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Relative abundance and diversity of arthropods in the maize (*Zea mays* L.) field of Kharkhari, Rajshahi, Bangladesh

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Abstract
Maize (*Zea mays* L.) represents the most important grain crop. Abundance and diversity of arthropods in the maize (*Zea mays* L.) field of Kharkhari, Rajshahi were studied from February 2019 to May 2019 which allows a closer look in biodiversity in maize crops. In the study area, a total of 1103 specimens were recorded under 11 Orders. The total number of identified specimen (N) and their relative abundance (%) were recorded as in Odonata (39, 3.54 %), Lepidoptera (74, 6.71 %), Coleoptera (181, 16.41 %), Hymenoptera (363, 32.91 %), Diptera (178, 16.14 %), Dermaptera (20, 1.81 %), Araneae (52, 4.71 %), Hemiptera (33, 2.99 %), Orthoptera (55, 4.99 %), Blattodea (1, 0.09 %) and Diplopoda (107, 9.70%). Among the collected specimen the status of Coleoptera, Hymenoptera, Diptera and Diplopoda were very common (VC); Lepidoptera, Orthoptera and Araneae were common (C); Odonata and Hemiptera were fairly common (FC); Dermaptera was rare (R) and Blattodea was very rare (VR). Diversity indices of Shannon (H), Simpson (1-D) and Margalef (DMg) were 1.96, 0.82 and 1.43, respectively. Menhinick richness (DMn), Berger-Parker dominance (d) and Pielous evenness index (J) were 0.33, 0.33 and 0.82, respectively. As the dragonfly and damselfly are excellent bio-indicator, survey of their populations at regular intervals may provide important biological information about the ecological condition of the study area.

Keywords: maize crop, arthropods, population diversity, relative abundance

Introduction

Maize (*Zea mays* L.) belongs to the family Poaceae, is the oldest and most important cereal with the highest production worldwide with a great increasing rate for its varied uses. This crop can be grown on a large commercial farm or as a garden crop and also in an industrial agriculture setup. In addition, it is important as feed for farm animals and for alcohol fabrication [1]. With the development of Poultry and fish farming, now maize has become a demanding crop in Bangladesh. In terms of area and production, it ranks 3rd just after rice and wheat. Because of the more nutritious status, it could be a good source of nutrients for undernourished and malnourished population in Bangladesh and diversely used for human consumption in roasted and fried form [2]. If the rigid food habit is to be diversified from rice to maize, it would probably be possible to reduce food shortage to a great extent.

Maize is not only an important human nutrient, but also a basic element of animal feed and raw material for the manufacture of many industrial products. The products include corn starch, maltodextrins, corn oil, corn syrup and products of fermentation and distillation industries. It is also being recently used as biofuel. So, the importance of export and import of maize is an important issue of world trade. In many countries, it is the basic staple food and an important ingredient in the diets of people [3].

Maize is a facultative short-day plant [4] and flowers in a certain number of growing degree days in the environment to which it is adapted [5]. It is cold intolerant, in the temperate zone maize must be planted in the spring. Its root system is generally shallow, so the plant is dependent on soil moisture. Field maize is left in the field until very late in the autumn to thoroughly dry the grain, and may, in fact, sometimes not be harvested until winter or even early spring [6].

Bangladesh being a tropical and humid country, the infestation of insect pests in every developmental stage of maize is very common [7] or indirectly by transmitting pathogenic microorganisms to the plant, causing diseases and consequently loss of fruit nutritional or market quality [8, 9]. The important maize pests found in Bangladesh are mostly Lepidopteran including *Plodia interpunctella*, *Agrotis ipsilon*, *Chilo partellus* and Coleopteran including *Sitophilus zeamais* and *Rhizopertha dominica*. Studies have shown that the Lepidopteran pests are dominating following the Coleopteran pests. Most of the pest is considered as major crop pests and attacks maize crop throughout the year [10]. Besides pest species, it also essential to know about bioindicators and bio-pollinators like butterflies, crickets and grasshopper. An extensive work was done on butterfly, cricket and grasshopper to observe their abundance in Rajshahi region [11-13]. In order to protect farmers' investment, it is crucial to locate and identify the pests and take suitable control measures before it's too late.

The principal objective of this study is to check out the arthropod species, their diversity and abundance in the maize field during the seedling stage, flowering stage, milky stage, ripening stage and post harvesting stage as well as in maize production.

Materials and Methods

Collection area

The maize field was situated at Kharkhari, Rajshahi, Bangladesh located in between north latitudes 24.006355

and east longitudes 89.249298. The total area of this field was about 40 century (2335 hectare) land. The study was carried out from the month of February, 2019 to May, 2019. The data were collected two days per week for up to four months. For collecting insects, sweeping net, mud pot, forceps, needles and direct hand wearing gloves were used. The insects were collected for four months, consisting of phase 1 (seedling stage); phase 2 (flowering stage); phase 3 (milky stage); phase 4 (ripening stage) and phase 5 (Post harvesting stage) following two sampling methods, sweeping net and pitfall trap.

Sampling technique

The maize plots are randomly swept by a sweeping net in a zigzag manner for a total of 10 sweeps per plot. Total 8 plots were selected in this field. Every plot was 1 square meter. Pitfall traps were also use to collect ground dwelling insects. Total of 23 mud pots were used for this method in which every pot was placed below the ground keeping the level of the ground and the pot entrance equal. Collected insects were stored in plastic jars. Scale and magnifying glass were used to identify insects. Insects are prepared for identification at the Crop Protection and Toxicology Laboratory, Department of Zoology, University of Rajshahi, Bangladesh. The insects were identified up to order.

Photography

DSLR Camera (Nikon D3200) and Macro Lens (Nikon AFS 40 mm 2.8G) were used for taking pictures of the preserved insects in the laboratory following standard preservation techniques. For such indoor photography, a ring flash was used to illuminate the selected specimen.

Calculation of status and relative abundance

The collected species were categorized into one of the five categories based on the number of sightings according to the classification given by Chowdhury *et. al.* [14]. However, the categories 'few' and 'rare', as found in these articles, were changed in the term 'rare' and 'very rare', respectively, in the present observation. Arthropod fauna was characterized into five categories such as VC, Very Common (>100 sightings); C, Common (51-100 sightings); FC, Fairly Common (26-50 sightings); R, Rare (11-25 sightings) and VR, Very Rare (1-10 sightings) [15, 16]. All the data were subjected to analysis with the help of Microsoft Excel 2016. Relative abundance (RA) was determined using the formula Alias and Retnani [17]. Biological diversity was measured by six widely-used indices of biodiversity, namely the Shannon-Weaver index, the Simpson diversity index, the Margalef diversity index, the Menhinick richness index, the Berger-Parker dominance index and the Pielou's evenness index [15, 16, 18, 19].

Results

The diversity and abundance of Arthropods were recorded from the month of February 2019 to May 2019 from the selected Maize field. Monthly observed arthropods and their relative abundance is show in Table 1 and 2, respectively. Total of 1103 Arthropods were collected during the study period of four months. Among the collected arthropods Coleoptera, Diplopoda, Diptera and Hymenoptera were very common (VC) (Table1) with 16.41%, 9.70%, 16.14% and 32.91% relative abundance, respectively (Table 2). Only the order Blattodea (1, 0.09%) had the lowest number of individuals which indicates a very rare (VR) status, while the order Dermaptera had shown a rare (R) status (20, 1.81%). The total number of observed arthropods of 11 Orders are shown in Table 1 and Figure 1. A histogram and a heat map of monthly relative abundance according to Orders are shown in Figure 2 and 3. The heat map clearly shows a high abundance of Hymenoptera in all the months of the study period. Relative abundance of observed individual by two sampling methods are shown in Table 3, where in the pitfall trap mostly soil dwelling arthropods were collected. Order Araneae, Blattodea, Dermaptera and Odonata was only collected by sweeping net. A comparison chart of sweeping net and pitfall trap collection and observation are show in Figure 4. Order-wise overall relative abundance calculated over four months are shown in Figure 5, which also indicated high abundance of Hymenoptera in the field. Descriptive statistical analysis of different diversity indices is shown in Table 4 and Biodiversity indices of the Phylum Arthropoda on the selected maize field according to the different diversity indices are shown in Table 5. Collected arthropods of different orders from the maize field are shown in the Figure 6-14.

Table 1: Monthly recorded specimen of the Phylum Arthropoda on the selected maize field.

Sl. No.	Order Name	Monthly Occurrence of Individuals				Total	Status
		February	March	April	May		
1.	Araneae	18	16	13	5	52	C
2.	Blattodea	0	1	0	0	1	VR
3.	Coleoptera	49	61	43	28	181	VC
4.	Dermaptera	11	9	0	0	20	R
5.	Diplopoda	0	1	0	106	107	VC
6.	Diptera	42	67	50	19	178	VC
7.	Hemiptera	8	2	4	19	33	FC
8.	Hymenoptera	90	68	82	123	363	VC
9.	Lepidoptera	7	7	27	33	74	C
10.	Odonata	7	4	9	19	39	FC
11.	Orthoptera	16	16	6	17	55	C
	Total	248	252	234	369	1103	

VC: Very Common (>100 sightings); C: Common (51-100 sightings); FC: Fairly Common (26-50 sightings); R: Rare (11-25 sightings) and VR: Very Rare (1-10 sightings)

Table 2: Monthly and overall relative abundance (RA) of Arthropoda in the selected maize field.

Order	Monthly RA (%)				Overall, RA (%)
	February	March	April	May	
Araneae	7.26	6.35	5.56	1.36	4.71
Blattodea	0.00	0.40	0.00	0.00	0.09
Coleoptera	19.76	24.21	18.38	7.59	16.41
Dermaptera	4.44	3.57	0.00	0.00	1.81
Diplopoda	0.00	0.40	0.00	28.73	9.70
Diptera	16.94	26.59	21.37	5.15	16.14
Hemiptera	3.23	0.79	1.71	5.15	2.99
Hymenoptera	36.29	26.98	35.04	33.33	32.91
Lepidoptera	2.82	2.78	11.54	8.94	6.71
Odonata	2.82	1.59	3.85	5.15	3.54
Orthoptera	6.45	6.35	2.56	4.61	4.99

Table 3: Relative abundance of arthropods collected by two sampling methods in selected maize field.

Order Name	Relative Abundance (%) of Individuals	
	Sweeping Net	Pitfall Trap
Araneae	6.94	0.00
Blattodea	0.13	0.00
Coleoptera	21.23	6.22
Dermaptera	2.67	0.00
Diplopoda	0.00	30.23
Diptera	13.22	22.32
Hemiptera	4.41	0.00
Hymenoptera	31.24	36.44
Lepidoptera	8.95	1.98
Odonata	5.21	0.00
Orthoptera	6.01	2.83

Table 4: Descriptive statistical analysis of different diversity indices found in the phylum Arthropoda on the selected maize field.

Sl No.	Order	Number of individuals (n)	N	p_i	p_i^2	ln p_i	p_i * ln p_i
1.	Araneae	52	1103	0.0471	0.0022	-3.0545	-0.1440
2.	Blattodea	1	1103	0.0009	0.0000	-7.0058	-0.0063
3.	Coleoptera	181	1103	0.1641	0.0269	-1.8073	-0.2966
4.	Dermaptera	20	1103	0.0181	0.0003	-4.0101	-0.0727
5.	Dilopoda	107	1103	0.0970	0.0094	-2.3330	-0.2263
6.	Diptera	178	1103	0.1614	0.0260	-1.8240	-0.2943
7.	Hemiptera	33	1103	0.0299	0.0009	-3.5093	-0.1040
8.	Hymenoptera	363	1103	0.3291	0.1083	-1.1114	-0.3658
9.	Lepidoptera	74	1103	0.0671	0.0045	-2.7017	-0.1813
10.	Odonata	39	1103	0.0354	0.0013	-3.3422	-0.1182
11.	Orthoptera	55	1103	0.0499	0.0025	-2.9985	-0.1496
	S= 11 (S-1)= 10 ln S= 2.3979 H_{max}= 2.397895	N=1103 lnN= 7.00579 √N= 33.21144 N_{max}= 363	$\sum p_i^2$= 0.18238			∑ pi*ln pi= -1.9600	

S= Total number of species, ln= The natural logarithm, p_i= The proportion $(\frac{n}{N})$ of individuals of one particular species, N= Total number of individuals, N_{max}= The number of individuals of the most abundant species, H_{max}= ln S.

Table 5: Biodiversity indices of the Phylum Arthropoda on the selected maize field.

Name of indices	Values		
	Overall	Collection by Sweeping net	Collection from Pitfall trap
Shannon-Wiener Diversity Index (H)	1.96	1.93	1.42
Simpson Diversity Index (1-D)	0.82	0.82	0.72
Margalef Diversity Index (D_{Mg})	1.43	1.36	0.82
Menhinick Richness Index (D_{Mn})	0.33	0.37	0.32
Berger-Parker Dominance Index (d)	0.33	0.31	0.36
Pielou's Evenness Index (J)	0.82	0.84	0.79

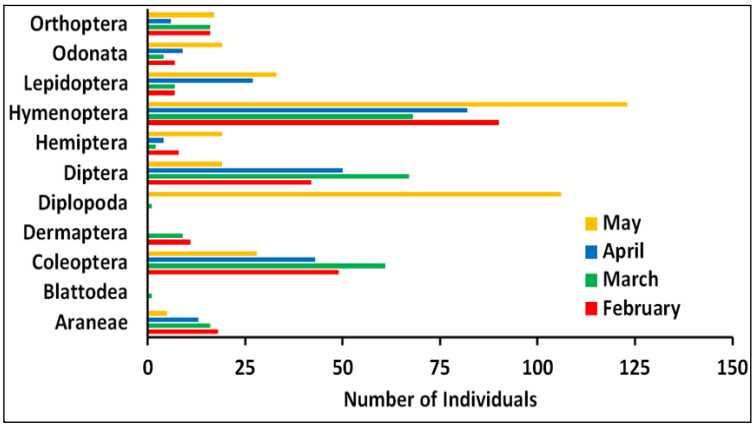

Fig 1: Number of arthropods observed in the selected maize field.

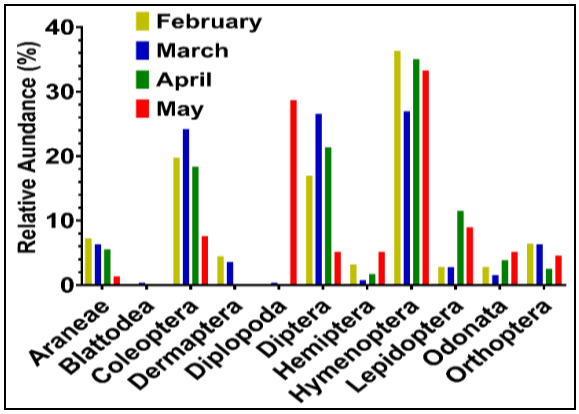

Fig 2: Monthly relative abundance with arthropod orders

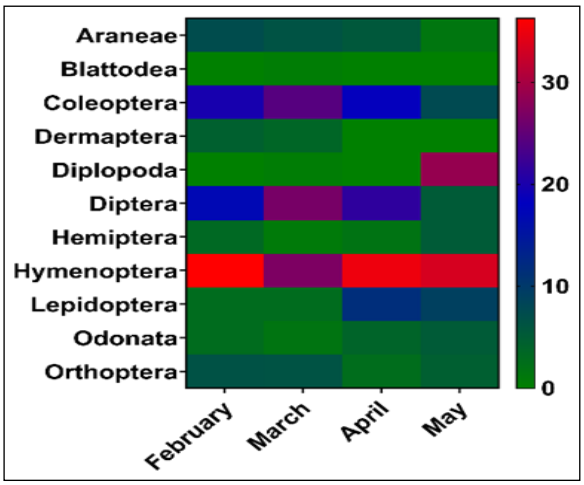

Fig 3: Heat map of monthly relative abundance.

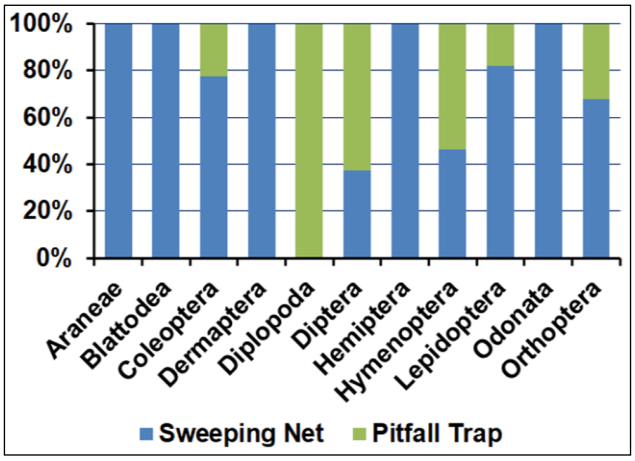

Fig 4: Comparison of observed individual (%) collected by two sampling method (Sweeping Net and Pitfall Trap)

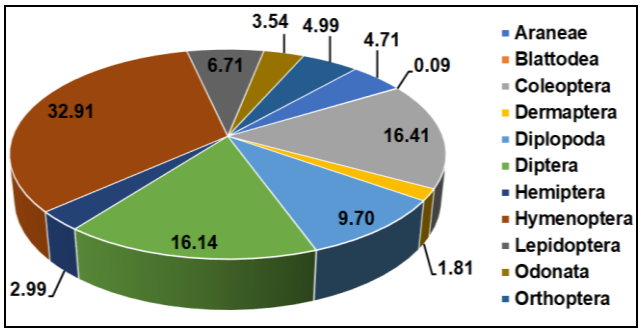

Fig 5: Overall relative abundance according to Order

Figure (Fig 6-14) of different individuals according to order and common name:

Fig 6: Order: Odonata (Dragon and Damsel Flies)

Fig 7: Order: Lepidoptera (Butterflies)

Fig 8: Order: Coleoptera (Beetles)

Fig 9: Order: Hymenoptera (Ants and Bees)

Fig 10: Order: Diptera (Fly)

Fig 11: Order: Dermaptera (Earwigs)

Fig 12: Order: Hemiptera (Bugs)

Fig 13: Order: Orthoptera (Grasshoppers)

Fig 14: Order: Araneae (Spiders)

Discussion

The results have indicated a neutral effect of maize field environments as production was satisfactory. It was found by Schmid *et. al.* [20] that the maize fields contained around 30% of the species compared to the uncultivated habitats, which is consistent with our results. This was remarkably clear in the intensive local survey, which indicated significantly lower species richness and diversity between maize fields and the adjacent habitat supports the result of Grez *et. al.* [21] that commercial crop field environment generally does not favor predatory arthropod species due to lack of food and shelter resources required by grassland adapted arthropod communities. Several studies have emphasized to the associated favorable microclimate, alternative prey and alternative food resources in enhancing arthropod diversity which supports our study [22-24]. Mandal *et. al.* [25] showed that in mustered crop field the abundant arthropod order was Hymenoptera, Lepidoptera and Diptera which is in agreement with our study. Several studies on the predator and pollinator species abundance have shown that hymenopteran and lepidopteran insects were the prominent mediator in different months of a year in Bangladesh [26-28]. Our study is in agreement with Mahdi *et. al.* [16] and Razzak *et. al.* [29] when concerning the soil dwelling arthropods in Bangladesh. Although, this study was conducted in a small maize field between north latitudes 24.006355 and east longitudes 89.249298, but the study may provide a baseline data on the arthropod species associated with maize agroecosystems within specific time frame. However, it may be necessary to conduct further studies over long time to identify and monitor priority species on the basis of other important factors.

Conclusion

The principal intention of this study was to find the diversity and abundance of arthropod species in maize field which in time benefits the farmers to ascertain the pest, predator and pollinator status of a crop for maximum productivity of the concerned crop. However, further extensive studies may determine the diversity patterns in commercial as opposed to subsistence farms. The development of the maize sector in the agricultural lands will facilitate for favorable environment which will provide a proper support network for poor marginalized farmers.

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