https://doi.org/10.33307/entomon.v47i1.684
Entomon 47(1): 27-32 (2022)
Article No. ent. 47103

Ascertaining foraging rate of pollinators in *Ricinus communis* L. in Haryana, India

Sudhanshu Bala Nayak, Manish K Yadav*, R. Nihal, V. Ramalakshmi, Lipsa Dash and Deepayan Padhy

Centurion University of Technology and Management, Paralakhemundi, Odisha, India.
Email: manish.yadav@cutm.ac.in

ABSTRACT: Foraging rate of different pollinator species under the genus *Apis* and non-*Apis* studied on two castor (*Ricinus communis*) hybrid under agro-ecological conditions of Haryana, revealed that irrespective of interspecific variation, the maximum foraging rate was found associated with *Apis florea* followed by *A. dorsata*, *A. cerana* and *A. mellifera.* Further, *Eristalnus* sp. visits of flowers were the lowest. Adding to the visiting frequency, honey producing bees (*Apis* sp.) visited significantly more flower per unit time compared to other pollinators (non-*Apis*) species. The study gave an idea of different foraging rates of different pollinators on castor flower.

KEYWORDS: Castor, *Apis*, non-*Apis* pollinators

INTRODUCTION

Ricinus communis L. commonly known as castor, belonging to the family Euphorbiaceae is grown throughout the India, for its oil content (Nayak *et al.,* 2020). Primarily it is native to Ethiopian region of tropical East Africa (Ladda and Kamthane, 2014). Crop yield mainly depends on insect mediated pollination. Foraging behaviour that impact gene flow can guide the design of pollinator strategies to mitigate gene flow (Brunet and Van Etten, 2019). The measurement of pollinator visitation frequency can clarify the relationships between pollinators, pollinated crops and the seed set (He *et al.,* 2019). Studies were carried out on the foraging behaviour of pollinating insects, honey bees and other pollinators, in castor flowers in 2018 and 2019.

MATERIALS AND METHODS

Experimental Area: Investigations were carried out to determine the foraging rates of different castor pollinators, on two castor hybrids GCH-7 and DCH-177 at Department of Entomology, CCS Haryana Agricultural University, Hisar, Haryana (29°10'N, 75°46'E, 215.2 m AMSL). All sampling was conducted in the year 2018 and 2019 on the castor cultivars (@1000m^2 area per each cultivar) and crops were grown at a temperature of 33 ± 2^{0}C. Depending up on the cultivar and the weather condition, flowering took place 65-75 days after sowing for. For raising a healthy crop, all the recommended crop production practices including fertilizer application, irrigation, weeding and other cultural operations were followed as per CCSHAU package of practices.

* Author for correspondence

Foraging rate: Foraging rate of different castor pollinators were recorded in terms of number of flowers visited per minute. Observations were recorded during peak flowering period of crop in the month of August and September, at two-hour interval starting from morning 06 00 to evening 18 00 h. For each major pollinator, fifteen observations were recorded at flowering stage of crop. Accordingly, the average number of flowers visited per minute was calculated for each species. After a flower was visited once, this specific flower was labelled; the type of bee that visited the flower was recorded. Pollinator's specimens were identified in the field by the authors using the identification key. The recorded data was analyzed by using three-way ANOVA in Randomized Block Design using SPSS software with Duncan Multiple range Test ranking.

RESULTS AND DISCUSSION

Foraging rate of pollinators on *R. communis* cv. GCH-7

The foraging rate *i.e.,* the average number of flowers visited by an individual forager varied irrespective of time and species. When considering the pooled mean data of two years (2018 and 2019) at different time intervals, the foraging rate ranged 1.324 to 11.694 flowers/ minute. Peak foraging rate was recorded at 10 00-12 00 h (11.694 flowers/ minute) followed by 12 00-14 00 h (8.509 flowers/ minute), while the lowest rate was found at 14 00-16 00 h (1.324 flowers/minute). During the peak period of activity the maximum number of flowers visited was by *Apis florea* (11.694 flowers/ minute), followed by *Apis dorsata* (9.595), *Apis cerana* (7.946) and *Apis mellifera* (7.626). Whereas lowest was recorded for *Eristalinus* sp. (2.876), followed by *Melipona bivolor* (3.423) and *Polistes* sp. (3.875). For *Megachile lanata*, *Polistes* sp. and *M. bicolor* foraging activity was not observed during 06 00-08 00 morning hour. No foraging activity was found for *Polistes* sp. and *Eristalinus* sp. during 16 00-18 00 h (Table 1).

Foraging rate of pollinators on *R. communis* cv. DCH-177

The forage rate (number of flowers visited per min) of different insect pollinators on *R. communis* cv. DCH-177 during 2018 and 2019 was pooled and observed that as in GCH-7, the cultivar DCH-177 also similar trend of forage rate (Table 2).. While considering the mean data at different time intervals, the foraging rate ranged between 1.156 to 8.944 flowers/minute where the peak foraging rate was recorded at 10 00-12 00 h (8.944 flowers/minute) followed by 08 00-10 00 h (6.374 flowers/minute) while the lowest rate was found at 14 00-16 00 h (1.156 flowers/minute) and 16 00-18 00 h (1.749 flowers/minute). During the peak period of activity the maximum number of flowers was visited by *A. florea* (8.944) followed by *A. dorsata* (8.037), *A. cerana* (7.463) and *A. mellifera* (6.631), whereas the low foraging rate were recorded for *Eristalinus* sp. (2.884), *M. bivolor* (3.334) and *Polistes* sp. (3.841). Like GCH-7 hybrid, for *M. lanata*, *Polistes* sp. and *Melipona bicolor* no foraging activity was observed during 06 00-08 00 morning hour. The highest foraging rate for all pollinators was recorded during 10 00-12 00 h respectively. No foraging activity was found for *Polistes* sp. and *Eristalinus* sp. during 16:00-18:00 h.

However, the pollinators were selective in choosing the castor hybrids and there were significant differences found regarding the foraging rates between two hybrids. Among the pollinators, *A. florea* had the highest foraging rate while the *Eristalinus* sp. was having with lowest foraging rate. Interaction of pollinator and cultivar was also differed significantly.

Foraging rate (number of flowers visited per min) are mainly governed by host factor (type of resources), flower anthesis, floret structure and environmental factors play an important role governing in field activity of social bees as well as solitary bees. The foraging rate of pollinators, determines the comparative tripping efficiency eventually (Martiniello *et al.,* 2003). Similar results observed by Jat *et al.* (2014), where they reported the mean foraging rate of *A. dorsata, A. mellifera*, and *A. florea* as 6.2, 6.4 and 6.6 (flower/min) on *T. alexandrinum* respectively. The observations at different hours of the days also showed the peak foraging rate between 10 00-12 00 h and it was followed by 12 00-14 00 h, while the lowest rate

Table 1. Foraging rate of pollinators on Castor cv. GCH-7 during 2018 & 2019 (data pooled)

Pollinator	06 00-08 00 h	08 00-10 00 h	10 00-12 00 h	12 00-14 00 h	14 00-16 00 h	16 00-18 00 h
Apis dorsata F.	6.929^{e}	7.735^{b}	9.595^{e}	8.509^{e}	7.376^{g}	5.895^{f}
Apis mellifera L.	6.255^{d}	7.525^{b}	7.626^{d}	7.620^{b}	6.181^{f}	4.628^{e}
Apis cerana F.	6.070^{d}	6.982^{b}	7.946^{d}	5.088^{c}	4.263^{e}	2.391^{bc}
Apis florea F.	3.928^{cd}	6.856^{b}	11.694^{f}	4.361^{c}	3.549^{d}	3.050^{d}
Vespa sp.	2.665^{b}	3.986^{a}	5.555^{c}	2.993^{b}	3.614^{d}	2.396^{bc}
Tetragonula iridipennis (Smith)	2.460^{b}	3.875^{a}	5.745^{c}	3.296^{b}	3.141^{c}	2.885^{cd}
Megachile lanata F.	0.000^{a}	3.769^{a}	4.691^{bc}	2.248^{a}	2.511^{b}	2.351^{b}
Meliopona bicolor Lepeletier	0.000^{a}	3.553^{a}	3.423^{a}	3.079^{b}	2.561^{b}	1.934^{b}
Polistes sp.	0.000^{a}	3.186^{a}	3.875^{ab}	2.190^{a}	2.286^{b}	0.000^{a}
Eristalinus sp.	2.026^{b}	3.168^{a}	2.876^{a}	2.171^{a}	1.324^{a}	0.000^{a}

Means followed by same letter in the column do not differ significantly by DMRT (P=0.01)

Table 2. Foraging rate of pollinators on *R. communis* cv. DCH-177 during 2018 & 2019 (pooled)

Pollinator	06 00-08 00 h	08 00-10 00 h	10 00-12 00 h	12 00-14 00 h	14 00-16 00 h	16 00-18 00 h
Apis dorsata F.	6.075^{d}	6.374^{c}	8.037^{ef}	6.021^{e}	4.501^{d}	4.020^{e}
Apis mellifera L.	5.505^{cd}	5.410^{b}	6.631^{d}	5.245^{d}	4.205^{d}	3.678^{e}
Apis cerana F.	6.070^{d}	5.970^{bc}	7.463^{de}	4.963^{d}	4.400^{d}	2.404^{c}
Apis florea F.	4.484^{c}	6.231^{bc}	8.944^{f}	3.736^{c}	3.736^{d}	2.925^{d}
Vespa sp.	1.773^{b}	3.959^{a}	5.257^{c}	2.429^{ab}	2.989^{c}	1.889^{bc}
Tetragonula iridipennis (Smith)	2.530^{b}	3.793^{a}	5.200^{c}	3.258^{c}	2.641^{bc}	2.010^{bc}
Megachile lanata	0.000^{a}	3.677^{a}	4.340^{bc}	2.241^{a}	2.253^{bc}	2.183^{bc}
Meliopona bicolor Lepeletier	0.000^{a}	3.553^{a}	3.334^{ab}	3.153^{bc}	2.061^{b}	1.749^{b}
Polistes sp.	0.000^{a}	3.186^{a}	3.841^{ab}	2.413^{ab}	2.036^{b}	0.000^{a}
Eristalinus sp.	2.788^{b}	3.189^{a}	2.884^{a}	2.044^{a}	1.156^{a}	0.000^{a}

Means followed by same letter in the column do not differ significantly by DMRT (P=0.01)

was found at 16 00-18 00 h. Similar activity had been documented in coriander by Shivashankara *et al.* (2016) who reported the daily activity of pollinators showed that foraging activity begins in the morning (its variable depending upon insect) and reached to maximum between 12 00 and 15 00 h, then decreased till sunset. Similarily Rizzardo *et al.* (2012) also observed that in early morning, the number of bees collecting pollen and nectar increasing slowly from 7 00 to 13 00 h and decreasing towards 17:00 h and peak period was in between 7:00 to 9:00 h decrease towards to the hottest time of the day (13:00 h). Current study is in line with by Reddy *et al.* (2015) and Maity *et al.* (2014), reported that climatic factor plays a significant role in influencing the foraging activity and behavior of social insects especially honeybees. Dalio (2018), recorded that the Asian bee, *A. cerana* visited more numbers of flowers per minute (18.10), followed by *A. mellifera* (17.36) and *A. dorsata* (13.87) while foraging rate of *A. florea* (7.53 flowers/min) was comparatively low on *Brassica napus*. Srivastava *et al.* (2017) reported the mean foraging rate was the maximum for *A. dorsata* (5.35 ± 0.33 flowers/min) followed by that of *A. mellifera* (4.87 ± 0.34 flowers/min), *A. cerana* (1.75 ± 0.23 flowers/min) and lowest foraging rate was recorded of *A. florea* (0.11 ± 0.09 flowers/min) on *Brassica oleracea*. Present observations were in line with findings of Mohapatra and Sontakke (2012) who recorded the mean foraging rate of 6.7-7.4 flowers/minute, 9.3-11.5 flowers/minute and 5.2-5.8 flowers/minute by *A. cerana, A. dorsata* and *A. florea* on sesame, respectively. Kunjwal *et al*. (2014) also reported that the *A. mellifera* was having highest foraging rate with 11.48 flowers followed by *A. dorsata* (4.03), *A. cerana* (2.09) and *T. laeviceps* (1.93) in mustard. However, Nagpal *et al*. (2019) in *B. juncea*, observed highest foraging rate with *A. cerana i.e.,* 13.92 flowers followed by *A. mellifera* (12.86), *A. dorsata* (10.35) and *A. florea* (6.99). In the case of *A. cerana* the highest foraging rate was observed (18.20 flowers/min) followed by *A. dorsata* (17.57), *A. mellifera* (17.32) and *A. florea* was found to be visited minimum number of flowers (6.45) on mustard (Poonam, 2019). Khamhari (2013) also reported the mean foraging rate varied from 6.84 to 12.13 flowers/minute in niger. Among different bee species, *A. mellifera* visited significantly more numbers of flowers (10.28 flowers/minute) followed by *A. cerana* (9.13 flowers/minute). The maximum foraging rate 12.13 flowers/minute was observed at 12 00 to 14 00 h, while the minimum rate was 6.84 flowers/minute observed at 16 00 to 18 00 h.

The present investigations based on the behaviour of various bees in context of two genotypes of castor namely GCH-7 and DCH-177, revealed that the maximum foraging rate is associated with *A. florea* which have their benefits of locality and small body size as well, followed by *A.dorsata A. cerana* and *A. mellifera*, while the minimum was by *Eristalnus* sp. In the case of their visiting frequency, honey producing bees have been visiting significantly more flowers in per unit time compared to other pollinator.

REFERENCES

Abrol D.P. (2011. Pollination biology: biodiversity conservation and agricultural production. Springer Science & Business.

Brunet J. and Van Etten M.L. (2019) The response of floral traits associated with pollinator attraction to environmental changes expected under anthropogenic climate change in high-altitude habitats. International Journal of Plant Sciences 180(9): 954-964.

Dalio J.S. (2018) Foraging Frequency of *Apis* Species on Bloom of *Brassica napus* L. The International Journal of Engineering and Science 7(2): 28-33.

He C., Zhang K., Hou X., Han D and Wang S. (2019) Foraging Behavior and Pollination Efficiency of Apis mellifera L. on the Oil Tree Peony 'Feng Dan'(Paeonia ostii T. Hong et JX Zhang). Insects 10(4):116.

Jat M.K., Chaudhary O.P., Kaushik H.D. and Tetarwal A.S. (2014) Floral biology studies of Role of pollinators on Egyptian clover pollination with special reference to honeybee at Sohag Governorate, Egypt Egyptian clover, *Trifolium alexandrinum* L. Research in Plant Biology 4(3): 16-21.

Khamhari D. (2013) Role of honey bee pollination in niger with special reference to *Apis mellifera.* Ph.D Thesis, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India.

Kunjwal N., Kumar Y. and Khan M.S. (2014) Flower-visiting insect pollinators of brown mustard, *Brassica juncea* (L.) Czern and Coss and their foraging behaviour under caged and open pollination. African Journal of Agricultural Research 9: 1278-1286.

Ladda P.L. and Kamthane R.B. (2014) *Ricinus communis* (castor): An overview. International journal of Research in Pharmacology, Pharmacotherapeutics *3*(2): 136-144.

Maity A., Chakrabarty S.K. and Yadav J.B. (2014). Foraging behaviour of honeybees (*Apis* spp.) (Hymenoptera: Apidae) in hybrid seed production of Indian mustard *(Brassica juncea*). Indian Journal of Agricultural Science 84(11): 1389-1394.

Martiniello P., Iannucci A. and Pinzauti M. (2003) Behavior of solitary pollinators and their effect on berseem and alfalfa seed yield and yield components in Mediterranean environments. Journal of New Seeds 5(4):17-27.

Mohapatra L.N. and Sontakke B.K. (2012) Behavioural studies on pollinators in sesame. Indian Journal of Entomology 74; 189-192.

Nagpal K., Yadav S., Kumar Y. and Singh R. (2019) Working behavioural studies of different *Apis* spp. on Indian mustard (*Brassica juncea*). Journal of Entomology and Zoology Studies 7(6): 143-150.

Nayak S.B., Kumar Y., Yadav S. and Sankara K. (2020) Percentage abundance of castor pollinators under Haryana condition. International Journal of Fauna and Biological Studies 7(6): 49-52.

Poonam (2019) Nectar secretion rhythms and foraging behaviour of honey bees in early sown rapseed mustard genotypes. Thesis. Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India.

Reddy P.V.R., Rashmi T. and Verghese A. (2015) Foraging activity of Indian honeybee, *Apis cerana* in relation to ambient climate variables under tropical conditions. Journal of Environmental Biology 36: 577-581.

Rizzardo R.A.G., Milfont M.O., Dasilva E.M.S. and Freitas B.M. (2012) *Apis mellifera* pollination improves agronomic productivity of anemophilous castor bean (*Ricinus communis)*. Anais da Academia Brasileira de Ciências 84 (4): 1137-1145.

Rollin O. and Garibaldi L.A. (2019) Impacts of honeybee density on crop yield: A meta analysis. Journal of Applied Ecology 56(5): 1152-1163.

Shivashankara R.M., Subbanna A.R.N.S., Kumar J. and More S. P. (2016) Diversity of Insect Pollinators and Foraging Behavior of Native Honey Bees on Coriander. Environment and Ecology 34(4): 1315-1319.

Srivastava K., Sharma D., Singh S. and Ahmad H. (2017) Foraging behaviour of honeybees in seed production of *Brassica oleracea* var. Italica Plenck. Bangladesh Journal of Botany 46(2): 675-681.

Waser N.M. and Ollerton J. (2006) Plant-pollinator interactions: from specialization to generalization. University of Chicago. pp 545-555.

(Received January 28, 2022; revised ms accepted March 16, 2022; printed March 31, 2022)