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Diversity and abundance of insect visitors/pollinators on different genotypes of *Brassica* spp.

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Abstract

Studies on diversity and abundance of insect pollinators on different cultivar of *Brassica* spp. were carried out and found eighteen bee species belonging to twelve families of five different orders were recorded visiting on the flowers of rapeseed-mustard genotypes. Order Hymenoptera contributed maximum diversity of pollinators followed by Diptera, Lepidoptera, Hemiptera and Coleoptera. Among hymenopterans, honey bees, *Apis cerana* F., *Apis mellifera* L., *Apis florea* F. and *Apis dorsata* F. were the most frequent visitors and in genotypes TH 68 and HNS 0901 experienced highest diversity. *A. mellifera* was most abundant during different day hours (1000. 1200. 1400 and 1600 h) among different *Apis* spp. on all genotypes. *A. mellifera*, *A. cerana* and *A. florea* population was found maximum in variety TH 68 whereas *A. dorsata* was most abundant on BSH-1 and HC-212. The mean densities of *A. mellifera* was maximum followed by *A. cerana*, *A. dorsata* and *A. florea*. *A. florea* was most abundant on variety TH 68 and genotype HC-212 (9.93 and 9.07 bees/m²/10 min respectively).

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Introduction

Rapeseed-mustard crop accounts about one-third of the oil produced in India, making it the country's key edible oilseed crop. Haryana is the second most important rapeseed-mustard producing state in the country with an area of 0.51 million ha, production of 0.95 million tonnes and productivity of 1830 kg/ha (2016-2017) which is highest in the country (Anonymous 2020). It is the major oilseed crop of Haryana, occupying 65 per cent of the area under cultivation during Rabi (winter) season. It is also the major bee forage crop in North India

and is visited by various insect pollinators. Rapeseed-mustard crop in India includes conventionally grown native species, namely brown sarson (*B. campestris* L. var. brown sarson), toria (*Brassica campestris* L. var. toria), yellow sarson (*B. campestris* L. var. yellow sarson), Indian mustard [*B. juncea* (L.) Czernj & Cosson], black mustard [*B. nigra* (L.) Koch] and taramira (*Eruca sativa* Mill) along with non-native species like white mustard (*Sinapis alba* L.), gobhi sarson (*B. napus* L.) and Ethiopian mustard/karanrai (*B. carinata*). The different *Brassica* spp. requires

external pollinating agents like insects for transfer of the pollen grains from anther to stigma. Among various insect pollinators that visited *B. juncea* flowers, honey bees viz. *A. dorsata*, *A. cerana*, *A. mellifera* and *A. florea* constituted the major proportion (Abrol 2007) and reported to be sympatric in existence on rapeseed mustard crop (Chaudhary 2006). Their capability to coexist successfully depends on sufficient food resource partitioning (Roubik 1989). For selection and exploitation of the host, different *Apis* spp. follows a precise pattern over time and space. Other important wild bees, pollinating *Brassica* oilseed crops include mining bees (Andrenidae), plasterer bees (Colletidae), mason bees, leafcutter bees (Megachillidae), sweat bees (Halictidae), carpenter bees (Xylocopidae) and other solitary bees (Kunjwal et al. 2014; Goswami et al. 2014). It is necessary to understand the importance of pollinators and pollinizers species richness or diversity in their natural habitat and role in crop improvement. The pollination with honeybees, knowledge about pollinizers, pollinators management and artificial pollination are major inventions to enhance the yield and quality in horticultural crops,

since they are highly cross pollinated crops, and promote beekeeping industry to produce good quality honey (Haldhar et al. 2018; Haldhar et al. 2021). Abundance and foraging behavior of honey bees vary from species to species and genotype to genotype of the host plants. Honey bees respond to specific odors of nectar (relative attractiveness to flowers) and the quantity of harvestable nectar influences the frequency of visits of honey bees to flowers.

Materials and Methods

Flower visitors/pollinators on different genotypes of rapeseed-mustard crop were collected by using a cone type hand net through sweeps at two hours interval during 1000 to 1600 hrs. Collected insects were killed and preserved as dry specimen for identification. The preserved and collected insects were further identified with the reference collection of Apiculture Laboratory, Department of Entomology, CCS HAU, Hisar (Haryana). Abundance of major flower visitors/pollinators on different *Brassica* spp. flowers was recorded by visual observation from per square meter area of crop for 10 minutes for three consecutive sunny days using a hand tally counter.



Plate 1: *Apis mellifera* visiting on mustard flowers



Plate 2: *Apis dorsata*



Plate 3: *Apis cerana*



Plate 4: *Apis florea*

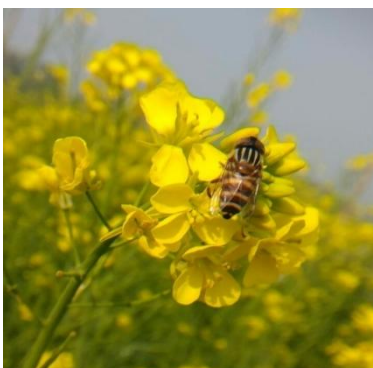


Plate 5: *Eristalinus* sp. visiting on mustard flowers



Results and Discussion

Diversity and abundance of insect pollinators/visitors was influenced by the number of flowers and also the maximum activity of pollinators was recorded during peak flowering (3rd stage of flowering) compared with 1st, 2nd, 4th and 5th stage of flowering. Insect visitors attracted more to the plants having more number of flowers as compared to plants with few flowers (Free 1993). Also, the activity of pollinators/visitors was highest on mid- hrs (1200-1400 h) of the day than at morning (1000h) and evening (1600h) and it was fluctuating with the time span of flower blooms and weather parameters i.e. temperature, relative humidity, wind speed and sunshine (hrs). In the present investigation during 2019-20 at Hisar (Haryana), flowers of various *Brassica* spp. attracted wide varieties of insects belonging to 5 orders, 12 families, 14 genera and 18 species. Out of them nine species were found belonging to order Hymenoptera, four to Diptera, three to Lepidoptera, one to Coleoptera and one to Hemiptera. The Hymenopterans were the major floral visitors comprising of nine species from four families viz. Apidae (*Apis cerana* Fabricius, *A. mellifera* Linnaeus, *A. florea* Fabricius, *A. dorsata* Fabricius, *Trigona* spp., *Xylocopa fenestrata* Fabricius.), Scoliidae (*Compsomeriella* sp.), Halictidae (*Lasioglossum* spp.) and Andrenidae (*Andrena* spp.)

They were followed in order of diversity by dipterans comprising of four species from three families viz., Syrphidae (*Episyrphus* sp. and *Eristalinus obscuritarsus* Meijere), Calliphoridae (*Chrysomya rufifacies* Macquart), Muscidae (*Musca domestica* Linnaeus). Dipterans were followed by Lepidopteran visitors comprising of three species from two families viz., Nymphalidae (*Danaus chrysippus* Linnaeus and *Venessa cardui* Linnaeus) and Pieridae (*Pieris brassicae* Linnaeus). The least diversified orders were Hemiptera consisting of one species viz., Pentatomidae (*Bagrada hilaris* Burmeister) and order Coleoptera comprising one species from family Coccinellidae (*Coccinella septempunctata*).

Out of these, *A. cerana indica*, *A. mellifera*, *A. florea* and *A. dorsata* were the major and most frequent visitors/pollinators. Das and Jha (2018) reported a total of thirteen insect species visiting Indian mustard among which six species were recorded from order Hymenoptera (*Apis florea*, *A. dorsata*, *A. mellifera*, *A. cerana indica*, *Ceratina* spp., *Halictus* spp. and), five species from order Diptera (*Muscadomestica*, Linnaeus *Episyrphus* spp., *Sarcophaga* spp., *Chrysomya* spp. and *Eristalinustabanoides* Jaennicke) and two species from order Lepidoptera (*Pieris* spp. and *Amata bicincta* Kollar). Hymenopteran insects were the most important visitors followed by Dipterans and Lepidopterans. Honey bees (*Apis* spp.) were

most abundant, consisting of about 74.52 per cent population of the total pollinators. Devi *et al.* (2017) observed eighty-eight insects belonging to 11 orders, 31 families and 63 genera which were visiting the flowers of Indian mustard. Among them hymenopterans visitors were most abundant comprising of 12 families viz. Formacidae, Andrenidae, Crabonidae, Vespidae, Pompilidae, Ichneumonidae, Tenthredinidae, Halictidae, Sphecidae, Scoliidae and Apidae).

Shakeel *et al.* (2018) reported a total of 20 species belonging to four orders i.e. Hymenoptera, Diptera, Lepidoptera and Coleoptera in *Eruca sativa* Mill. and *Brassica rapa* L. The highest abundance of pollinator

species belonged to Hymenoptera. The most prominent insect pollinator species were *A. mellifera* followed by other three honey bee species of *A. cerana*, *A. florea*, and *A. dorsata*, respectively. From Diptera, four species of syrphid fly and one species from Muscidae; from order Lepidoptera *Pieris brassicae*, *Vanessa cardui*, and *Papilio demoleus* were recorded. Lady bird beetle *Coccinella septempunctata* was recorded from Coleoptera order as occasional visitor. It was noticed that *E. sativa* attracted more insect pollinators than *B. rapa* which may be attributed to different amount and chemical properties of nectar, with number of pollen grains, and flower canopy of both crops.

Table 1. Flowers visiting insects/pollinators on different rapeseed-mustard varieties/ genotype at Hisar

S. N.	Common name	Scientific name	Family	Order
1.	European honey bee	<i>Apis mellifera</i> Linnaeus***	Apidae	Hymenoptera
2.	Indian honey bee	<i>Apis cerana indica</i> Fabricius***	Apidae	Hymenoptera
3.	Giant honey bee	<i>Apis dorsata</i> Fabricius***	Apidae	Hymenoptera
4.	Little honey bee	<i>Apis florea</i> Fabricius***	Apidae	Hymenoptera
5.	Sting less bee	<i>Trigona</i> spp.**	Apidae	Hymenoptera
6.	Carpenter bee	<i>Xylocopa fenestrata</i> Fabricius***	Apidae	Hymenoptera
7.	Sand bee	<i>Andrena</i> sp.***	Andrenidae	Hymenoptera
8.	Sweat bee	<i>Lasioglossum</i> sp. ***	Halictidae	Hymenoptera
9.	Scoliid wasp	<i>Campsomeriella</i> sp. ***	Scoliidae	Hymenoptera
10.	Hover fly	<i>Episyrphus</i> sp.**	Syrphidae	Diptera
11.	Hover fly	<i>Eristalinus</i> sp.**	Syrphidae	Diptera
12.	Blow fly	<i>Chrysomya rufifacies</i> Macquart*	Calliphoridae	Diptera
13.	House fly	<i>Musca domestica</i> Linnaeus*	Muscidae	Diptera
14.	Monarch butterfly	<i>Danaus chrysippus</i> Linnaeus*	Nymphalidae	Lepidoptera
15.	Painted lady butterfly	<i>Vanessa cardui</i> Linnaeus*	Nymphalidae	Lepidoptera
16.	Cabbage butterfly	<i>Pieris brassicae</i> Linnaeus*	Pieridae	Lepidoptera
17.	Painted bug	<i>Bagrada hilaris</i> Burmeister*	Pentatomidae	Hemiptera
18.	Ladybird beetle	<i>Coccinella septempunctata</i> *	Coccinellidae	Coleoptera

*Less frequent visitors; **Frequent visitors; ***Most frequent visitors

Abundance of *Apis* spp. at 1000 h on various rapeseed-mustard varieties/genotypes

Data on the abundance of various *Apis* spp. on different varieties/genotypes of rapeseed-mustard at 1000 h of the day during 2019-20 have been depicted in Fig 1. At 1000 h, *A. mellifera* was most abundant among different *Apis* spp. on all varieties/genotypes except HC-212, BSH-1, Giriraj (DRMRIJ-31) and RCH-1. *A. mellifera* population was found maximum in variety TH 68 (22.93 bees/m²/10 min) and minimum in Nigra (10.20 bees/m²/10 min) and in all other varieties/genotypes population vary from 10.20-16.87 bees/m²/10 min with significant variation. *A. cerana* population vary from 8.87-14.47 bees/m²/10 min in different varieties/genotypes and all these varieties/genotypes vary significantly from each other except genotype HNS 0901 which was found statistically at par with variety T-27. *A. dorsata* was most abundant on genotype HC-212 (15.20 bees/m²/10 min) and variety BSH-1 (14.87 bees/m²/10 min) with non-statistical variations and rest of varieties/genotypes vary significantly from each other. Population of *A. florea* was most abundant on variety TH 68 (11.33 bees/m²/10 min) and its population varied from 5.00-10.53 bees/m²/10 min on rest of the varieties/genotypes.

Abundance of *Apis* spp. at 1200 h on various rapeseed-mustard varieties/genotypes

Fig 2 shows the data on abundance of different *Apis* spp. on the flowers of various varieties/genotypes of rapeseed-mustard at 1200 h of the day during 2019-20. At 1200 h, *A. mellifera* was most abundant among different *Apis* spp. on all varieties/genotypes except Nigra, T-27, BSH-1, Giriraj (DRMRIJ-31) and HC-212. *A. mellifera* population was found maximum in variety TH 68 (26.80

bees/m²/10 min) and minimum in Nigra (12.53 bees/m²/10 min) and in all other varieties/genotypes population vary from 13.27-19.80 bees/m²/10 min with non-significant variation. *A. cerana* was most abundant in variety TH 68 (18.33 bees/m²/10 min) and minimum in Nigra (7.47 bees/m²/10 min) and their population vary from 7.47-17.00 bees/m²/10min in different varieties/genotypes and all these varieties/genotypes vary significantly from each other except RH 725, RH 0502, HNS 0901 and BSH-1. Population of *A. dorsata* was most abundant on variety BSH-1 (19.20 bees/m²/10 min) and genotype HC-212 (17.67 bees/m²/10 min) with statistically variations and its population vary from 9.93-14.60 bees/m²/10 min. *A. florea* was most abundant on variety TH 68 (14.13 bees/m²/10 min) and least abundant in genotype RCH-1 (6.80 bees/m²/10 min) and its population in rest of the varieties/genotypes vary from 6.80-12.53 bees/m²/10 min and all these varieties/genotypes vary non-significantly from each other.

Abundance of *Apis* spp. at 1400 h on various rapeseed-mustard varieties/genotypes

Abundance of four *Apis* spp on flowers of different rapeseed-mustard varieties/genotypes at 1400 h of the day has been presented in Fig 3. At 1400 h, *A. mellifera* was most abundant among different *Apis* spp. on all varieties/genotypes except HC-212, BSH-1, Giriraj and RCH-1. *A. mellifera* population was found maximum in variety TH 68 (30.00 bees/m²/10 min) and minimum in Nigra (14.33 bees/m²/10 min) and in all other varieties/genotypes population vary from 14.33-23.47 bees/m²/10 min with significant variation. *A. cerana* was most abundant in variety TH 68 (20.53 bees/m²/10 min) and minimum in Nigra (8.87 bees/m²/10 min) and their population vary

from 8.87-18.93 bees/m²/10 min in different varieties/genotypes and all these varieties/genotypes vary significantly from each other except HNS 0901, HC-212 and BSH-1 which were found at par with each other. Population of *A. dorsata* was most abundant on variety BSH-1 and genotype HC-212 (22.40 and 20.13 bees/m²/10 min) and least abundant on Giriraj and RCH-1 (11.40 bees/m²/10 min) with statistical variations and its population vary from 12.53-16.87 bees/m²/10 min in all other varieties/genotypes. *A. florea* was most abundant on variety TH 68 (16.67 bees/m²/10 min) and least abundant in genotype RCH-1 (8.13 bees/m²/10 min) and its population in rest of the varieties/genotypes vary from 8.13-14.87 bees/m²/10 min and all these varieties/genotypes vary significantly from each other except variety YSH 401 which was found at par with variety BSH-1.

Abundance of *Apis* spp. at 1600 h on various rapeseed-mustard varieties/genotypes

The data on abundance of various *Apis* spp. on the crop blooms of various rapeseed-mustard varieties/genotypes at 1600 h of the day is represented in Fig 4. At 1600 h, bees *A. mellifera* was most abundant among different *Apis* spp. on all varieties/genotypes except HC-212, Giriraj and RCH-1. *A. mellifera* population was found maximum in variety TH 68 (18.73 bees/m²/10 min) and minimum in Nigra (8.93 bees/m²/10 min) and in all other varieties/genotypes population vary from 9.13-15.07 bees/m²/10 min with non-significant variation. *A. cerana* population was most abundant in variety TH 68 (11.27 bees/m²/10 min) and minimum in Nigra (6.40 bees/m²/10 min) and in all other varieties/genotypes their populations vary from 7.93-11.00 bees/m²/10 min with non-significant variation from each other except

BSH-1, Nigra, T-27, Giriraj and RCH-1 which vary significantly from each other. Population of *A. dorsata* was most abundant on variety BSH-1 and genotype HC-212 (15.07 and 14.00 bees/m²/10 min) and least abundant on Nigra (7.47 bees/m²/10 min) and its population vary from 7.67-10.33 bees/m²/10 min in all other varieties/genotypes with non-statistical variations. *A. florea* was most abundant on variety TH 68 and genotype HC-212 (9.93 and 9.07 bees/m²/10 min respectively) and least abundant on genotype RCH-1 and Nigra (5.53 and 6.07 bees/m²/10 min respectively) and its population vary from 6.07-8.67 bees/m²/10 min in all other varieties/genotypes with non-significant differences except TH 68 and HNS 0901.

Pudasaini *et al.* (2015) found honey bees were the dominant group of pollinators in rapeseed (*Brassica campestris* var. *toria*) and among honey bees *A. mellifera* was most dominant pollinator (36.34%) followed by *A. florea* (12.45 %), *A. cerana* (11.14 %) and *A. dorsata* (5.68 %). Similarly, *Andrena* sp. (3.71 %) and *Megachilus* sp. (0.66 %) were also recorded. The other pollinators constituted 22.05 per cent, which included Diptera, Lepidoptera, Orthoptera, Coleoptera and Heteroptera. Roy *et al.* (2014) reported that the abundance of *A. dorsata* was maximum (18 %) in mustard (*Brassica juncea* L.) followed by *A. cerana* (15 %) and *A. florea* (4 %). It was observed that the different weather conditions affected the abundance of honey bees. Vishwakarma and Chand (2017) recorded maximum per cent pollinators' species from order Hymenoptera (44.43 % and 42.22 %) followed by Diptera (36.71 % and 34.36 %), Lepidoptera (17.61 % and 17.86 %), Coleoptera (0.46 % and 4.26 %) and Hemiptera (0.40 % and 1.29 %) in var. Seeta and Benoy respectively. Amongst 14 genera, *Apis* was found to be the most dominant one

in all the varieties and *A. mellifera* was recorded to be most dominant pollinator followed by *A. dorsata*, causing 24.94 per cent pollination in var. Seeta and 23.13 per cent in var. Benoy. The dipteran, *Stomorphina* sp. was found to be a moderately good pollinator.

Srivastava *et al.* (2017) found Hymenopterans were the most dominant (98.18 %) visitors in the bloom of broccoli (*Brassica oleracea* var. *Italica* Plenck). Among the hymenopteran species, *Apis*

dorsata F. was highest in number (47.88 %) followed by *Apis mellifera* L. (30.65 %), *Apis cerana* F. (16.31 %), *Apis florea* F. (3.32 %) and others bees (1.82 %). Shakeel *et al.* (2018) found that in *Eruca sativa* Mill. and *Brassica rapa* L., highest abundance of pollinator species belonged to Hymenoptera. The most prominent insect pollinator species were *A. mellifera* followed by other three honey bee species of *A. cerana*, *A. florea*, and *A. dorsata*, respectively.

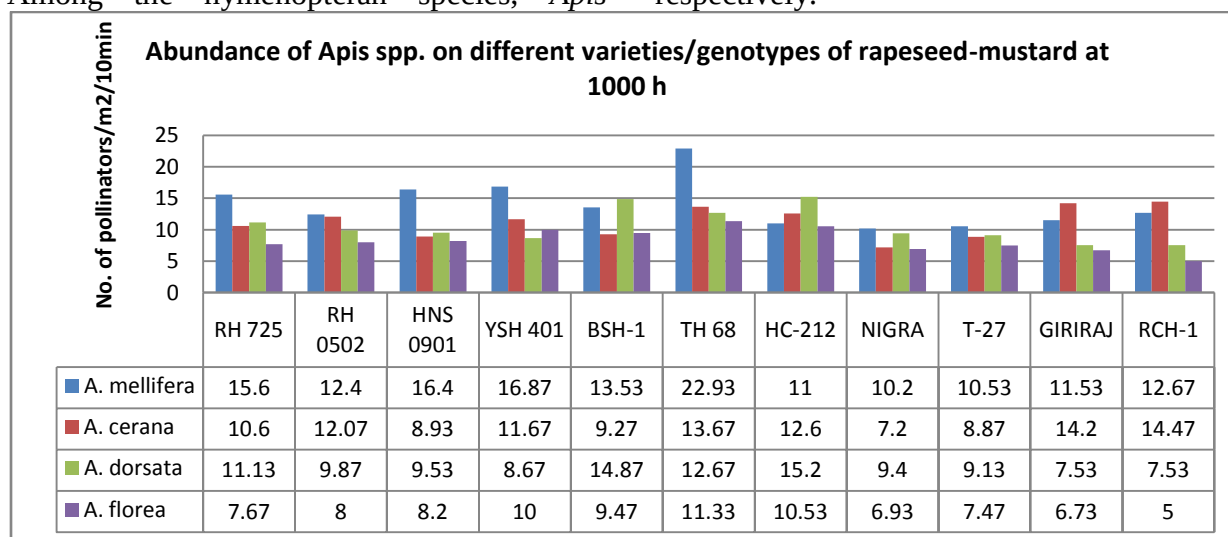


Fig 1. Abundance of *Apis* spp. on different varieties/genotypes of rapeseed-mustard at 1000h at Hisar during 2019-20

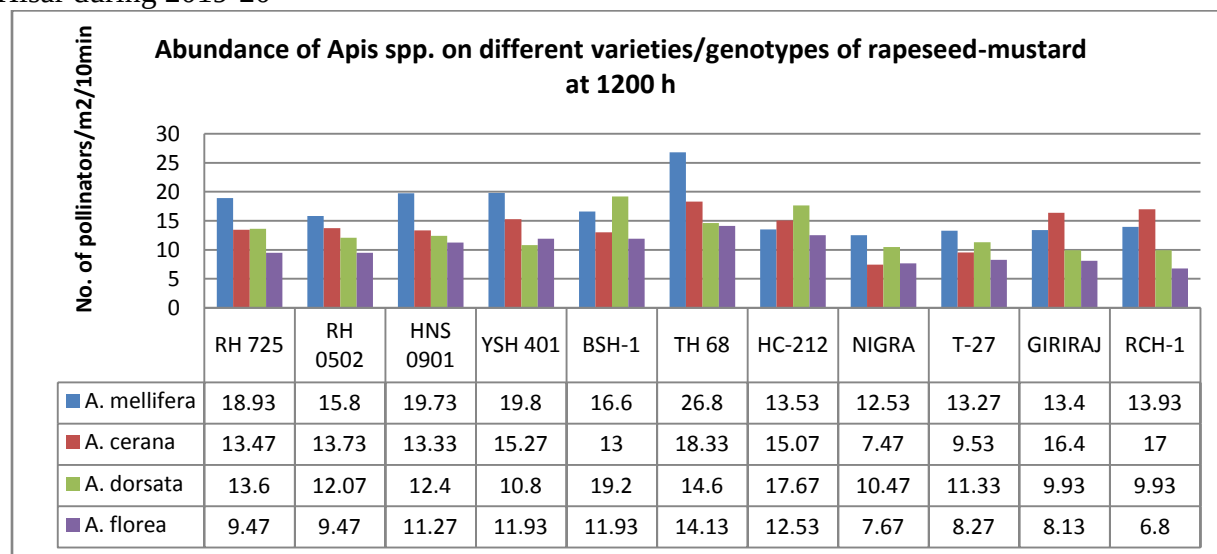


Fig 2. Abundance of *Apis* spp. on different varieties/genotypes of rapeseed-mustard at 1200h at Hisar during 2019-20

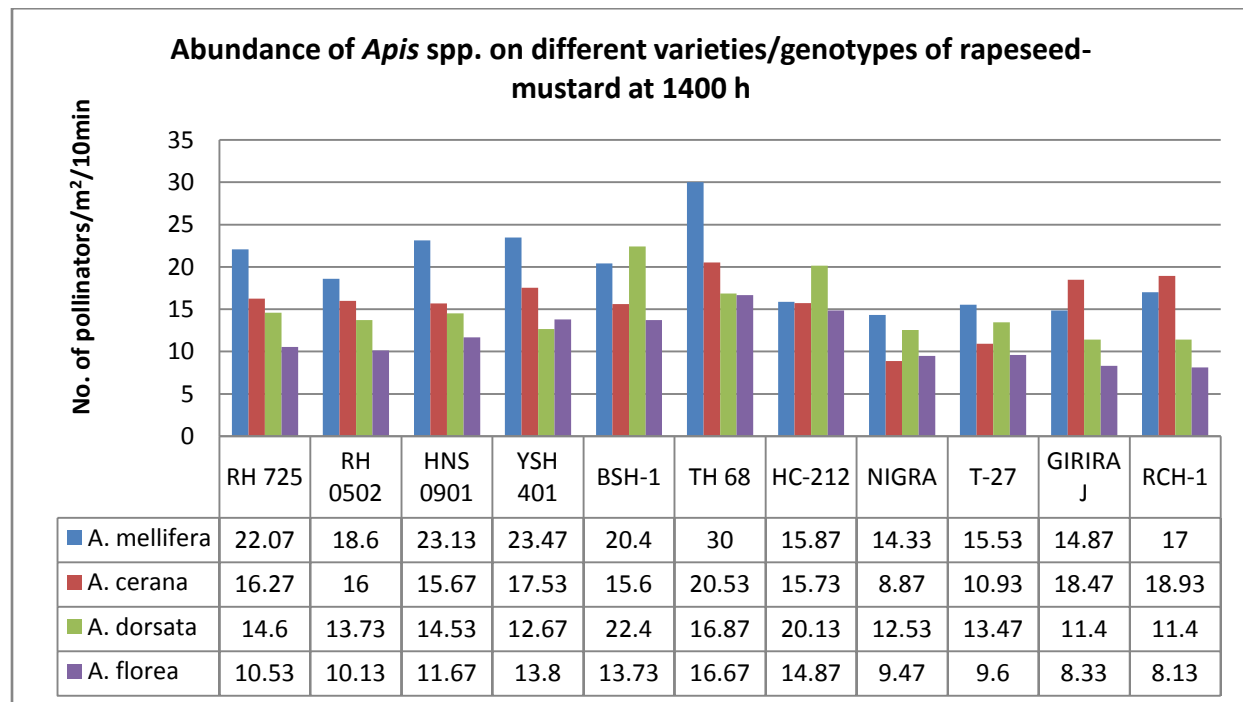


Fig 3. Abundance of *Apis* spp. on different varieties/genotypes of rapeseed-mustard at 1400h at Hisar during 2019-20

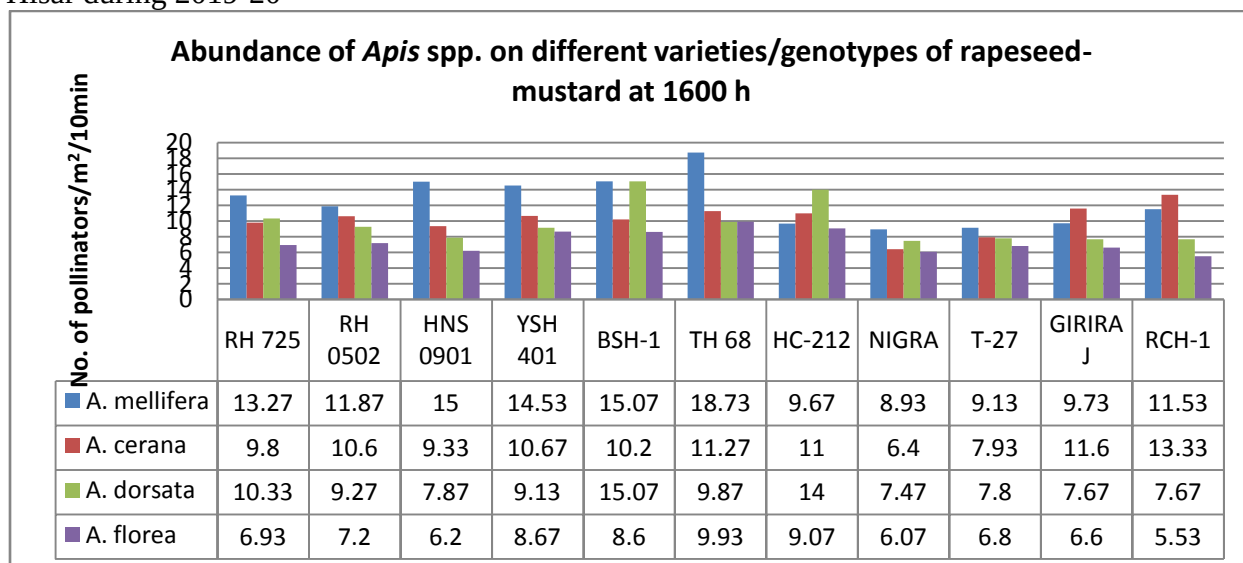


Fig 4. Abundance of *Apis* spp. on different varieties/genotypes of rapeseed-mustard at 1600h at Hisar during 2019-20

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