DIVERSITY AND ABUNDANCE OF POLLINATORS IN DIFFERENT WINTER CROPS AT SHER-E-BANGLA AGRICULTURAL UNIVERSITY CAMPUS, DHAKA

Hossain, M. S., M. M. Rahman, M. E. Hossain, S. Sarkar[1] and K. Rahman[2]

Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh; [1]Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh; [2]Department of Agriculture Extension, Ministry of Agriculture, Bangladesh

Abstract

The study was conducted at Sher-e-Bangla Agricultural University campus to document the diversity and abundance of pollinators of five commonly grown winter crops, *viz.*, mustard, coriander, niger, black cumin and linseed from October 2020 to February 2021. A total number of fifteen species was identified under eleven genera, nine subfamilies, nine families and seven super families. The study revealed that honey bees, halictids, nymphalids, coccinellids, butterflies and dipterans of genera *Apis*, *Halictus*, *Lasioglossum*, *Aglais*, *Coccinella*, *Pieris*, *Eurema*, *Musca*, *Syrphid* and *Calliphora* belonging to the families Apidae, Halictidae, Nymphalidae, Coccinellidae, Pieridae, Muscidae, Syrphidae and Calliphoridae, respectively were present in the field. The species diversity was high in mustard with 15 species while it was low in linseed (5 species). The honey bees, *Apis sp.* and sweat bees, *Halictus* sp. were common pollinators of all five oilseed crops, while the housefly, *Musca domestica* was specific to mustard. The honey bee, *Apis* sp. was predominant among all the insect pollinators in five oilseed crops. The Species Richness (SR), Shannon-Weaver index ($H^{'}$), Community dominance and Question of similarity indices were applied to determine the diversity and abundance of pollinators.

***Key words*:** Pollinators; Diversity; Winter crops; *Apis* sp.; *Halictus* sp.

INTRODUCTION

Winter crops, which are also called 'Robi foshol' locally, are important in Bangladesh. There are many crops grown in this season, but spices and oil seed crops are major where mustard, black cumin, linseed, niger and coriander play an important role to ensure food security and nutrition. Oil seed crops contain oil and fatty acids in their seeds and the oil is extracted from their seeds either as vegetable or industrial oil. The major oilseed crops grown in Bangladesh are mustard, sesame, groundnut, black cumin and linseed. The minor oil crops are niger, soybean, sunflower, safflower and castor. The major contribution of oil comes from mustard (64.58%) followed by sesame (7.01%) and groundnut (invisible oil 6.85%) (BBS 2020). At present, oilseed crops are grown in 478947.36 hectares which is 5.46% of the cultivable land producing 9,72,000 tons of oilseeds annually (BBS 2020). While in case of spices, the area under the spices cultivation is 0.4 million hectares with annual production of 2.5 million metric tons and the annual demand of spices seeds is 3.0 million metric tons. Spices cover almost 2.6 percent of total cropped area in Bangladesh (BBS 2020).

The domestic production of edible oil can only meet about 20% of the country's annual demand and rest 80% is imported which costs more than BD Tk. 20 billion. It was found that in the imported oils and oilseeds, soybean ranks the first (4,34,000, t = 50%) followed by palm oil (3,41,000, t = 39%), and the rests are mustard and sunflower oil (97,000, t = 11%) (BARI 2008). Edible oils play a very important role in human nutrition (Yanai *et al*. 2015). Oils were not only important for human diets, but also serves as important raw material for industrial use, such as in making soaps, paints, varnishes, hair oils, lubricants, textile auxiliaries, pharmaceuticals, etc. Oilcakes and meals are used as animal feeds and manures (Rizvi *et al*. 2012).

In Bangladesh, oil crops have been neglected by farmers, researchers, extension workers and policy planners. Research Institutes never had adequate resources at their disposal to follow a systematic

Research and Development program that would bring the oilseed crops high on their priorities. Poor yielding capacity and volatile, though subdued, demand have pushed these crops onto the marginal lands where they produce very poor yields since hardly any inputs are given or adequate management practices followed. Result is that production, area and productivity of most oilseed crops are declining (Hamjah 2014) and the production of oilseed cannot meet up country's annual demand. A lot of foreign exchange is spent every year for importing edible oils and oilseeds to fulfill the domestic requirement (Hossain 2017). Poor pollination is one of the major problems of low yield production and optimum pollination is one of the important factors in increasing the production and productivity of crop yield and essential for the propagation of a multitude of plant species. Pollination plays an important role in the reproduction and fruit set for flowering plant communities (Corbet *et al*. 1991, Buchman and Nabhan 1996).

Besides, the diversity of organisms is crucial for the correct functioning of ecosystem (Sivaperuman and Venkataraman 2018). Indices describe general properties of communities that enable comparison of completely different regions, taxa and organic process levels. Therefore, they are of elementary importance for environmental observation and conservation (Mollenhauer *et al*. 2018). Insect is the earth's most diverse organisms, accounting 1,013,825 species out of total 1,635,250 species representing around 80% of world's recorded fauna and acting as central players in most of the major biomes of the planet notably the tropics where they show a massive species richness and variety of specializations (Roskov *et al*. 2015 and Loxdale 2016).

Different types of pollinators are found in oilseed crops. Honey bee (*Apis mellifera*) is found as the main insect pollinator during flowering season. Cross pollination of entomophiles crops by honeybees is considered as one of the effective and cheapest methods for triggering the crop yield both qualitatively and quantitatively (Singh *et al*. 2005 and Mohapatra *et al*. 2010). Chowdhury (2020) have shown that butterflies are also good pollinators of forest vegetation. Hence, the present study was undertaken to study the diversity and abundance of pollinators in different winter crops at Sher-e-Bangla Agricultural University campus, Dhaka.

MATERIAL AND METHODS

Samplings were made weekly from October 2020 to February 2021 with a sweeping net at Sher-e-Bangla Agricultural University (SAU) Campus situated at 23º74´´N latitude and 90º35´´ E longitude with an elevation of 8.45 meter above the sea level and consisting of 87 acres of land. The climate of the SAU campus is typically tropical monsoon, characterized by hot humid summer and dry chilled winter. The region has a mean annual rainfall of about 207 cm; temperature varies from 59.5^0F in January to 78.8^0F in May. Ecologically, the SAU falls under the region of Madhupur Tract (AEZ-28).

Some of the collected specimens were identified up to species level and the rest specimens were identified up to genus level using morphological technique. For morphological identification, mounted specimens were imaged with an Entovision Imaging System. The specimens were preserved at the Insect Museum of the Department of Entomology at Sher-e-Bangla Agricultural University. Microsoft Office Excel 2019 was used for statistical analysis.

Biodiversity of the community of SAU campus was calculated using the Shannon-Weaver

$$\text{diversity index, } H' = -\sum_{i=1}^{i=N} \text{pi} \log 2 \text{ pi}$$

where, *pi* is the proportion of each super family within the community, N expresses the total number of super families within the community.

The community dominance was also evaluated from the Shannon-Weaver diversity index by following the formula: $\frac{Y1+Y2}{Y} \times 100$

In this equation, Y expresses the total number of genus within a community; Y_1 expresses the super family having the highest genus, and Y_2 expresses the super family having the second highest genus.

RESULTS AND DISCUSSION

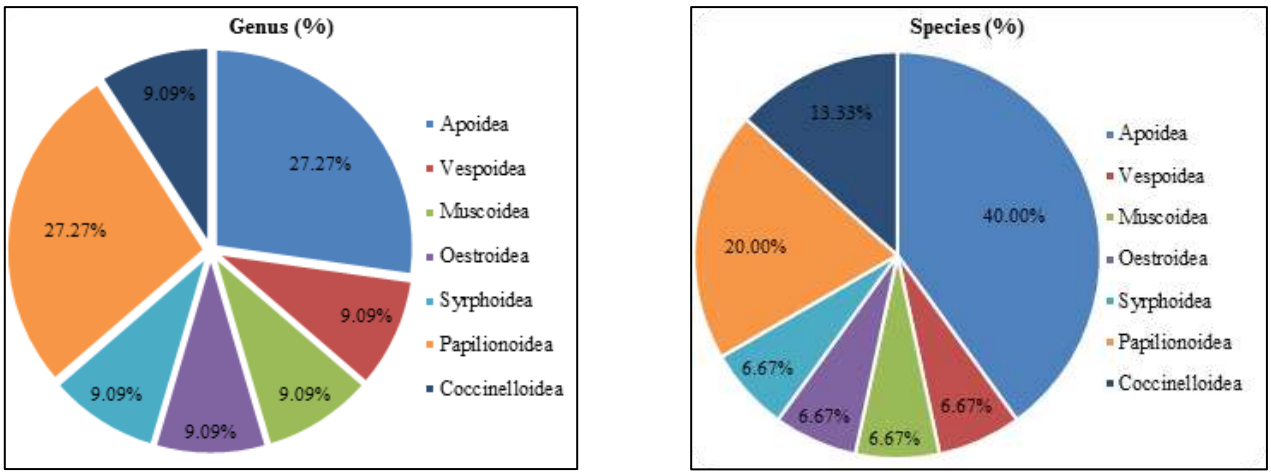
Diversity and abundance of pollinators in mustard field

A total number of 11 genera was identified under nine subfamilies, nine families and seven super families. There were 15 species under 11 genera. The diversity of genus and species in Apoidea was three and six, respectively; in Vespoidea one and one, respectively; in Muscoidea one and one, respectively; in Syrphoidea one and one, respectively; in Coccinelloidea one and two, respectively; in Papilionoidea three and three, respectively; in Oestroidea one and one, respectively (Table 1).

Table 1. Total number of identified genera and species in mustard field.

Super family	Family	Subfamily	Genus	Species
Apoidea	Apidae	Apinae	*Apis*	*A. mellifera* *A. cerana* *A. dorsata* *A. florea*
	Halictidae	Halictinae	*Lasioglossum* *Halictus*	*Lasioglossum* sp. *Halictus* sp.
Vespoidea	Formicidae	Formicinae	*Camponotus*	*C. compressus*
Muscoidea	Muscidae	Muscinae	*Musca*	*M. domestica*
Oestroidea	Calliphoridae	Calliphorinae	*Calliphora*	*Ca.erythrocephala*
Syrphoidea	Syrphidae	Syrphinae	*Syrphid*	*Syrphid* sp.
Papilionoidea	Pieridae	Coliadinae	*Pieris* *Eurema*	*P. rapae* *E. simulatrix inouei*
	Nymphalidae	Nymphalinae	*Aglais*	*Ag. cashmiriensis*
Coccinelloidea	Coccinellidae	Coccinellinae	*Coccinella*	*Co. undecimpunctuta* *Co. septempunctata*
Total	**9**	**9**	**11**	**15**

The most dominant super family of species individuals (40%) was observed in Apoidea followed by Papilionoidea (20%) and Coccinelloidea (13.33%) while in other super families the species observed was 6.67%. The highest diversity in genera was obtained from the super families Apoidea and Papilionoidea (27.27%) followed by other super families with similar diversity (9.09%) (Fig. 1).



a **b**

Fig.1. Diversity observed in super families: **a**. genus; and **b**. species.

The Shannon-Weaver diversity index in mustard field for genus and species was 1.8 and 1.68, respectively with 15 species richness, where the evenness was 0.66 and 0.62, respectively. There were 55% and 60% community dominance for genus and species, respectively in mustard field (Table 2).

Table 2. Biodiversity index assessment (Genus and species).

Super family	Genus				Species			
	Number	pi	log_2pi	$pi(log_2pi)$	Number	pi	log_2pi	$pi(log_2pi)$
Apoidea	3	0.27	-1.30	-0.35	6	0.40	-0.92	-0.37
Vespoidea	1	0.09	-2.40	-0.22	1	0.07	-2.71	-0.18
Muscoidea	1	0.09	-2.40	-0.22	1	0.07	-2.71	-0.18
Oestroidea	1	0.09	-2.40	-0.22	1	0.07	-2.71	-0.18
Syrphoidea	1	0.09	-2.40	-0.22	1	0.07	-2.71	-0.18
Papilionoidea	3	0.27	-1.30	-0.35	3	0.20	-1.61	-0.32
Coccinelloidea	1	0.09	-2.40	-0.22	2	0.13	-2.01	-0.27
Total	11		14.59	-1.80	15		15.37	-1.68
Species Richness	15							15
H'	1.8							1.68
H_{max}	2.71							2.71
Evenness	0.66							0.62
Community dominance	55%							60%
Question of Similarity	1							1

Diversity and abundance of pollinators in coriander field

A total number of six genera was identified under six subfamilies, six families and four super families. There were nine species under six genera. The diversity of genus and species in Apoidea is two and five, respectively; in Syrphoidea one and one, respectively; in Papilionoidea one and one, respectively; in Coccinelloidea one and one, respectively (Table 3).

Table 3. Total number of identified genera and species in coriander field.

Super Family	Family	Subfamily	Genus	Species
Apoidea	Apidae	Apinae	*Apis*	*A. mellifera* *A. cerana* *A. dorsata* *A. florea*
	Halictidae	Halictinae	*Lasioglossum*	*Lasioglossum* sp.
Syrphoidea	Syrphidae	Syrphinae	*Syrphid*	*Syrphid* sp.
Papilionoidea	Pieridae	Coliadinae	*Eurema*	*E. simulatrix inouei*
	Nymphalidae	Nymphalinae	*Aglais*	*Ag. cashmiriensis*
Coccinelloidea	Coccinellidae	Coccinellinae	*Coccinella*	*Co. septempunctata*
Total	**6**	**6**	**6**	**9**

The most dominant super family of species individuals was observed in Apoidea (55.56%) followed by Papilionoidea (22.22%) and Syrphoidea (11.11%). The Highest diversity in genera was obtained from both Apoidea and Papilionoidea super families (33.33%) followed by other super families with similar diversity (16.67%) (Fig. 2).

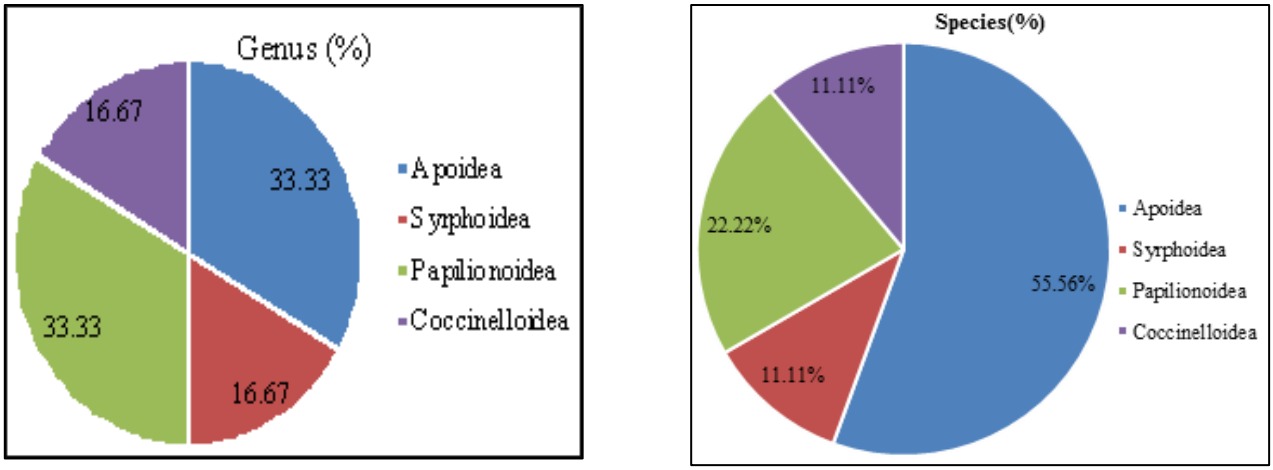


Fig. 2. Diversity observed in super families: **a**. genus; and **b**. species.

The Shannon-Weaver diversity index in coriander field for genus and species was 1.33 and 1.15, respectively with nine species richness, where the evenness was 0.61 and 0.52, respectively. There were 67% and 77% community dominance for genus and species, respectively in mustard field (Table 4).

Table 4. Biodiversity index assessment (Genus and species).

Super family	Genus				Species			
	Number	**pi**	**$\log_2$pi**	**Pi($\log_2$pi)**	**Number**	**pi**	**$\log_2$pi**	**Pi($\log_2$pi)**
Apoidea	2	0.33	-1.10	-0.37	5	0.56	-0.59	-0.33
Syrphoidea	1	0.17	-1.79	-0.30	1	0.11	-2.20	-0.24
Papilionoidea	2	0.33	-1.10	-0.37	2	0.22	-1.50	-0.33
Coccinelloidea	1	0.17	-1.79	-0.30	1	0.11	-2.20	-0.24
Total	6		5.78	-1.33	9		-6.49	-1.15
Species Richness	9				9			
$H^{'}$	1.33				1.15			
H_{max}	2.19				2.19			
Evenness	0.61				0.52			
Community dominance	67%				77%			
Question of Similarity	1				1			

Diversity and abundance of pollinators in niger field

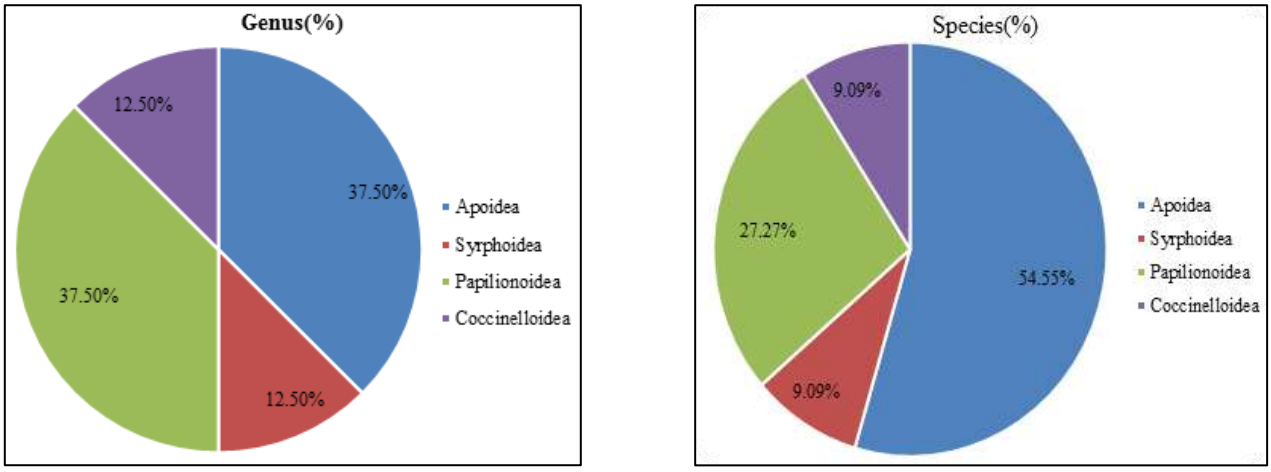
The total identified genus was eight under six subfamilies, six families and four super families. There were 11 species under eight genera. The diversity of genus and species in Apoidea three and six, respectively; in Syrphoidea one and one, respectively; in Coccinelloidea one and one, respectively; in Papilionoidea three and three, respectively (Table 5).

The most dominant super family of species individuals (54.55%) was observed in Apoidea followed by Papilionoidea (27.27%) and Coccinelloidea (9.09%).

Table 5. Total number of identified genera and species in niger field.

Super family	Family	Subfamily	Genus	Species
Apoidea	Apidae	Apinae	*Apis*	*Apis mellifera* *Apis cerana* *Apis dorsata* *Apis florea*
	Halictidae	Halictinae	*Halictus* *Lasioglossum*	*Halictus* sp. *Lasioglossum* sp.
Syrphoidea	Syrphidae	Syrphinae	*Syrphid*	*Syrphid* sp.
Papilionoidea	Pieridae	Coliadinae	*Eurema* *Pieris*	*E. simulatrix inouei* *Pieris rapae*
	Nymphalidae	Nyphalinae	*Aglais*	*Aglais cashmiriensis*
Coccinelloidea	Coccinellidae	Coccinellinae	*Coccinella*	*Coccinella septempunctata*
Total	**6**	**6**	**8**	**11**

Highest diversity in genera was obtained from superfamily Apoidea and Papilionoidea (37.50%) followed by other super families with similar diversity (12.50%) (Fig. 3).



a **b**

Fig. 3. Diversity observed in super families: **a**. genus; and **b**. species.

The Shannon-Weaver diversity index in niger field for genus and species was 1.26 and 1.12, respectively with 11 species richness, where the evenness was 0.53 and 0.47, respectively. There were 75% and 81% community dominance for genus and species respectively in mustard field (Table 6).

Table 6. Biodiversity index assessment (Genus and species).

Super family	Genus				Species			
	Number	pi	$\log_2$pi	Pi($\log_2$pi)	Number	pi	$\log_2$pi	Pi($\log_2$pi)
Apoidea	3	0.38	-0.98	-0.37	6	0.55	-0.61	-0.33
Syrphoidea	1	0.13	-2.08	-0.26	1	0.09	-2.40	-0.22
Papilionoidea	3	0.38	-0.98	-0.37	3	0.27	-1.30	-0.35
Coccinelloidea	1	0.13	-2.08	-0.26	1	0.09	-2.40	-0.22
Total	8		6.12	-1.26	11		6.70	-1.12
Species Richness	11				11			
H'	1.26				1.12			
H_{max}	2.39				2.39			
Evenness	0.53				0.47			
Community dominance	75%				81%			
Question of Similarity	1				1			

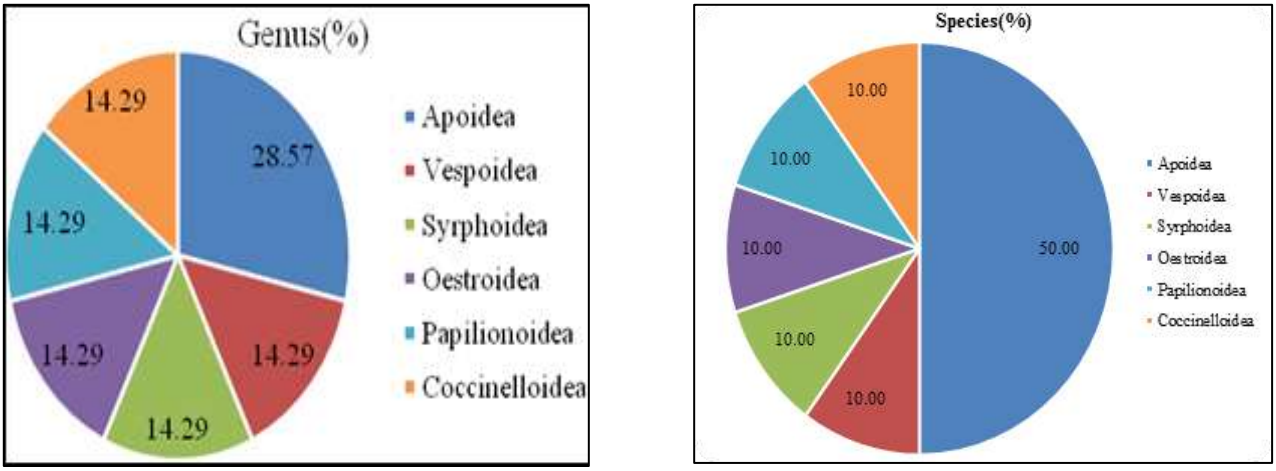
Diversity and abundance of pollinators in black seed field

From black seed filed, a total number of seven genera was identified under seven subfamilies, seven families and six super families. There were 10 species under seven genera. The diversity of genus and species in Apoidea was two and five, respectively; in Vespoidea one and one, respectively; in Syrphoidea one and one, respectively; in Coccinelloidea one and one, respectively; in Papilionoidea one and one, respectively; in Oestroidea one and one, respectively (Table 7).

Table 7. Total number of identified genera and species in black seed field.

Super family	Family	Subfamily	Genus	Species
Apoidea	Apidae	Apinae	*Apis*	*A. mellifera* *A. cerana* *A. dorsata* *A. florea*
	Halictidae	Halictinae	*Lasioglossum*	*Lasioglossum* sp.
Vespoidea	Formicidae	Formicinae	*Camponotus*	*C. compressus*
Syrphoidea	Syrphidae	Syrphinae	*Syrphid*	*Syrphid* sp.
Oestroidea	Calliphoridae	Calliphorinae	*Calliphora*	*Ca. erythrocephala*
Papilionoidea	Nymphalidae	Nymphalinae	*Aglais*	*Aglais cashmiriensis*
Coccinelloidea	Coccinellidae	Cocccinellinae	*Coccinella*	*Coccinella septempunctata*
Total	**7**	**7**	**7**	**10**

The most dominant superfamily of species individuals (50%) was observed in Apoidea followed by other superfamilies (10%). Highest diversity in genera was obtained from super family Apoidea (28.57%) which was followed by other superfamilies with similar diversity (14.29%) (Fig. 4).



a **b**

Fig. 4. Diversity observed in super families: **a**. genus; and **b**. species.

The Shannon-Weaver diversity index in black seed field for genus and species was 1.75 and 1.50, respectively with 10 species richness, where the evenness was 0.71 and 0.65, respectively. There were 43% and 60% community dominance for genus and species, respectively in mustard field (Table 8).

Table 8. Biodiversity index assessment (Genus and species).

Super family	Genus				Species			
	Number	**pi**	**log_2pi**	**Pi(log_2pi)**	**Number**	**pi**	**Log_2pi**	**Pi(log_2pi)**
Apoidea	2	0.29	-1.25	-0.36	5	0.5	-0.69	-0.35
Vespoidea	1	0.14	-1.95	-0.28	1	0.1	-2.30	-0.23
Syrphoidea	1	0.14	-1.95	-0.28	1	0.1	-2.30	-0.23
Oestroidea	1	0.14	-1.95	-0.28	1	0.1	-2.30	-0.23
Papilionoidea	1	0.14	-1.95	-0.28	1	0.1	-2.30	-0.23
Coccinelloidea	1	0.14	-1.95	-0.28	1	0.1	-2.30	-0.23
Total	7		10.98	-1.75	10		12.21	-1.50
Species Richness	10				10			
H or H'	1.75				1.5			
H_{max}	2.3				2.3			
Evenness	0.71				0.65			
Community dominance	43%				60%			
Question of Similarity	1				1			

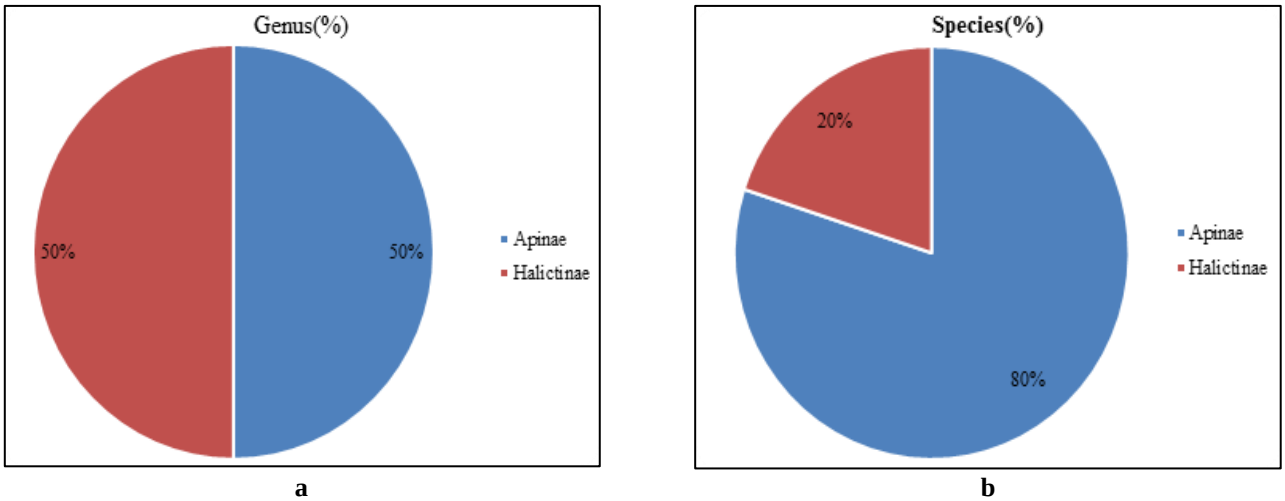
Diversity and abundance of pollinators in linseed field

A total number of 2 genera was identified under two subfamilies, two families and one super family. There were five species under two genera (Table 9).

Table 9. Total number of identified genera and species in linseed field.

Super family	Family	Subfamily	Genus	Species
Apoidea	Apidae	Apinae	*Apis*	*A. mellifera* *A. cerana* *A. dorsata* *A. florea*
	Halictidae	Halictinae	*Lasioglossum*	*Lasioglossum* sp.
Total	**2**	**2**	**2**	**5**

The most dominant subfamily of species individuals (80%) was observed in Apinae followed by Halictinae (20%). In case of genus, similar diversity was obtained from both subfamilies (50%) (Fig. 5)



a **b**

Fig. 5. Diversity observed in super families: **a**. genus; and **b**. species.

The diversity of genus and species in Apinae was one and four, respectively; in Halictinae one and one, respectively (Table 10).

Table 10. Biodiversity index assessment (Genus and species).

Subfamily	Genus				Species			
	Number	pi	log_2pi	$Pi(log_2pi)$	Number	pi	log_2pi	$Pi(log_2pi)$
Apinae	1	0.5	-0.69	-0.35	4	0.8	-0.22	-0.18
Halictinae	1	0.5	-0.69	-0.35	1	0.2	-1.61	-0.32
Total	2		1.38	-0.69	5		1.83	-0.50
Species Richness	5				5			
H'	0.69				0.5			
H_{max}	1.61				1.61			
Evenness	0.43				0.31			
Community dominance	100%				100%			
Question of Similarity	1				1			

Diversity as a community ecological concept refers to the heterogeneity in a community or assemblage of different organisms (Bakar and Khan 2016). Chowdhury and Bashar (2021) have also expressed diversity indices as a good indicator of insect diversity in Bhawal and Madhupur Sal Forests of Bangladesh. Thus, diversity is dependent upon the number of species present (Species richness) and the distribution of all individuals among the species (Evenness) (Rahman *et al*. 2017). Therefore, diversity index value of the present study may support Lotfalizadeh *et al.* (2016) where the high species richness and Shannon indices, such as an area interpretation of light trap catches of insects is affected by daily variation in weather that alters flight.

The major pollinators in the studied oilseed crops were honey bee and Halictids. *Apis sp*. was found to be predominant and common pollinator in five oilseed crops. The establishment of flower rich field margin increases the pollinator population for greater efficiency. As *Apis sp*. was found to be inconsiderable numbers in mustard, the same may be used as a bee flora to sustain their populations in lean periods to enhance optimum and effective pollination in cropped ecosystems.

REFERENCES

BARI. 2008. Adoption and Relative Profitability of Mustard Production in Bangladesh, *Annual Research Report 2007-08*, Oilseed Research Centre, BARI, Joydebpur, Gazipur, Bangladesh., pp. 38-53.

Bakar, M. A. and M. M. H. Khan. 2016. Diversity of insect pests and natural enemies as influenced by growth stages and pest management practices in rice. *Bangladesh J. Agric. Res*. **41**(3): 461-470.

BBS. 2020. *Yearbook of Agricultural Statistics of Bangladesh*. Statistics Division. Ministry of Planning, Dhaka, Bangladesh. 148 pp.

Buchmann, L. S. and P. G. Nabhan. 1996. *The Forgotten Pollinators*. Island Press, Washington DC, USA. 292 pp.

Chowdhury, M. A. K. 2020. Foraging behaviour of some papilionid butterflies in Bhawal and Madhupur sal forests of Bangladesh. *J. biodivers. conserv. bioresour. manag.* **6**(2): 55-68.

Chowdhury, M. A. K. and M. A. Bashar. 2021. Diversity and abundance of some insect fauna in Bhawal and Madhupur Sal Forests of Bangladesh. *J. biodivers. conserv. bioresour. manag.* **7**(1): 11-24.

Corbet, S. A., I. H. Williams and J. L. Osborne. 1991. Bees and the pollination of crops and wild flowers in the European community. *Bee World.* **72**(2): 47-59.

Hamjah, M. A. 2014. Climatic Effects on Major Oilseed Crops Production in Bangladesh: An Application of Multiple Regression Model. *J. Econ. Sustain. Develop.* **5**(19): 45-59.

Hossain, T. 2017. *Bangladesh Oilseeds and Products Annual*. Global Agricultural Information Network, USDA Foreign Agriculture Service (GAIN Report No. BG7002), USA., pp. 2-5.

Lotfalizadeh, H., Z. A. Bayegan and M. R. Zargaran. 2016. Species diversity of Chalcidoidea (Hymenoptera) in the rice fields of Iran. *J. Entomol. Res. Soc.* **18**(1): 99.

Loxdale, H. D. 2016. Insect science - a vulnerable discipline? *Entomol. Exp. Appl.* **159**(2):121-134.

Mohapatra, L. N., B. K. Sontakke and N. Rana Singh. 2010. Enhancement of crop production through bee pollination. *Orissa review*. pp. 44-47.

Mollenhauer, H., M. Kasner, P. Haase, J. Peterseil, C. Wohner, M. Frenzel, M. Mirtl, R. Schima, J. Bumberger and S. Zacharias. 2018. Long-term environmental monitoring infrastructures in Europe: observations, measurements, scales, and socio-ecological representativeness. *Sci. Total Environ.* **624**: 968-978.

Rahman, M., M. A. Maleque, M. S. Uddin and J. Ahmed. 2017. Abundance and diversity of beneficial insect and spider species on rice ecosystem in Sylhet region. *J. Sylhet Agric. Univ.* **4**(1): 63-70.

Rizvi, R., I. Mahmood, S. A. Tiyagi and Z. Khan. 2012. Conjoint effect of oilseed cakes and *Pseudomonas fluorescens* on the growth of chickpea in relation to the management of plant parasitic nematodes. *Brazilian Arch. Biol. Technol.* **55**(6): 801-808.

Roskov, Y., L. Abucay, T. Orrell, D. Nicolson, T. Kunze, A. Culham, N. Bailly, P. Kirk, T. Bourgoin, R. E. DeWalt and W. Decock. 2015. *Species 2000 and ITIS Catalogue of Life*. Annual checklist. DVD. Species 2000: Naturalis, Leiden, the Netherlands. 884 pp.

Singh, R., B. K. Chaudhary, Bhowmick and R. P. Singh. 2005. Honeybee flora of Bihar, Uttar Pradesh and Madhy Pradesh. *International Beekeeping Congress*. 53 pp.

Sivaperuman, C. and K. Venkataraman. 2018. *Indian Hotspots: Vertebrate Faunal Diversity, Conservation and Management.* Vol. 1. Springer, Singapore. 397 pp.

Yanai, H., H. Katsuyama, H. Hamasaki, S. Abe, N. Tada and A. Sako. 2015. Effects of dietary fat intake on HDL metabolism. *J. Clin. Med. Res*. **7**(3): 145-149.