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Studies on Foraging Behaviour of Honeybees on Flowers of Rapeseed Crop

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This paper represents foraging behaviour of honeybees on the flowers of rapeseed crop; *Apis cerana indica* started foraging at 07.10hr and ceased their foraging activity at 17.25hr. Thus, the duration of foraging activity was 10.15hr which was maximum foraging period, followed by *A. florea* (08.00hr to 05.00hr and 09.00hr) and *A. dorsata* (07.50hr to 03.00hr and 07.10hr) respectively. *A. cerana indica* spent maximum time of 6.57 ± 0.43 sec/flower followed by *A. dorsata* 6.55 ± 0.26 sec/flower and and *A. florea* 4.4 ± 0.27 sec/flower. Maximum number of flowers visited by *A. dorsata* of 11.3 ± 2.3 flowers/ min then *A. cerana indica* of 9.7 ± 2.6 flowers/ min and *A. florea* of 6.3 ± 1.2 flowers/ min.

Keywords: Foraging; honey bee; rapeseed; A. cerana indica; A. dorsata; A. florea.

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1. INTRODUCTION

"Pollination is an essential process in maintaining a healthy and bio-diverse ecosystem. Pollination not only improves the yield of the crop, but it also contributes to uniform and early pod setting" [1]. "It increases the yields in the number of pods, seed per pod, seed weights per plant" [2]. "Insect pollination is the most economic and important to increase the yield of crops" [3,4]. "Various insect groups play an important role in pollination of different agricultural, horticultural and medicinal herbs crops. It belongs to the orders hymenoptera, diptera, coleoptera, lepidoptera, thysanoptera, hemiptera and neuroptera" [5-8]. "Bees are best pollinator because of suitable body size, hairiness, thoroughness, steadfastness, floral constancy and its populations" [9].

Honeybees have also been documented as the most frequent visitors of rapeseed flowers [10]. "They visit rapeseed flowers for collection of both pollen and nectar which results into florets cross pollination" [11,12]. The act of gathering pollen and nectar from bee flora is known as foraging behavior for the production of honey.

Earlier few works has been reported to be done on the foraging behaviour of honey bee and its role in pollination of rapeseed in different places by some research workers [13-17]. "But it has become increasingly clear that the pollination needs of a crop species vary greatly with locality concerned where it is grown" [17]. It is therefore, necessary to study the foraging behaviour of honey bees under the agro climatic conditions and also the role of honey bee in the quantity and quality of rapeseed production.

2. MATERIALS AND METHODS

The field experiment was conducted at Binjagiri Agriculture Research Station, Chhatabara, Bhubaneswar, IAS, SOADU during *Rabi* 2022-23 on rapeseed was Sushree. The experiment was laid out in RBD with 4 treatments (viz., T1- OP with spray application of honey 5% solution, T2- OP with spray application of sugar 10% solution, T3- OP with spray application of jaggery 10% solution and T4- OP without spray) and 5 replications. Observations on frequent visit of insect pollinators and honey bees to the rapeseed flowers were recorded daily on per square meter area of open pollinated (without spray) plot for 5 min at 09.00, 11.00, 13.00, 15.00hr during peak flowering period. Observations on the foraging behaviours of the bees were made on control plot without any spray with a stop watch on the daily time of initiation and cessation of foraging, total duration of foraging activity, peak foraging hours, number of flowers visited per minute by one bee, time spent on flowers at different hours of the day.

The foraging speed of honey bees was recorded in terms of time spent in second on a single flower by the insect forager collecting either nectar or pollen on the flowers of rapeseed crop at two hourly intervals starting from 9.00AM to 3.00PM during peak blooming period consecutively for 5 days from open pollinated plot. Foraging rate was assessed on the basis of number of flowers visited by an individual forager per minute of time at two hourly intervals starting from 9.00AM to 3.00PM during peak blooming period for 5 days from open pollinated plot. Pollen foragers were recognized by observing pollen load situated on hind leg baskets. For recording nectar foragers when bees protruded their proboscis for collecting nectar at the base of ovary, such bees were recognized as nectar forager. The pollen and nectar foraging time was noted for various bee species.

3. RESULTS AND DISCUSSION

3.1 Foraging Time of Honeybees

Foraging time (time spent in seconds on a single flower by the insect forager collecting either nectar or pollen) of different bee species on *B. nigra* flowers was recorded during peak blooming period at different day hours and presented in Table 1 and Fig. 1. On an average, maximum foraging time was observed by *A. cerana indica* (6.57 ± 0.43 sec/flower), *A. dorsata* (6.55 ± 0.26 sec/flower) and *A. florea* (4.4 ± 0.27 sec/flower). However, the time spent on a single flower was higher for *A. cerana indica* (7.04 s), *A. florea* (4.80 s) at 11.00 am and by *A. dorsata* (6.84 s) at 9.00 am of the day hours.

In an earlier study carried out by Kumar et al. [18] revealed that *A. mellifera* exhibited higher foraging speed than solitary bees on mustard flower. More recently, Kunjwal et al. (2014) reported that *A cerana indica* spent more of 3.10 s in Kranti variety than *A. mellifera* (2.23 s) and *A dorsata* (3.03 s) in EC399313 variety. According to them *A. mellifera* showed maximum foraging speed which was more or less similar at 12.00 pm and 2.00 pm, 2.25 s and 2.24 s respectively while *A. cerana* at 4.00 pm (0.74 s). For *A*

dorsata it was observed highest at 2.00 pm (1.05 s) whereas *T laeviceps* had a maximum foraging speed of 9.88s at 12.00 pm.

3.2 Foraging Rate of Honeybees

The foraging rate (number of flowers visited by an individual forager per minute of time) of different bee species on *B. nigra* flowers was recorded during peak blooming period at different day hours (Table 2, Fig. 2). On an average foraging rate of different bee species observed in the present study was highest with 11.3 ± 2.3 flowers/ min by *A. dorsata*, 9.7 ± 2.6 flowers/ min by *A. cerana indica* and 6.3 ± 1.2 flowers/ min by *A. florea*.

Considering the number of flowers visited per minute by honeybee species at different day hours, *A. dorsata* and *A. florea* covered maximum flowers of 12.9 – 13.5/min and 6.3 – 8.1/min respectively during 9.00 to 11.00 am. Whereas *A. cerana indica* was found to visit more number of flowers per minute (11.5 – 12.5) during 11.00 am to 1.00 pm. It was observed that during the peak activity of *A. dorsata* there was a transient decrease in *A. c. indica* activity. This is due to the asymmetric interspecific competition, which could cause *A. cerana indica* to move its peak activity later (11:00 am-1:00 pm) than *A.dorsata* (9.00 -11.00 am).

Abrol and Kapil [19] reported that "the foraging rates of various bee species differed substantially in different oilseed crops in Hisar, India. In various cruciferous crops, *A. florea* visited 4.2 to 8.5 flowers per minute and 10.2 in sunflowers, whereas *A. dorsata* visited 4.9 to 13.5 flowers per minute in cruciferous crops". Rana et al. [20] observed "higher foraging activity at 12.00 hr of both *A. mellifera* and *A cerana indica* than at 09.00 hr. However, in both the species, there were no significant differences in the population of bees between 12.00 and 15.00 hr". Kunjwal et al. [21] revealed that "the overall mean of foraging rate of insect pollinators observed in the study was highest with 11.48 flowers/min by *A. mellifera*, 2.09 flowers/min by *A. cerana indica*, 4.03 flowers/min by *A. dorsata* and 1.93 flowers/min by *T. laeviceps* at 12.00 pm". However, in our observations higher number of bees of *A. dorsata* was observed than *A. cerana indica* followed by *A. florea*. *A mellifera* was completely absent in our investigation in rape seed crop.

Table 1. Foraging time of honeybee species on flowers of the rapeseed crop during peak blooming period

Honeybee pollinators	Time spent in second/flower/honeybee*				Mean ± SD
	9:00 AM	11:00 AM	1:00 PM	3:00 PM	
A. cerana	6.80	7.04	6.36	6.08	6.57 ± 0.43
A. dorsata	6.84	6.68	6.44	6.24	6.55 ± 0.26
A. florea	4.36	4.80	4.28	4.16	4.4 ± 0.27
A. mellifera	00	00	00	00	00

**Mean data of 5 days observations at 5 locations*

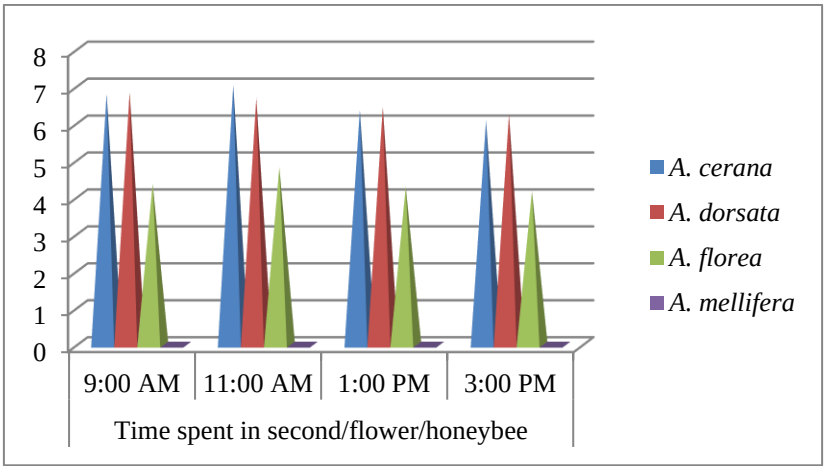

Fig. 1. Foraging speed of honeybees on flowers of rapeseed crop at different day hours

Table 2. Foraging rate of honeybee species on flowers of rapeseed crop during the peak blooming period

Honeybee pollinators	Number of flowers visited/min/honeybee*				Mean ± SD
	9:00 AM	11:00 AM	1:00 PM	3:00 PM	
A. cerana	7.8	11.5	12.5	7.1	9.7 ± 2.6
A. dorsata	12.9	13.5	10.4	8.7	11.3 ± 2.3
A. florea	6.3	8.1	5.7	5.4	6.3 ± 1.2
A. mellifera	00	00	00	00	00

**Mean data of 5 days observations at 5 locations*

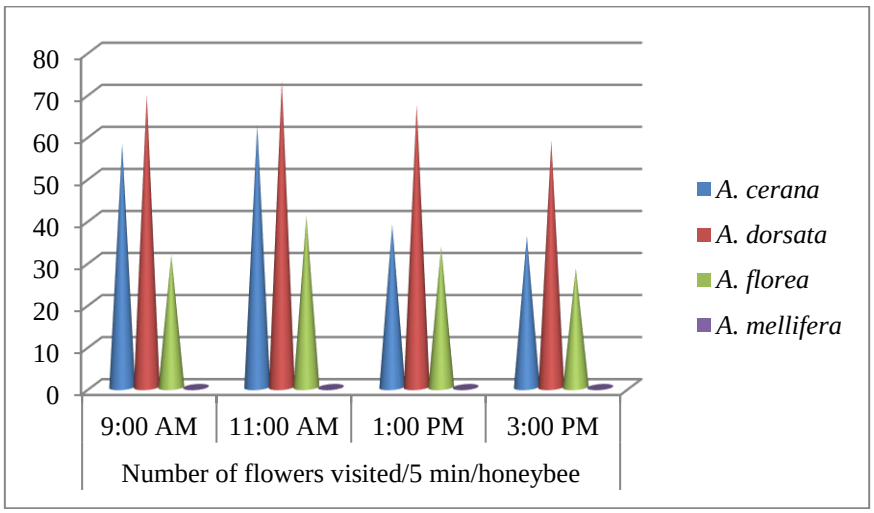

Fig. 2. Foraging rate of honeybees on flowers of rapeseed crop at different day hours

Table 3. Foraging period and peak period activity (Commencement and Cessation) of honeybee species on flowers of rapeseed crop

Honeybee pollinators	Period of activity		Duration (hrs.)	Peak activity	Weather Parameters
	Commencement (AM)	Cessation (PM)			
A. cerana	7.10	5.25	10.15	11.00 AM – 1.00 PM	Temp.°C - 21.38
A. dorsata	7.50	3.00	7.10	9.00 AM – 11.00 AM	RH (%) - 76.73
A. florea	8.00	5.00	9.00	9.00 AM – 11.00 AM	
A. mellifera	-----	-----	-----	-----	

**Mean data of 5 days observations at 5 locations*

3.3 Foraging Period of Honeybees

The data regarding the commencement and cessation of foraging time of honeybee species is presented in Table 3. The foraging period of *A. cerana indica, A. dorsata* and *A. florea* was 10.15 hrs, 7.10 hrs and 9.00 hrs respectively with peak activity during 11.00 am to 1.00 pm for *A. cerana indica* and 9.00-11.00am for *A. dorsata* and *A. florea.* In addition, *A. cerana indica* began its diurnal activity earlier (07:10 h) and ended later (5.25 pm *i.e.*, 17:25 h) than *A. dorsata* (07:50h and 3:00 pm (15.h), respectively). Their period of activity was influenced by weather parameters like temp of 21.38°C and relative humidity of 76.73% during growth period, as evidenced by earlier findings of Mahfouz et al. [22], Roy et al. [23] and Osman et al. [24].

4. CONCLUSION

On an average, maximum foraging speed was observed by *A. cerana indica* (6.57 ± 0.43

sec/flower) followed by *A. dorsata* (6.55 ± 0.26 sec/flower) and *A. florea* (4.4 ± 0.27 sec/flower). However, the time spent on a single flower was higher for *A. cerana indica* (7.04 s), *A. florea* (4.80 s) at 11.00 am and by *A. dorsata* (6.84 s) at 9.00 am of the day hours.

The foraging rate was highest with 11.3 ± 2.3 flowers/ min by *A. dorsata*, 9.7 ± 2.6 flowers/ min by *A. cerana indica* and 6.3 ± 1.2 flowers/ min by *A. florea*. Considering the number of flowers visited/ min by honeybee species at different day hours, *A. dorsata* and *A. florea* covered maximum flowers of 12.9 – 13.5/min and 6.3 – 8.1/min respectively during 9.00 to 11.00 am. Whereas *A. cerana indica* was found to visit more number of flowers per minute (11.5 – 12.5) during 11.00 am to 1.00 pm. It was observed that during the peak activity of *A. dorsata* there was a transient decrease in *A. cerana indica* activity. This is due to asymmetric interspecific competition, which could cause *A. cerana indica* to move its peak activity later (11:00am-1:00 pm) than *A. dorsata* (9.00 - 11.00am).

The foraging period of *A. cerana indica, A. dorsata* and *A. florea* was 10.15 hrs, 7.10 hrs and 9.00 hrs respectively with peak activity during 11.00 am to 1.00 pm for *A. cerana indica,* 9.00-11.00am for *A. dorsata* and *A. florea.* In addition, *A. cerana indica* began its diurnal activity earlier (07:10 h) and ended later (5.25 pm *i.e.*, 17:25 h) than *A. dorsata* (07:50h and 3:00 pm (15.h)**.** Their period of activity was influenced by weather parameters like temp of 21.38°C and relative humidity of 76.73%.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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