Original Research Article

Preference of Indian honey bee, *Apis cerena indica* Fab. (Hymenoptera: Apidae) for varying sucrose concentrations and colours

ABSTRACT

Nectar foraging provides honey bees with essential energy and enhance pollination, supporting biodiversity. Flower colour attracts and guide them to nectar rich flowers promoting effective pollination. With this background, a study was conducted at apiary, University of Agricultural Sciences, Dharwad to investigate the preference of honey bees to different concentrations of sucrose and colours. It was found that the highest activity of honey bees occurred between 10 AM to 11 AM. Among the different sucrose concentrations offered, honey bees showed a preference for 40 per cent concentration with an average of 9.53 bees/petri plate/5 mins over others. Colour preference experiment demonstrated that honey bees preferred yellow color the most, followed by blue, white and red, with 9.07, 6.00, 3.67 and 1.60 bees/petri plate/5 mins, respectively. The present study revealed that honey bees optimize their foraging activity by choosing flowers with higher nectar amounts and yellow coloured flowers.

Keywords: Concentrations of sucrose; colours; honey bees; preference; foraging

1. INTRODUCTION

Honey bees (*Apis* spp.) play a crucial role in global ecosystems and agriculture by serving as primary pollinators for a vast array of flowering plants, including many crops essential for human food production [1,2]. Their role in pollination is indispensable, as they facilitate the reproduction of plants through the transfer of pollen between flowers, which is essential for fruit and seed production. This process not only supports biodiversity in natural ecosystems but also sustains agricultural productivity and food security worldwide. In addition to their ecological significance, honey bees are economically valuable, contributing billions of dollars annually to the global economy through their pollination services for crops such as almonds, apples and blueberries [3,4]. Their foraging behavior is finely tuned to select floral resources based on specific traits such as sugar concentration in nectar and the colour of flowers. Understanding these preferences is crucial for comprehending how honey bees optimize their foraging efficiency and contribute to ecosystem services like crop pollination.

The concentration of sugar in nectar serves as a primary attractant for honey bees during foraging trips. Nectar's sugar content directly correlates with the energy yield bees gain per foraging effort [5]. Studies have shown that bees prefer higher sugar concentrations, as these provide greater energy rewards essential for sustaining hive activities, supporting larval development and producing honey [6]. In addition to sugar concentration, honey bees exhibit distinct preferences for flower colours. Bees possess a remarkable ability to perceive a wide range of colors, including ultraviolet (UV) wavelengths that are invisible to humans [7,8]. Flowers with certain colours, such as yellow, blue, white and red are particularly attractive to bees due to their spectral properties and the presence of UV patterns that guide bees to nectar and pollen rewards [9,10,11]. Understanding the importance

of sugar concentration and flower colour in honey bee foraging behavior is critical for advancing our knowledge of pollination ecology and informing agricultural practices. By examining existing research, this study aims to elucidate how these factors influence honey bee foraging. This knowledge is essential for developing strategies to enhance habitat management and conservation efforts that support honey bees as key pollinators in both natural and agricultural landscapes.

2. METHODOLOGY

To investigate honey bees' preferences for sucrose concentration and flower colour, a study was conducted during winter, 2022-23 at the apiary of the University of Agricultural Sciences, Dharwad. Dharwad is located in northern transitional agriculture zone-8 of Karnataka and situated at 15°26'N latitude and 75°07'E longitude at an altitude of 678 m above mean sea level. The temperature and relative humidity varies between 13.30 °C to 36.50 °C and 57.5 per cent to 93.20 per cent, respectively and receives 776 mm mean rainfall per annum.

Different concentrations of sucrose (= sugar) solution (0%, 10%, 20%, 30% and 40%) were prepared in the laboratory by mixing specific amounts of sucrose and water to achieve the desired concentrations. Each concentration of sucrose solution (20 ml) was then dispensed into separate petri plates and placed in front of an Indian honey bee colony ensuring equal exposure and accessibility to the bees. The number of bees visiting each sucrose concentration was recorded over 5-minute intervals. Following the determination of the preferred concentration of sucrose solution from the previous experiment, petri plates containing 20 ml of the preferred concentration were wrapped in coloured papers representing different flower colours *viz*., yellow, blue, white and red and offered to honey bees. Observations were recorded over consecutive days by counting the number of bees for 5 minutes, at every one hour, starting at 9 AM and finishing at 12 noon every day.

3. RESULTS AND DISCUSSION

3.1 Preference of honey bees to different concentrations of sucrose

Least number of bees/petri plate/5 mins were found between 9 AM to 10 AM across all concentrations. However, the maxiumm activity of honey bees was observed from 10 AM to 11 AM *viz*., 0.20, 1.00, 1.60, 4.80 and 11.60 at 0, 10, 20, 30 and 40 per cent of sucrose concentration, respectively. Further, the activity declined from 11 AM to 12 noon (Table 1). The mean number of bees/petri plate/5 mins is depicted in figure 1. Maximum number of bees were noticed in 40 per cent sucrose concentration (9.53) followed by 30 (4.13), 20 (1.40), 10 (0.73) and 0 per cent (0.07).

Table 1. Preference of honey bees to different concentrations of sucrose solution

Period of observation	No. of bees/petriplate/5 mins				
	0 %	10 %	20 %	30 %	40 %
9 AM to 10 AM	0.00 ± 0.00	0.80 ± 0.84	2.00 ± 1.58	4.40 ± 2.07	8.80 ± 3.83
10 AM to 11 AM	0.20 ± 0.45	1.00 ± 1.00	1.60 ± 0.89	4.80 ± 2.17	11.60 ± 3.21
11 AM to 12 PM	0.00 ± 0.00	0.40 ± 0.55	0.60 ± 0.89	3.20 ± 1.79	8.20 ± 2.28
Mean	0.07 ± 0.12	0.73 ± 0.31	1.40 ± 0.72	4.13 ± 0.83	9.53 ± 1.81

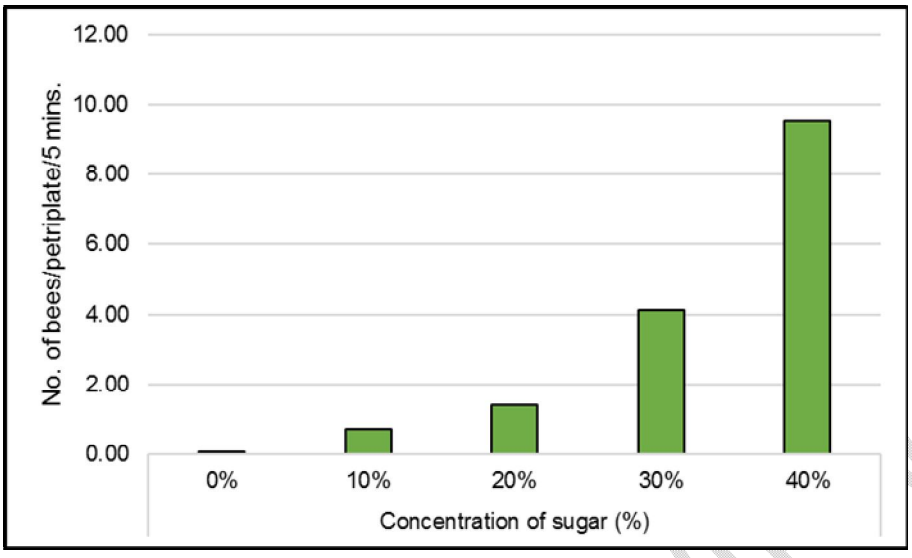

Fig. 1. Influence of different concentrations of sugar on honey bees preference

Honey bees, in general, forage in nectar concentrations ranging from 35 to 65 per cent sugar [12] and different bee species can present preference for nectars in different concentrations [13]. Higher concentration of sugar reduces the number of foraging visits by workers. In addition, syrup viscosity increases as sugar concentration also increases. Nicolson [14] remarked that nectar viscosity is a more important factor than concentration when choosing food sources since low viscosity enables bees to drink more quickly reducing imbibing time, in this way, allowing for transporting greater volumes to the nest. Silva *et al*. [15] observed foraging peak of stingless bee, *Plebeia flavocincta* from 9:00 to 11:30 AM and showed preference for higher syrup concentrations (60 % and 70 %) are in close agreement with present study.

3.2 Preference of honey bees to different colours

For colour preference study, the most preferred concentration of sucrose solution *i.e*., 40 per cent was selected. Similar to first experiment, the least number of bees were recorded between 9 AM to 10 AM across different coloured petri plates. Whereas, maximum activity was observed between 10 AM to 11 AM with 4.00, 1.80, 9.80 and 6.20 bees/petri plate/5 mins in white, red, yellow and blue coloured petri plates, respectively (Table 2). Among the different colours selected, honey bees preferred yellow colour over others recording maximum mean number of bees/petri plate/5 mins (9.07) followed by blue (6.00), white (3.67) and red (1.60) (Fig. 2).

Table 2. Preference of honey bees to different coloured petri plates

Period of observation	No. of bees/petriplate/5 mins.			
	White	Red	Yellow	Blue
9 AM to 10 AM	3.20 ± 2.05	1.80 ± 1.10	8.60 ± 4.34	6.00 ± 3.32
10 AM to 11 AM	4.00 ± 2.00	1.80 ± 0.45	9.80 ± 4.44	6.20 ± 2.39
11 AM to 12 PM	3.80 ± 1.64	1.20 ± 0.84	8.80 ± 3.70	5.80 ± 3.03
Mean	3.67 ± 0.42	1.60 ± 0.35	9.07 ± 0.64	6.00 ± 0.20

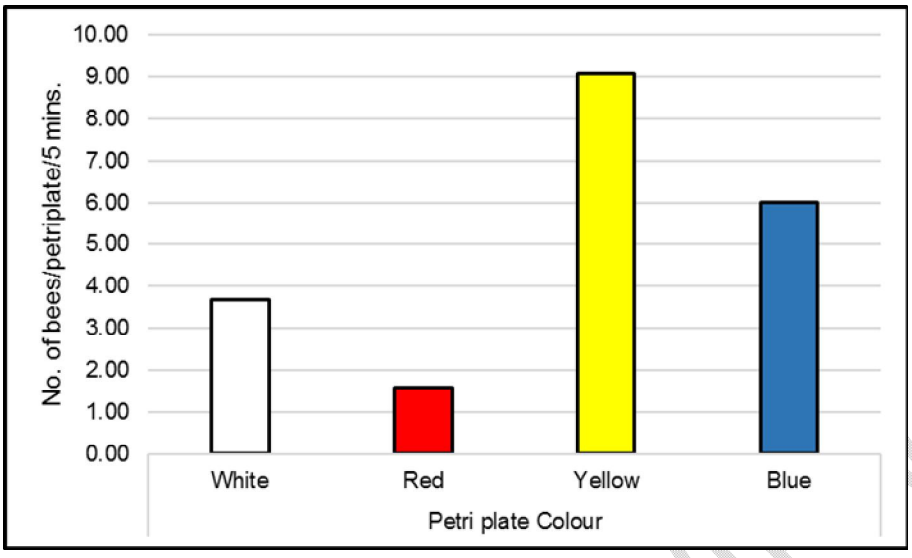

Fig. 2. Preference of honey bees to different colours

In the visible spectrum, 380 nm - 760 nm (violet - blue - green - yellow - orange - red), honey bees see best at yellow and blue colours. They also see ultraviolet light as a distinct color (invisible to human eye) and many flowers have ultraviolet markings. Bees are not able to see the colour red, so they rarely pollinate red flowers. *Apis mellifera* showed a significant preference for yellow over blue [16,11]. These colour preferences are closely tied to the evolutionary adaptation of bees' visual systems and the ecological strategies of flowering plants [17]. Flowers that match bees' colour preferences are more likely to receive frequent visits, promoting effective pollen transfer and enhancing plant reproductive success [18].

4. CONCLUSION

The present study revealed that, among the different concentrations of sucrose solutions offered, honey bees preferred 40 per cent followed by decreasing trend of 30, 20 and 10 per cent. Yellow colour attracted more number of honey bees compared to blue, white and red. Thus it can be concluded that honey bees optimize their foraging activity by choosing flowers with higher nectar amounts and yellow coloured flowers.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

REFERENCES

1 Klein AM, Vaissiere BE, Cane JH, Steffan-Dewenter I, Cunningham SA, Kremen C et al. Importance of pollinators in changing landscapes for world crops. Proceedings of the royal society B: Biologi Sciences. 2007;274(1608);303-313.

2 Potts SG, Biesmeijer JC, Kremen C, Neumann P, Schweiger O, Kunin WE. Global pollinator declines: trends, impacts and drivers. Trends in Ecology and Evolution. 2010;25(6);345-353.

3 Aizen MA, Harder LD. The global stock of domesticated honey bees is growing slower than agricultural demand for pollination. Current Biology. 2009;19(11):915-918.

4 Gallai N, Salles JM, Settele J, Vaissiere BE. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological Economics. 2009;68(3):810-821.

5 Chittka L, Thomson JD, eds. Cognitive ecology of pollination: animal behaviour and floral evolution. Cambridge University Press. 2001.

6 Waser NM, Chittka L, Price MV, Williams NM, Ollerton J. Generalization in pollination systems, and why it matters. Ecology. 1996;77(4):1043-1060.

7 Lunau K, Maier EJ. Innate colour preferences of flower visitors. Journal of Comparative Physiology A. 1995;177:1-19.

8 Giurfa M, Vorobyev M, Kevan P, Menzel R. Detection of coloured stimuli by honeybees: minimum visual angles and receptor specific contrasts. Journal of Comparative Physiology A. 1996;178:699-709.

9 Dyer AG, Chittka L. Biological significance of distinguishing between similar colours in spectrally variable illumination: bumblebees (*Bombus terrestris*) as a case study. Journal of Comparative Physiology A. 2004;190:105-114.

10 Leonard AS, Papaj DR. 'X' marks the spot: the possible benefits of nectar guides to bees and plants. Functional Ecology. 2011;25(6):1293-1301.

11 Salman AA, Azzazi MF. Determination of Honey Floral Sources Using Pollen Grains. Journal of Jazan University - Applied Sciences Branch. 2013;2(2):45-56.

12 Roubik DW. On optimal nectar foraging by some tropical bees (Hymenoptera: Apidae). Apidologie. 1995;26:197-211.

13 Basari N, Ramli SN, Khairi NAS. Food reward and distance influence the foraging pattern of stingless bee, *Heterotrigona itama*. Insects. 2018;9(4):138.

14 Nicolson SW. Honey bees prefer warmer nectar and less viscous nectar regardless of sugar concentration. Proceedings of The Royal Society B: Biological Sciences. 2013;280:1767.

15 Silva JGD, Meneses HM, Freitas BM. Foraging behavior of the small-sized stingless bee *Plebeia flavocincta*. Revista Ciencia Agronomica. 2019;50:484-492.

16 Guez D, Zhu H, Zhang SW, Srinivasan MV. Enhanced cholinergic transmission promotes recall in honey bees. Journal of Insect Physiology. 2010;56:1341-1348.

17 Goulson D. Foraging strategies of insects for gathering nectar and pollen, and implications for plant ecology and evolution. Perspectives in Plant Ecology, Evolution and Systematics. 1999;2(2):185-209.

18 Ollerton J, Winfree R, Tarrant S. How many flowering plants are pollinated by animals?. Oikos. 2011;120(3):321-326.