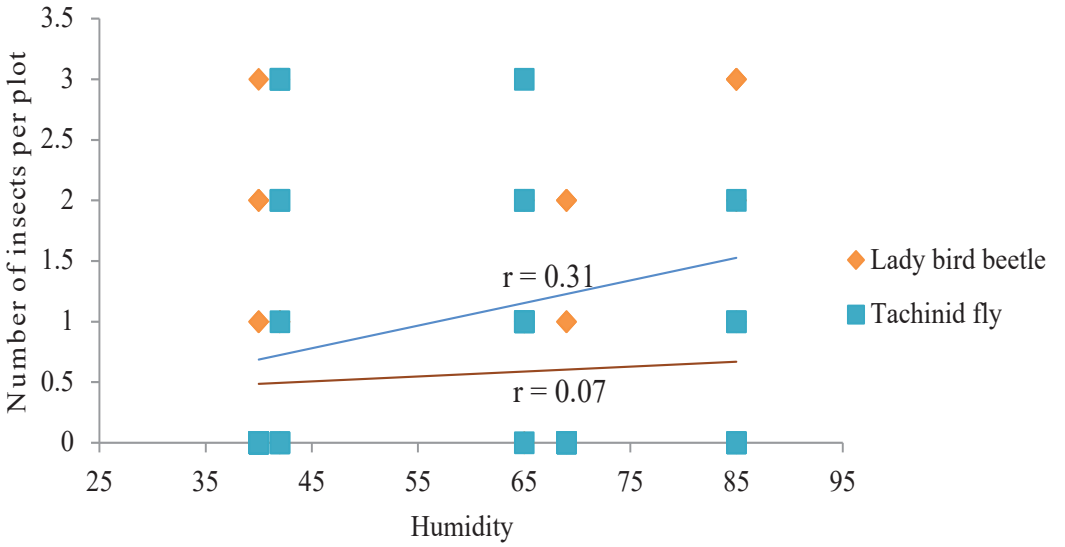


Fig. 8. Effect of relative humidity on natural enemies' populations of maize crop in Sylhet

DISCUSSION

Our study revealed the presence of seven insect species which belong to six different orders. Among the species, non-biting midge were the most dominant species followed by fall armyworm, cutworm, ladybird beetle, grasshopper, tachinid fly and spider. Dhillon *et al.* (2013) mentioned armyworms, cutworms, earworms, grain moths and borers as the most devastating pest of maize. Non-biting midges are not major arthropod associated with maize plant. The high abundance of midges in our experimental area could be due to their preference for aquatic habitats, as our site was located near a riverside (Naser and Roy 2012).

Our results also signified that 51% of the arthropods found in the maize field did not show any significant impact and acted as neutral species whether 30% of the arthropods exhibited as pest, 10% was predator, 5% was parasitoid, and 4% was pollinator. Among these, diptera was the most abundant insect order followed by lepidoptera, coleoptera, orthoptera, hymenoptera, and hemiptera. Kane *et al.* (2023) checked insect pest of maize where heteroptera was dominant order followed by coleoptera and orthoptera. The variation in insect order abundance could be attributed to factors such as genetic variation of crop, habitat complexity, crop diversification, and agricultural practices (Meena *et al.* 2023, He *et al.* 2019).

The present study exhibited that cutworms were observed only at seedling stage. Cutworm larvae cut the stem of maize seedlings near soil surface. A sixth-instar-cutworm larva cause significant damage to seedlings (Devi 2020). In contrast of cutworms, honeybees were prevailed at reproductive stage. In male flowers of maize, 97.13% of the flower visitors were honeybees (Abrol 2012). Though maize is wind-pollinated crop, but the presence of honeybee significantly enhances number of seed set (Alemberhe and Gebremeskel 2016). Fall armyworm, grasshopper, tachinid fly, and spider were observed in both vegetative and reproductive stage. Fall armyworms are one of the most severe pests of maize responsible for 60% of yield loss in maize by feeding the plant's young tissues (Hernández-Trejo *et al.* 2018). Grasshoppers cause minimal damage to corn during their immature stages; however, once they reach adulthood, they migrate to the field edges, feeding on leaves, the tips of the ears, and sometimes chewing on the stalks. In cases of severe infestation, they can completely strip the plants, leading to the destruction of most of the field (Hernández-Zul *et al.* 2012). Tachinid flies are parasitoid that can be

used to reduce the population of fall armyworms in maize fields (Hernández-García *et al.* 2021). Non-biting midge and ladybird beetle were recorded throughout the growing season of maize. Ladybird beetles are effective to control pest population in maize field (Nyukuri *et al.* 2012). The study also checked the correlation among the environmental factors (temperature, humidity) with pests and natural enemies. Preference of temperature and humidity varies from species to species. Non-biting midge, fall armyworm, and tachinid fly showed a positive correlation with temperature while grasshopper and ladybird beetle showed a negative correlation with temperature. Additionally, fall armyworm, grasshopper, ladybird beetle, and tachinid fly represent a positive correlation with relative humidity while non- biting midge showed a negative correlation. Temperature and humidity showed a great impact on population dynamics, developmental and survival responses (Régnière *et al.* 2012, Khan *et al.* 2018).

CONCLUSIONS

Maize (*Zea mays*), is a very new crop in Sylhet district of Bangladesh. This is the first report where the abundance and diversity of insect pests of maize in Sylhet were documented. The study categorized the pests and beneficial arthropods and also documented the presence of insect pests at different growth stages of the maize, providing a comprehensive understanding of insect pests dynamics of maize in Sylhet. This research provides a foundation for developing effective integrated pest management (IPM) strategies. The successful documentation of pest diversity and abundance will aid in the implementation of targeted pest management in different stages of maize, conserving natural enemies, ultimately supporting sustainable maize cultivation and improving its yield in Sylhet.

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