



Studies on abundance and visitation rate of pollinators in radish (*Raphanus sativus* L.)

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ABSTRACT: Radish, (*Raphanus sativus* L.) a popular edible root vegetable (Family: Brassicaceae), is a highly cross-pollinated crop completely dependent on pollinators for seed set and yield. The present study was carried out at the experimental field of ICAR- Indian Institute of Horticultural Research, Bengaluru, during the *rabi*, 2020- 2021, to study the foraging behaviour of insect pollinators of *R. sativus*. Results indicated that four insect species from Hymenoptera viz., *Apis florea*, *Apis dorsata*, *Tetragonula iridipennis*, and *Apis cerana* and a butterfly, *Delias eucharis* (common jezebel larva), were observed visiting radish flowers. Peak insect visitor activity was observed between 09.00 A.M. to 10.00 A.M. and 12.00 P.M. to 01.00 P.M. during peak flowering time in January. Among the four species of honey bees, *T. iridipennis* was the most abundant (29%), followed by *A. cerana* (28%), *A. florea* (25 %) and *Apis dorsata* (18%).

Keywords: Radish, *Raphanus sativus* L., pollinator visitation rate, honey bee

INTRODUCTION

Radish, *Raphanus sativus* L. (Family: *Brassicaceae*), is a popular edible root vegetable native to the Mediterranean region. It is a cross-pollinated crop with a sporophytic system of self-incompatibility; hence, it completely dependant on pollinators. Pollinators of major field and horticultural crops include honey bees, bumblebees, and many species of solitary bees. The extent of natural cross-pollination in radish is 65% (Stewart *et al.*, 2002). However, the low seed yield problem in radish prevails ranging from 2 to 20g/plant in open pollination. The reason for less seed setting could be due to lesser pollinator availability and visitation and only a few reports are available in radish. Hence, in the present study, an experiment was carried out to determine the abundance of pollinators and their visitation rate in radish in open pollination.

MATERIALS AND METHODS

The field experiment was conducted during the *rabi* season from 2020 to 2021 at ICAR-Indian Institute of Horticultural Research, Bengaluru. The radish (Cv. Arka Nishant) was planted on October 25, 2020, in a plot of 6.6 × 3.6 m, and the experimental design followed was factorial RBD with three replications. The number of plants per plot was 40, with a spacing of 60×60cm. An abundance of major insect pollinators on radish flowers was recorded during the peak flowering period of the crop. The number of pollinators visiting per plant/minute was noted in five randomly selected plants. These observations were recorded from 07:00 A.M. to 05:00 P.M. at half an hour at ten-minute intervals for seven days

each at peak flowering. Insecticides were not used during the blooming period to encourage pollinator activity.

RESULTS AND DISCUSSION

During the study period, it was observed that only honey bee species visited radish flowers regularly and abundantly, whose observations are documented in this study. Apart from these bees, few butterflies were observed in a scattered and negligible proportion, of which only the identity of common jezebel (*Delias eucharis*) could be established. Data on visitation rates by different honey bee species on radish (Cv. Arka Nishant) flowers at different hours during February, 2021 are represented in Table 1. Irrespective of the day hours, the significantly highest number of bees visited in a minute (4.85) was by *T. iridipennis*, followed by *A. cerana* (4.55) and *A. florea* (4.13). It was almost half of the bees visited by *A. dorsata* (2.90 bees/plant/minute) (Table 1). The study was in agreement with Divija *et al.* (2022) and Sharma *et al.* (2016) on radish blooms Cv. Pusa Himani and Pritish *et al.* (2012) on Radish Cv. Punjab Safeda. The work by Nandini *et al.* (2018) on okra flower also supported that the abundance of Hymenopterans was maximum than other insects.

Irrespective of the bee species, significantly the highest number of bees visited (6.50 bees/plant/min) between 11:00 to A.M. to 12:00 P.M. of a day, followed by 10:00 to 11:00 AM, 9:00 AM to 10:00 AM and 12:00 AM to 13:00 P.M., which were on par with each other (11-14% bees/plant/min) (Fig.1). Similarly, Mahfouz *et al.* (2012) observed a maximum number of honeybees from 9:00 AM to 11:00 AM. The number of bees was

Table 1. Visitation rate of pollinators in radish Cv. Arka Nishant (number per plant per minute) during daytime

Bee Species	0700 - 0800	0800 - 0900	0900 - 1000	1000 - 1100	1100 - 1200	1200 - 1300	1300 - 1400	1400 - 1500	1500 - 1600	1600 - 1700	Mean A
<i>Apis florea</i>	3.44	4.14	4.44	5.86	6.00	5.16	3.71	3.13	2.71	2.71	4.13
<i>Apis cerana</i>	0.29	5.43	6.86	5.43	6.43	4.44	5.00	5.02	4.43	2.15	4.55
<i>Tetragonula iridipennis</i>	2.72	2.43	7.44	8.14	9.43	7.14	2.86	2.72	3.29	2.29	4.85
<i>Apis dorsata</i>	0.71	4.00	2.30	1.71	4.14	3.29	2.71	2.85	4.14	3.15	2.90
Factors	C.D.			SE(d)			SE(m)				
Bee Species	0.030			0.015			0.010				
Day hours	0.047			0.023			0.017				
Bee Species X Day hours	0.094			0.047			0.033				



Fig 1. Insect foragers on radish flowers

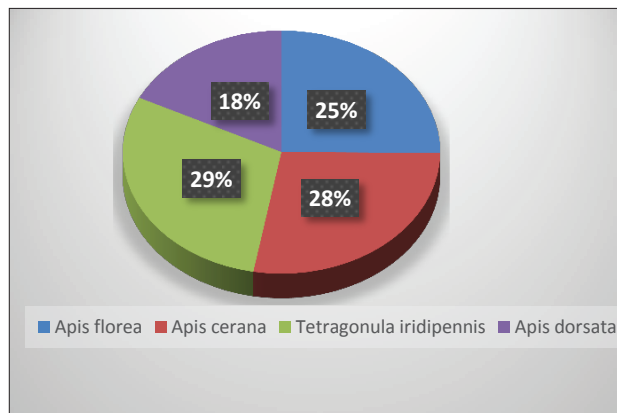


Fig 2. Proportion of insect visitors on radish during the peak flowering period

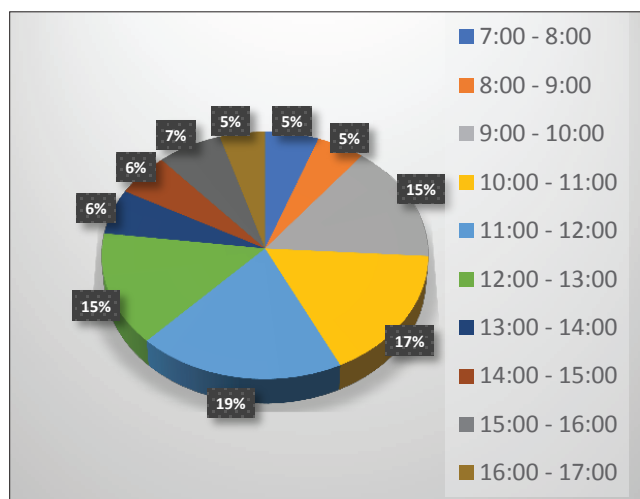


Fig 3. The abundance of insect visitors on radish flowers from morning 7 AM to evening 5 PM

drastically reduced from 3:00 PM to 4:00 PM. Neeraj and Ramashrit (2005) also found that the maximum foragers (*Apis* spp.) were at 11:00 AM, while the least number was observed at 3:00 PM.

When both the bee species and day hours were considered, significantly highest flowers were visited by *T. iridipennis* between 11:00 AM to 12:00 noon, followed by *A. cerana* and *A. florea*, which were on par with each other and less number of visitations by *A. dorsata*. Among the four species studied, *A. cerana* was the early visitor in huge numbers (5.43 flowers at 8:00 to 9:00 AM and 10:00 to 11:00 AM which was statistically third highest for that species after 11:00 AM to 12:00 noon and 9:00 to 10:00 AM to 13:00 hr of a day and during the rest of the day, it was half of the mean flower visited. Flower visitation by *A. florea* was almost consistent for most of the day, with peak hours from 11:00 AM to 12:00 noon. The *A. dorsata* visitation rate appeared in

a tri-modal distribution with peaks from 11:00 to 12:00 noon, 15:00 to 16:00, and 9:00 to 10:00AM (Table 1). *T. iridipennis* had the highest abundance (29 %) of the four honey bee species, followed by *A. cerana* (28 %) and *A. florea* (25 %), with *A. dorsata* being the lowest (Fig. 2). They play an important role in flower pollination. The total abundance of all visitor bees was most significant in the middle of the day, *i.e.*, at 10 AM and 01.00 PM. Murphy and Robertson (2000) also reported that the abundance and diversity of insect pollinators varied considerably between observational periods. Other studies also illustrated that the abundance of insect pollinators differed across the time of the day but increased around midday (10:00 AM to 12:00 noon) (Semida and Elbanna 2006; Andrej and Anton 2006). Considering all these parameters for establishing the effective visitors of the crops, *T. iridipennis*, *A. cerana*, and *A. florea* were the most effective visitors of the radish crop in this study.

CONCLUSION

Based on the current findings, radish flowers were found to be highly attractive to a wide range of insect species, particularly those in the order Hymenoptera. *Tetragonula iridipennis*, *Apis cerana*, *Apis florea*, and *Apis dorsata* were the most abundant and frequent visitors to the radish flower, according to abundance and visitation rate.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to the Director, ICAR- IHR, Bengaluru for providing the necessary facilities for the experiment.

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MS Received: 06 November 2022
MS Accepted : 28 December 2022