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A review on pollinators diversity on mustard

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Abstract
The present review has been undertaken to understand the pollinator's diversity of mustard in different agro-climatic zones. The present investigation reports that as mustard is a self-incompatible plant it attracts an array of diversified pollinators for its seed production. Order wise Hymenoptera is the dominant one where honeybees, wasps and leaf cutter bees are mostly predominant. Adults of Lepidopterans and Dipterans come next to Hymenopterans. The present review also envisages that the past status of diversity in pollinators on mustard was much higher as compared to present status of diversity of pollinators.

Keywords: review, pollinators diversity, mustard

Introduction
Indian mustard (*Brassica* sp.) is an oil seed plant belonging to family Brassicaceae and order Brassicales. It has been used for production of condiment mustard, dry mustard powder also. The flowers with 4 bright yellow petals with a central core. The central core consists of one yellow pistil and 4-6 shorter yellow stamens. It is a self-incompatible crop due to which it is solely dependent upon different pollinators to transfer the pollen from male flowers to female flowers. In this review the different pollinators associated with pollinatoion of mustard has been thoroughly reviewed.

Result and Discussion
For the entitled study on pollinators diversity on mustard a thorough review has been collected which is discussed below.
Muhammad *et al*. in his research "Insect pollinators diversity and abundance in *Eruca sativa* Mill. (Arugula) and *Brassica rapa* L. (Field mustard) crops" during 2016-18 at The University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan. They have recorded 21 major species of insect pollinators pollinating mustard flowers. Those 21 pollinators species belonging to 12 families of 4 different orders. Among orders Hymenoptera order with 5 different families was the most dominant one comprising of 11 different insects followed by Diptera (5), Lepidoptera (4) and Coleoptera (1). The percentage of contribution is show in Figure No. 1.

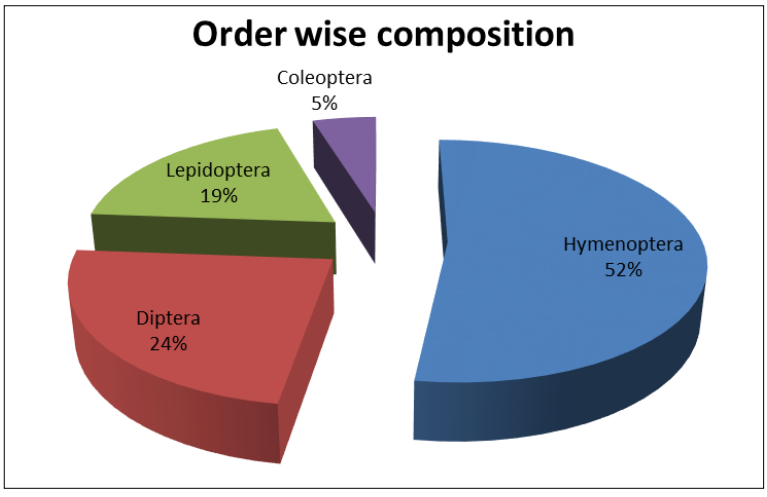

Fig 1: Order wise composition of pollinators of mustard

Among 12 different families, Apidae was the most dominant one consisting of 7 different pollinators followed by Syrphidae (4) and Pieridae (2). The percentile contribution of other families are shown in Figure No. 2.

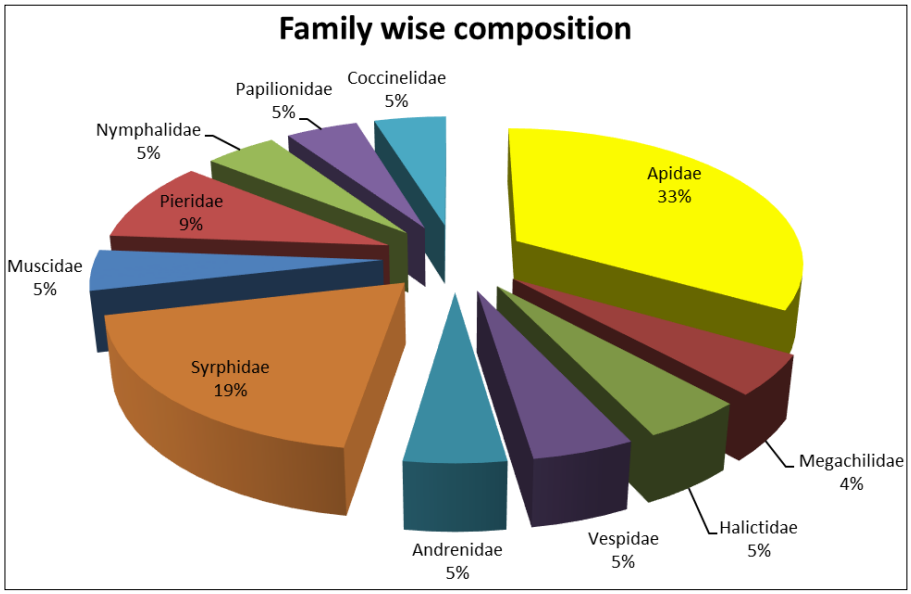

Fig 2: Family wise composition of pollinators of mustard

The insect pollinators collected included four *Apis* species of honey bees. *A. mellifera* was the dom- inant pollinators followed by *A. cerana*, *A. florea*, and *A. cerana* respectively. Other pollinators from the order Hymenoptera were the large carpenter bees of species *Xylocopa fenestrata*, *X. pubescens*, *Megachile* sp., *Lasioglossum* sp., *Polistes olivaceus*, and *Andrena pilipes*. Insect pollinators from the order Diptera were *Episyrphus balteatus*, *Eristalis tenax*, and *Eristalis aeneus*. Pollinators from order Lepidoptera were *Vanessa cardui*, *Pieris brassicae*, and *Papilio demo- leus*. Insect visiting flowers from order Coleoptera observed was *Coccinella septempunctata*. They mainly visited the flowers of both plants for nectar and pollen collection. Lepidopteran were mainly visited for nectar purpose while hymenoptera and Diptera were for both. Coleoptera mainly visited for pollen collection. In Hymenoptera mostly pollinators were from family Apidae.

Roy *et al*. in 2014 has conducted a research on foraging activities of the insect visitors of Mustard in West Bengal. In thir studies they have reported 24 different insects pollinating over mustard flowers. These 24 insects were belonging to thirteen different families of six different orders. Among six different orders, Lepidoptera (33%) was the dominant one (Figure No. 3).

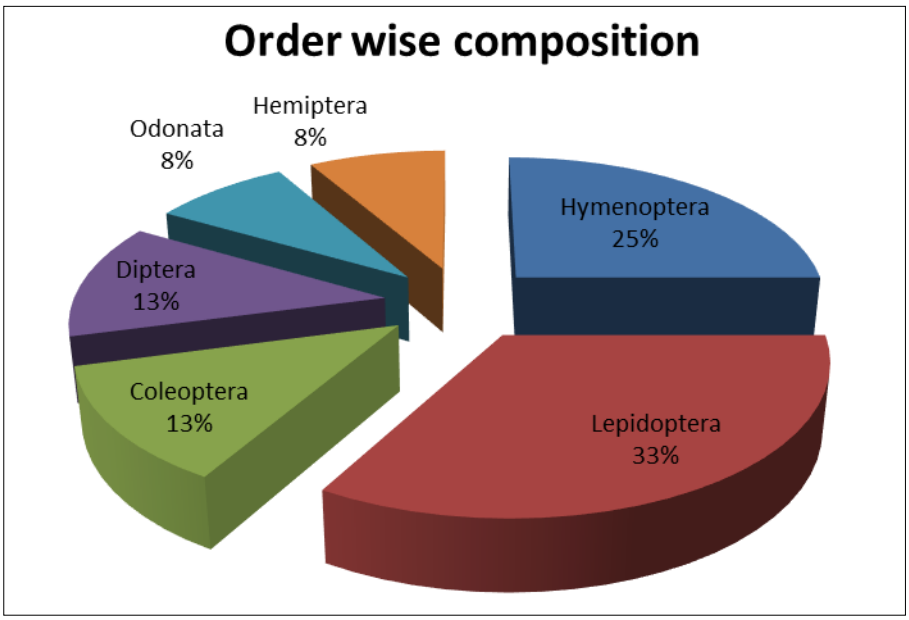

Fig 3: Order wise composition of pollinators of mustard

Among 13 different families Family Nymphalidae consisting of 4 insects was the most dominant one followed by Apidae (3). The other families with their contribution are depicted in Figure No. 4.

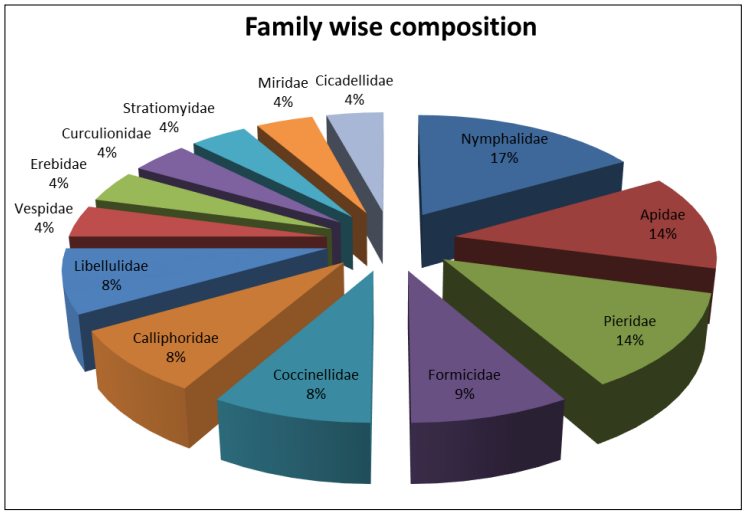

Fig 4: Family wise composition of pollinators of mustard

Among the pollinators, *Apis dorsata* was highest in number (18%) among the visitors of mustard flower, followed by *Coelophora unicolor* (16%), *Apis cerana indica* (15%), *Solenopsis geminata* (15%), *Vespa* sp (5%). Among the dipterans, *Chrysomya megacephala* (4%) and *Stomorhina discolor* (4%); *Coccinella septempunctata* (4%) of Coleoptera and leafhoppers (3%) of Hemiptera were found in mustard flowers. Others insect species like *Danaus chrysippus*, *Euploea core*, *Junonia atlites*, *Junonia almana*, *Catopsilia pomona*, *Delias eucharis*, *Pieris brassicae*, *Amata cyssea* of Lepidoptera, *Brachythemis contaminate* and *Crocothemis servilia* of Odonata, *Diacamma rugosum* of Hymenoptera, *Capsus stramineus* of Hemiptera and *Hermetia illucens* of Diptera were very insignificant in numbers.

Goswami *et al*. in his studies on impact of honey bee pollination on pod set of mustard (*Brassica juncea* l.: cruciferae) at pantnagar during 2013 has revealed that the mustard flowers were attracting 19 different insects belonging to belonging to 9 different families of two orders. Among the orders Hymenoptera (15) was the most dominant one consisting of 7 families followed by Diptera (4). (Figure No. 5)

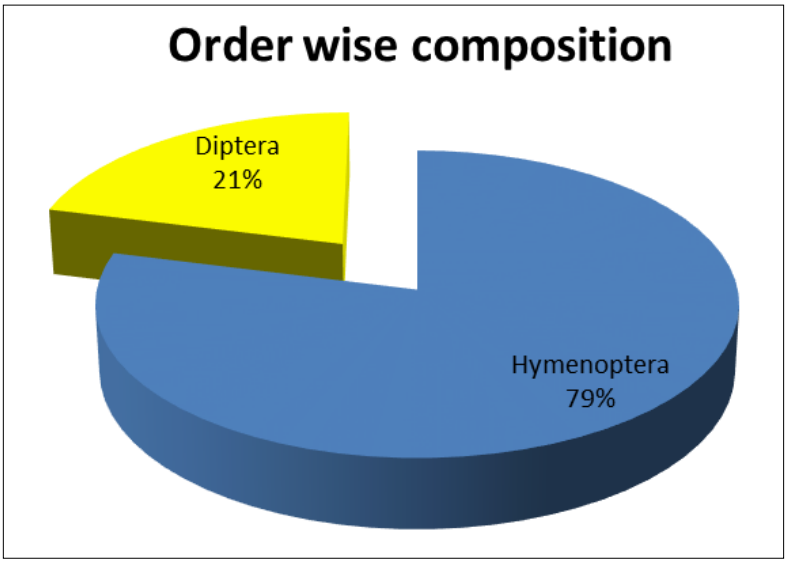

Fig 5: Order wise composition of pollinators of mustard

Among families from Ordeer Hymenoptera and Diptera, Family Apidae (6) was the most dominant one followed by Scollidae (3), Syrphidae (3), Halictidae (2), Magachilidae (1), Anthophoridae (1) and Sphecidae (1) Xylocopidae (1) and Muscidae (1). Besides this some Lepidopterans visitor belonged to families Pieridae (1) observed on mustard flowers. Different pollinators pollinating mustard flower are mentioned in the given Table No. 1

Table 1: Diversity of different insect visitors on flowers of mustard (*B. juncea*) at Pantnagar

S. No.	Insect visitor	Common name	Order	Family
1	*Apis mellifera*	Italian honey bee	Hymenoptera	Apidae
2	*Apis dorsata*	Rock bee	Hymenoptera	Apidae
3	*Apis cerana indica*	Indian honeybee	Hymenoptera	Apidae

4	*Apis florea*	Little honeybee	Hymenoptera	Apidae
5	*Ceratina sexmaculata*	Small carpenter bee	Hymenoptera	Apidae
6	*Tetragonula laeviceps*	Stingless bee	Hymenoptera	Apidae
7	*Scolia (Discolia) binolata*	Scolid wasp	Hymenoptera	Scollidae
8	*Campsomeriella annulata*	Scolid wasp	Hymenoptera	Scollidae
9	*Campsomeriella collaris*	Scolid wasp	Hymenoptera	Scollidae
10	*Megachile disjuncta*	Leaf cutter bee	Hymenoptera	Megachilidae
11	*Xylocopa iridipennis*	Carpenter bee	Hymenoptera	Xylocopidae
12	*Anthophora* sp.	Digger bee	Hymenoptera	Anthophoridae
13	*Halictus* sp.	Sweat bee	Hymenoptera	Halictidae
14	*Nomia* sp.	Alkali bee	Hymenoptera	Halictidae
15	*Sphex* sp.	-	Hymenoptera	Sphecidae
16	*Syrphus corollae*	Syrphid fly	Diptera	Syrphidae
17	*Episyrphus valtiatus*	Syrphid fly	Diptera	Syrphidae
18	*Eristalis tenax*	Drone fly	Diptera	Syrphidae
19	*Musca domestica*	House fly	Diptera	Muscidae

Naumkin *et al.* in his studies conducted at Orel State Agrarian University, Orel City, Russia during 2000-2012 has recorded 83 species of insect pollinators. Insects from 10 different taxonomic groups have been identified out of which 57% of the collected insects are hymenopterans. The percentile contribution of pollinators on mustard is enlisted below.

Table 2

№	Insects groups	% of total number
1	Wild bees (Apidae)	42,3
2	Anthomyias (Anthomyiidae)	19,8
3	Honey bees (Apis mellifera)	13,8
4	Flower flies (syrfids) (Syrphidae)	10,2
5	Ichneumons (Johneumonidae)	8,1
6	Golden-eyed flies (Chrysopidae)	1,5
7	Ladybirds (Coccinellidae)	1,4
8	Bumblebees (Bombys)	0,9
9	Soldier beetles (Cantharidae)	1
10	Ground beetles (Carabidae)	1

Conclusion

The present review concludes that being a self-incompatible plant, mustard attracts a diversified numbers of pollinators for its seed production. Order wise Hymenoptera is the most dominant comprising of honeybees, wasps and leaf cutter bees followed by Adults of Lepidopterans and Dipterans. The present review also envisages that the present status of diversity in pollinators on mustard is much more lower as compared to past status of diversity of pollinators.

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