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PARTIAL SOLAR ECLIPSE AFFECTS *APIS MELLIFERA* L FORAGING ACTIVITY

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ABSTRACT

Bees use sun's position for navigation and thus a solar eclipse may affect this capability. Present study was conducted during partial solar eclipse on June 21, 2020 at Ludhiana, Punjab. *Apis mellifera* L foragers' activity at the hive entrance was recorded through a digital bee counter. Bees' activity increased normally, i.e. 771 and 823 bees/ 15 mins coming in and going out of the hive, respectively before the start of eclipse phase. At peak obscuration it decreased slightly but non-significantly. Changes in hive temperature and humidity might have limited the recruitment of foragers. Hence, no peak activity was recorded during peak obscuration, which otherwise was recorded on ordinary days at 1345 hr.

Key words: *Apis mellifera*, bees' activity, digital bee counter, partial solar eclipse, ordinary day, peak obscuration, foragers, entry. exit, hive, temperature, humidity

Sun is the most important star that supports life on this planet. Besides as a source of energy, it acts as lighthouse for navigation by bees through its position along with the polarization pattern of the sky (Homberg, 2004). Honey bees are highly social organisms with a high degree of polyethism. Worker caste performs the majority of tasks and foraging is one such activity among several other tasks. The foraging bees navigate the surroundings and upon successfully finding the source for foraging, they memorize the path and finally transfer the information to their fellow worker bees. To achieve such a high degree of precision in this task, forager bees have excellent mental capabilities that help in learning, memorizing and transferring the message (Srinivasan, 2010). The navigating bees use the sun's position and transfer the information. In this manner, the food resources are foraged efficiently. Hence, its absence will render the bees to stop foraging because of lack of compass for locating its nest. A number of studies have been conducted to understand the bees' behaviour during the event of total solar eclipse (Galen et al., 2018; Waiker et al., 2019), while limited literature are available on the effect of partial solar eclipse on bees. Since *Apis mellifera* (L), is an important hive bee species, ensures livelihood and food security to beekeepers and farmers, any adverse effect on its foraging either due to natural or anthropogenic activity will lead to huge loss. Hence, the present study was conducted to understand the effects of partial solar eclipse on *A. mellifera* activity in which change in bees activity was studied on the basis of data on the bees activity recorded through a digital bee counter.

MATERIALS AND METHODS

The research was carried out on a rear phenomena i.e. partial solar eclipse visible on June 21, 2020 in India. Observations were recorded at Punjab Agricultural University Apiary, Ludhiana (N 30°53'55'', E 75°48'3'') where partial solar eclipse started at 1020 hr with peak obscuration at 1159 hr and ended at 1344 hr (Anonymous, 2020). Two *A. mellifera* queenright colonies (9 bee-frame strength) equalized with respect to brood area (390-410 cm^2), honey production (620-725 g) and pollen area (200-250 cm^2) were used. The effect of the partial solar eclipse on the bees was recorded as change in the bees' activity (number of bees coming in and going out of the colony) at the hive entrance on the day of solar eclipse (SE) and one day before and after the solar eclipse. Digital bee counter; BeeSCAN II Lowland Electronics bvba, Belgium (digitally sense the bees' traffic at the entrance of a hive) equipped with a Datalogger (recording the number of bees moving in and out of the hive/ unit time) was used. The equipment was made operational from 0845 to 1600 hr, thus covering the full event. The data (bees' activity/ minute) were summed up for 15 min hence there were 4 readings/ hour. The data were subjected to standard statistical procedure for factorial design using SAS software. The differences in treatment means were compared using LSD (p=0.005).

RESULTS AND DISCUSSION

The event of solar eclipse occurred in the 25th standard meteorological week. The prevailing weather

conditions have been depicted in Fig. 1. of bees' activity was statistically at par during eclipse and non-eclipse days. This showed that there was no reduction in the normal working duration as a result of solar eclipse. The bees' activity during the progression (1020-1159 hr onwards) or extinction (1159-1344 hr onwards) phase of solar eclipse did not cease completely (Table 1). Galen et al. (2018) and Waiker et al. (2019) also reported similar results which may be due to the capacity of bees to make correction while dealing with cue mismatch i.e. change in light intensity (Zhang and Pahl, 2012). Due to solar eclipse the bees got >4 normal working hours to consolidate the memory about the change in light intensity occurred. The overall mean bees' activity i.e. incoming and outgoing were statistically at par. This condition was same during other times of the day also. This showed that bees' activity did not cease completely on the day of partial solar eclipse. This was not true in the case of total solar eclipse (Galen et al., 2018). The complete cessation of bees' activity was attributed due to comparatively far lower visibility cues under dim light (Uetz et al., 1994).

The temperature and relative humidity at 1000 hr on the day of solar eclipse were 35.0°C and 55.7%, respectively (Fig. 2). It increased a little (35.5°C at 1130 hr) and decreased thereafter upto 1230 hr (31.8°C) i.e. progression phase of solar eclipse while inside the hive it varied a little. The maximum difference between eclipse and an ordinary day temperature and relative humidity during 1230-1330 hr was + 6.2°C and -13.2%, respectively. A comparatively lower reduction in temperature with corresponding increase in relative humidity was recorded by Pillai (1956) from Trivandrum during a partial solar eclipse (1037-1458 hr with peak at 1235 hr) visualized during 1955 while Galen et al. (2018) found a decrease in 10-15°C during a total solar eclipse. Galen et al. (2018) attributed the drop in sun light as the major cause and rejected the role of decrease in temperature; while Waiker et al. (2019) denied the role of both the temperature and ambient light but accepted relative humidity to affect the foraging. Burrill and Dietz (1981) reported temperature to have positive effect while solar radiation intensity had a mixed effect.

On the day of solar eclipse the atmospheric relative humidity and temperature had significant effect on mean

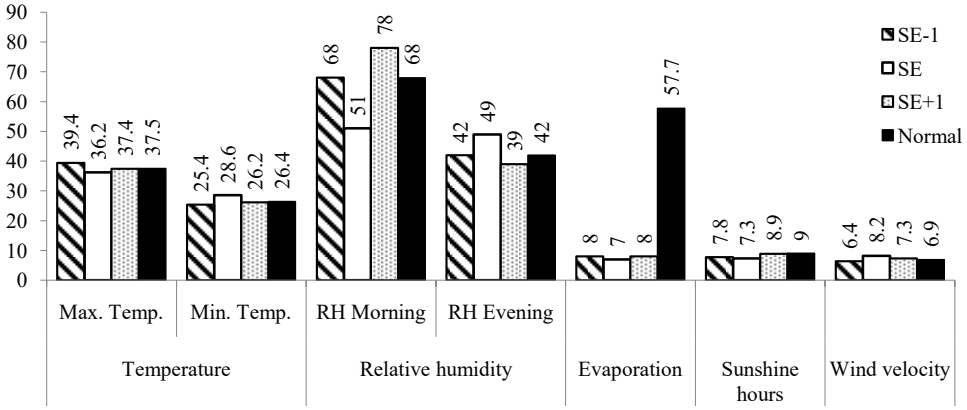

Fig. 1. Weather conditions during solar eclipse (SE0) with respect to ordinary days (SE-1 & SE+1; one day before and after solar eclipse) and normal conditions for the standard meteorological week

Table 1. *Apis mellifera* forager bees' mean activity at the hive entrance during ordinary days and on the day of solar eclipse

Time interval (Hr) (A)	Bees' activity i.e. mean number of bees/15 min (B)				
	In	Out	In (SE)	Out (SE)	Mean
0845-1000	545.89± 11.94	612.48± 9.09	663.35± 27.74	745.33± 21.72	641.76± 17.28
1001-1130	615.00± 18.74	654.17± 17.87	771.83± 25.08	823.50± 25.18	716.15± 20.03
1131-1300	641.92± 23.50	661.75± 25.04	689.08± 54.84	714.25± 24.78	676.75± 18.98
1301-1430	1826.42± 261.83	2059.00± 282.20	904.67± 29.84	931.00± 25.15	1430.27± 136.33
1431-1600	1360.42± 121.21	1398.92± 122.42	979.50± 29.66	1018.50± 31.06	1189.33± 55.09
Mean	997.92± 108.13	1077.26± 120.16	801.69± 26.73	846.52± 25.10	

SE stands for Solar eclipse, while in or out shows the bees' activity on an ordinary day, respectively. In and Out stands for bees coming in and going out of the hive LSD (p=0.05): A = 112.82; B= 126.13; AXB = 252.27

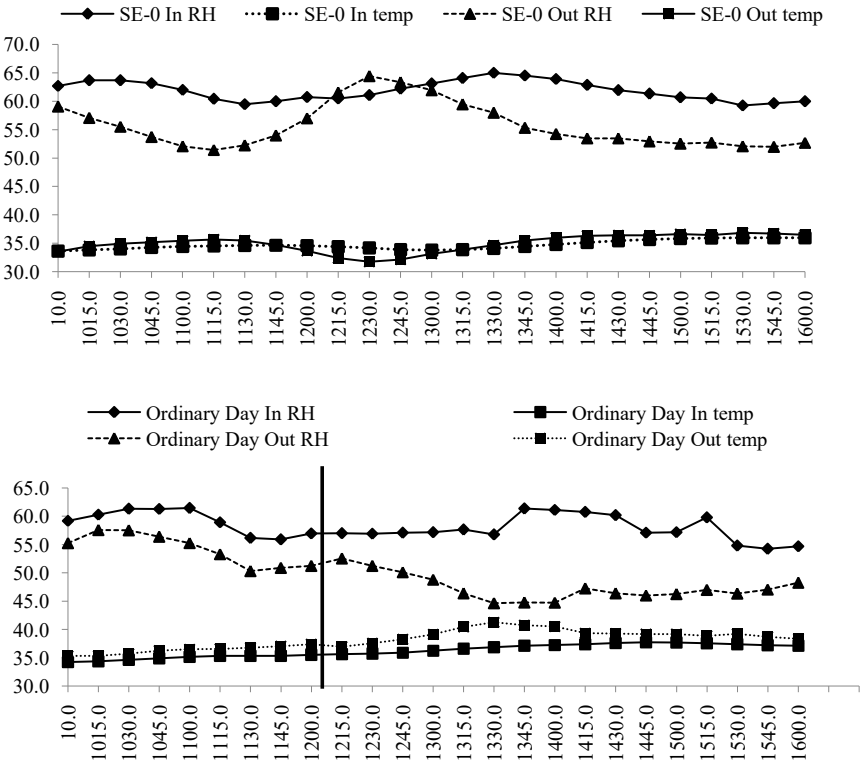

Fig. 2. Comparative temperature (ºC) and humidity inside (In) and outside (Out) the hive during a solar eclipse (SE0) and ordinary days

number of incoming (-0.49, p=0.006 and 0.52, p=0.004; df=25, respectively) and outgoing bees (-0.56, p=0.002 and 0.58, p=0.001; df=25, respectively). On ordinary days, data at 1301-1430 hr, the mean number of bees coming in the hive (1826.42± 261.83) was significantly higher due to recruitment of more foragers than the preceding time intervals which were statistically at par. The mean number of bees going out also followed similar trend. On the day of partial solar eclipse, the bees' activity increased with time during 1000-1130 hr which decreased thereafter to 689.08± 54.84 incoming and 714.25± 24.78 outgoing bees/15 min corresponding to time of peak solar eclipse (Table 1). Overall, no peak in activity was recorded as otherwise observed during ordinary days (Fig. 3). Since, the bees' activity was observed to be affected by environmental as well as hive temperature and humidity, the decrease in temperature and relative humidity during progression

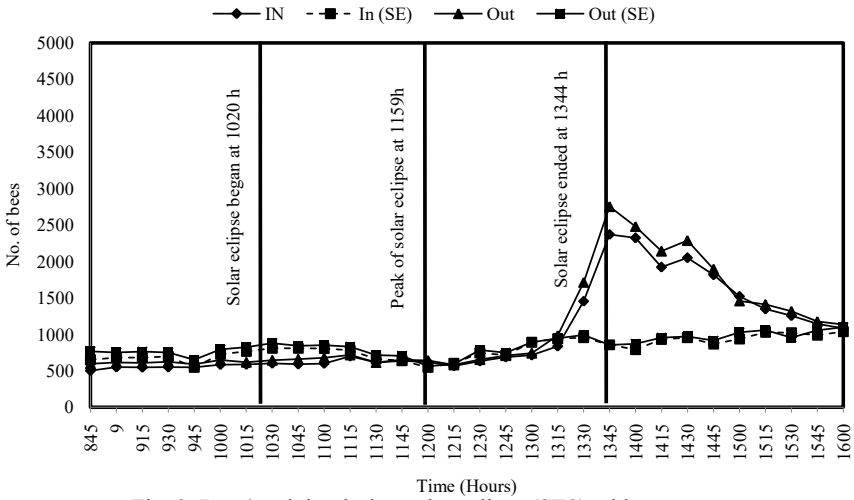

Fig. 3. Bees' activity during solar eclipse (SE0) with respect to ordinary days (one day before and after solar eclipse)

of eclipse may have checked the recruitment of foragers during peak eclipse phase. Woyke et al. (2000) found that on a partial eclipse (80%) 43 to 68% lesser number of foragers left the hives as compared to a sunny day. The lowest activity was observed 20 min before to 20 min after the maximum obscuration. It was also reported that the lowest number of foragers returned to hive even after one hour of solar eclipse. On the basis of this study, the authors advocated that the foraging activity was affected due to increasing and decreasing phases of eclipse but not due to obscuration. In case of *Apis dorsata*, higher bee activity was recorded by Roonwal (1957) during a solar eclipse day. Hains and Gamper (2017) also reported a disruption in honey bee (*A. mellifera*) foraging flight activity during a partial solar eclipse (1353-1633 hr with maximum at 1517 hr) using individual flight path tracking system. Overall, foraging flight activity, correlated with irradiance, had an increase of 15% at maximum obscuration (39%). In this study, the homing abilities of honey bees were not compromised during progression of sun eclipse and bees can efficiently use the navigational cues even during obscuration. Data on the orientation flights undertaken by the bees to reorient their navigational compass revealed that on an ordinary day 5.5 and 4.0 bees took short flights/ min at 1200 and 1500 hr, respectively; while at the same time, comparatively higher number of bees undertook shorter flights i.e. 15.5 and 12.5 bees/ min, respectively. It has been found that during the period of partial solar eclipse, temperature of hive decreased with an increase in humidity and this showed effect on bees' activity. The activity over the various time periods remained static i.e. at par with the activity recorded before the onset of solar eclipse. This showed that the obscuration had checked the recruitment of the foragers.

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AUTHOR CONTRIBUTION STATEMENT

AC planned and conceived the present study and conducted the experiment. PKC gave necessary guidance. RK and BM helped in data recordings. JS helped in data analysis and interpretation. RK prepared manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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