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Changes in Honeybee Behavior Induced by a Total Solar Eclipse in an Apiary

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ABSTRACT

This study investigates the behavioral and foraging responses of honey bees (*Apis mellifera L.*) to the total solar eclipse on August 11, 1999, in a Hungarian apiary. Using video recordings, the departures and returns of foraging bees were monitored throughout the eclipse. Results revealed that foraging activity sharply declined as light intensity dropped below 10%. In the minutes leading up to totality, pollen-collecting foragers returned en masse to the hives, while departures nearly ceased. During and immediately after totality, bees exhibited disoriented behavior, including difficulty locating their hives, collisions, and abnormal buzzing sounds. Many displayed signs of fatigue, such as immobility, slow walking, and intense abdominal pulsation indicative of heavy breathing. Interestingly, bees returning from foraging resumed normal activity more quickly than those directly affected at the hive. Foraging activity remained subdued for approximately one hour post-eclipse, despite favorable temperature conditions.

These observations highlight how sudden environmental changes, particularly alterations in light intensity and sky polarization, profoundly influence honey bee behavior. The findings enhance our understanding of how bees rely on environmental cues for navigation and activity regulation, with potential implications for apiary management and ecological research during similar phenomena.

Keywords: total solar eclipse, honey bee, Apis mellifera, foraging activity, behavioral disturbance.

INTRODUCTION

During a solar eclipse, several characteristics of the physical environment—such as solar radiation components, sky polarization patterns, and meteorological elements—undergo changes [1, 3, 9, 10]. These changes can influence the activity of both diurnal and nocturnal animals, including insects [7, 8] and birds [2].

Bees are one of the most important and easily observable groups of diurnal insects. Szentkirályi & Szalay [7] demonstrated, with the involvement of several beekeepers, that the foraging activity of honey bee workers measurably changed during the total solar eclipse, and they successfully documented several characteristic behavioral responses.

Our objective was to continuously monitor and document changes in honey bee behavior during the eclipse in an apiary located within the path of totality using video recording.

MATERIALS AND METHODS

The observations related to the solar eclipse were conducted in the apiary of András Szabó, consisting of 150 colonies, near Jászszentlászló, Hungary (Bács-Kiskun County, 46°34'N, 19°46'E), close to the centerline of the path of totality, in an acacia grove. The hives of the production colonies consisted of 10-frame Hunor brood chambers and 10-frame Hunor honey supers, with frames of identical size. The bee species was Carniolan. The video-recorded observation was conducted by the author, who is a beekeeper, using a camera directed at the entrance and landing board of a specific hive.

On August 10, 1999, the weather was sunny and warm, followed by increasing cloud cover in the evening. On the morning of August 11 (at 5:30 AM), a strong thunderstorm with lightning and hail lasted for about half an hour, thanks to a marked cold front passing through the Jászszentlászló area [3, 10]. The cool, cloudy morning was followed by partial clearing after 10 AM local time, with occasional cloud cover until the eclipse. Around 11 AM, the temperature began to

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rise, and the Sun occasionally emerged. The eclipse began at 11:29:17 local time and ended at 14:16:29. Totality lasted from 12:52:29 to 12:54:49, for 2 minutes and 20 seconds.

The air temperature was measured with a digital thermometer accurate to 0.1°C, 0.5 meters above ground in the shade, next to the hives. The temperature reached a maximum of 29.5°C at 11:40, just before totality, and a minimum of 19.6°C was recorded 10 minutes after totality. The temperature dropped by 9.9°C during the observation period.

From the repeated viewing of the video footage, data characterizing the bees' foraging activity and changes in behavioral elements could be retrospectively determined. Every ten minutes, the number of bees that flew out for foraging in one minute, as well as the number of workers returning with pollen or only nectar or water, was counted. The temporal changes in these activities are shown in Figure 1. Further analyses can be found in the article by Szentkirályi and Szalay [7].

RESULTS

The video recording commenced at 11:37, when the temperature was 25.3°C. Prior to the solar eclipse, the bees continued their foraging activities intensively and uninterruptedly until 12:10. The following changes were documented during the solar eclipse:

- **11:40** Due to a brief period of sunshine, the temperature peaked at 29.5°C. Subsequently, the air temperature gradually decreased until the first ten minutes after totality.
- **11:49** The sky was again veiled with thin clouds.
- **11:50** The temperature measured 23.8°C. Approximately the same number of bees were observed leaving the hives as were returning.
- **12:00** The temperature dropped to 22.0°C.
- **12:01** The sky became overcast. The number of departing and returning bees was nearly equal.
- **12:03** The Sun emerged from behind the clouds.
- **12:04** Pollen-carrying activity was consistent.
- **12:05** onwards The Sun was obscured by clouds.
- **12:10** The temperature recorded was 20.9°C. The atmosphere in the apiary resembled that of late afternoon.
- **12:20** The temperature fell to 20.6°C. From this point onwards, more bees returned than departed for foraging.
- **12:23** The Sun re-emerged. The air temperature slightly increased to 20.8°C.
- **12:25** The sky became cloudy again (21.0°C).
- **12:30** The temperature was recorded at 20.9°C. The dimming became increasingly noticeable.
- **12:35** A twilight-like darkness akin to evening at 19:00; numerous bees gathered at the entrance, with the Sun occasionally reappearing.
- **12:40** The temperature measured 20.3°C. The sky remained cloudy.
- **12:42-12:43** The Sun was shining while the sky appeared gray. The number of returning bees began to increase.
- **12:45** There was a sudden surge in the number of bees returning with pollen, while the frequency of departures decreased.
- **12:48** The Sun shone brightly. Due to the mass return of pollen-carrying bees, there was significant commotion in front of the hives. Bees not only entered their own hives but also intruded into neighboring ones.
- **12:49** The Sun was again obscured by clouds, and the shadows were not visible. The pitch of the bees' buzzing increased, becoming louder.
- **12:50** The temperature was 19.7°C. The Sun emerged again, with incoming bees flying up to the top of the hives.
- **12:51** Continuous dimming occurred as the eclipse approached totality, resulting in near-darkness. Bees that were outside flew above the acacia trees, buzzing as if swarming.
- **12:52:29-12:54:49** During the total eclipse, the temperature remained at 19.7°C. The darkness resembled night. A large number of bees were seen hovering in the air outside the hives. Bees disappeared from the entrances and retreated inside the hives, where the buzzing sound diminished.
- **12:55** Light began to return. The bees moved from the trees toward the hives, creating chaos among them. They collided with various objects, including the observer's body, the camera, tree trunks, and the hives. All bees attempted to enter the hives simultaneously, resulting in significant disarray at the entrances.
- **12:56-13:00** Prior to the end of totality, many bees entered other hives and returned with their pollen loads upon the Sun reappearing. Pollen-carrying bees seemed to almost fall onto the landing board, with their abdomens pulsating strongly. After landing, they did not immediately enter the hives. They were observed sitting motionless, not only on the landing boards but also on the hive's front walls. Their posture suggested they were leaning forward at an angle of approximately 10 degrees, pressing against the landing board. They moved their antennae to detect the scents associated with their own colony emanating from within the hive. They appeared fatigued and struggled to move under the weight of the pollen. One examined bee was seen fanning with its wings, rhythmically expanding and contracting its abdominal segments, bending the last segment (where the venom sac is located) downwards, while standing in an unusually wide-legged stance. Many such sluggish bees were observed. Activity at the landing

boards ceased. Only a few bees were seen flying; the air felt very humid and cool.

- **13:02** The temperature was 19.6°C. Bees that had experienced the total eclipse while foraging on flowers outside were now returning to the hives, appearing fresh and not fatigued.
- **13:03** The Sun was shining, evoking a morning atmosphere. Bee activity came to a complete halt, with no bees entering or leaving the hives.
- **13:04** The Sun shone brightly, and the temperature remained at 19.6°C.
- **13:06** No bees were in the air.
- **13:07** The temperature was 19.6°C. No bees were flying. Pollen-laden bees had also retreated into the hives. There was no activity at the entrance, and the buzzing had quieted down.
- **13:10** The temperature was recorded at 19.7°C. The temperature began to rise. The minimum temperature of 19.6°C persisted for six minutes. The sky was veiled with thin clouds, and fast-moving clouds approached from the south.
- **13:11** The temperature was 19.8°C. More bees began to appear at the entrance.
- **13:14** The temperature was 19.9°C. There was still no mass departure of bees.
- **13:19** The temperature measured 20.2°C. The Sun was shining. The video recording concluded.

Following the last temperature measurement, we continued to observe the bees for nearly an hour. By around 14:00, normal activity had still not resumed in the hives, and significant movement was not observed, with only one or two bees leaving the hives.

EVALUATION

It is a general observation that when a large, thick cloud passes in front of the Sun, or when a thunderstorm approaches, the darkness causes bees to cease their foraging activities and immediately return to their hives [5, 6, 7].

Based on this, it was expected that the increasing and accelerating darkness accompanying the solar eclipse would trigger the return of foraging bees. According to our observations, around 12:40, when the relative light intensity of the Sun had already decreased to 10%, the bees began to respond strongly to this environmental change, and subsequently, they returned en masse to their hives.

Earlier, the collection of pollen, nectar, and water (the latter being very important during the brood-rearing period) was carried out with appropriate intensity, meaning that the number of departing and returning bees was roughly in balance per unit of time. Until 12:40, the number of bees leaving the hive continuously increased (Figure 1); after that, it significantly decreased, and for a longer period during and after the total eclipse, departures nearly ceased. The number of bees returning with pollen moderately increased until 12:40, fluctuating depending on the passage of the clouds. After that, there was a dramatic increase in the number of workers returning with pollen. Most bees returned to the hives in the few minutes preceding the total eclipse (see Figure 1 at 12:50).

In contrast, the number of bees carrying nectar or water showed much less fluctuation during the entire period before the total eclipse, maintaining more or less the same activity level, and only increased slightly in the last 10 minutes (Figure 1). The reason for this is unknown; however, it can be stated that only a small fraction of the workers was not carrying pollen.

By the onset of the first darkness, a significant number of bees were unable to enter their hives in time; they had to wait outside during the total eclipse and only returned afterward. Ten minutes after the total eclipse, there was practically no further return of bees. It was generally characteristic of the bees' behavior that, following the total eclipse, there was a prolonged period— in this case, lasting about an hour—during which normal foraging activity did not resume [7].

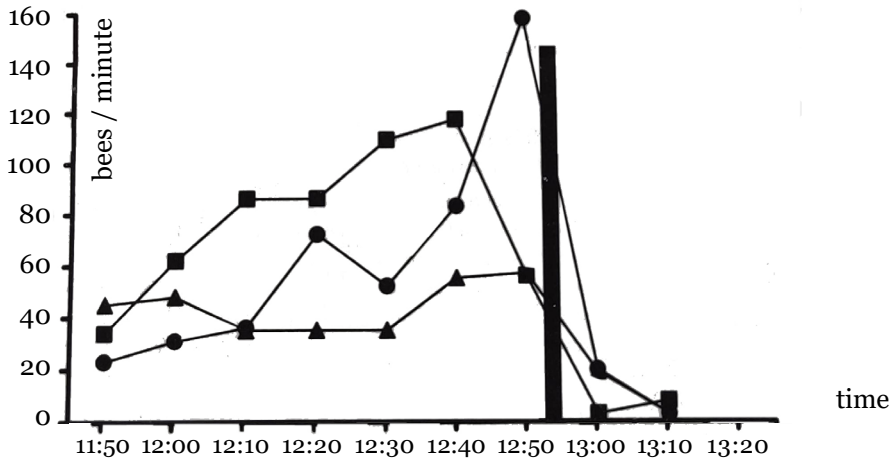

Figure 1. The number of foraging honey bee workers flying out or returning per minute at the entrance of a hive during the total solar eclipse. ■ : bees flying out; ● : bees returning with only nectar or water; ▲: bees returning with pollen.

However, this persistently low level of activity was not caused by temperature changes, as we recorded values above 20°C following the total eclipse, but rather by a response to the temporary decrease in light intensity caused by the solar eclipse.

Another documented change in the behavior of the bees was confusion, which was observed for several minutes during the total eclipse, as well as immediately before and after it. This was manifested in two ways: firstly, many bees were unable to find their own hives and mistakenly entered foreign hives; secondly, the bees that remained outside produced an unusual buzzing sound, and in the minutes following the total eclipse, they collided with everything around them, suggesting a disorientation.

These phenomena have also been reported in other beekeeping studies during solar eclipses [7]. Since this confusion occurred exclusively during the total eclipse and in its immediate vicinity, it is plausible that the significant alteration of the sky's polarization pattern during this period played a role in its development [1, 7]. This assertion is supported by the fact that bees utilize the polarization pattern of the sky for navigation during flight [1, 4].

In the minutes following the total eclipse, many worker bees appeared to exhibit signs of fatigue (e.g., immobility, sluggish walking, pulsing abdomens, and intense breathing). This may have been related to the behavioral disruption caused by the solar eclipse. Alternatively, it could have been due to the fact that the bees trapped outside had depleted their sugar reserves necessary for the energy-intensive operation of their flight muscles during the additional 3-4 minutes of flight associated with the eclipse, which they had to endure while carrying pollen.

According to some local observations, when foraging from a specific source, worker bees can relatively accurately calculate their "fuel," as from the third flight onward, they only take in as much nectar as is sufficient for an additional 100-150 meters of travel. If the honey bladder of the bees is emptied, they lack the energy for flight, and they can even perish [5, 6]. However, those bees that experienced the total eclipse while foraging far from the hive and returned later in the light did not show signs of fatigue, clearly flying back fresh and without confusion.

Upon multiple reviews of the video footage, other deviations from normal behavior were also observed. Notably, after the total eclipse, foraging bees did not immediately fly off from the entrance; instead, they first walked outside the front of the hive at a distance of 10-15 cm before taking off into the air. It was also observed during the total eclipse and in the following one or two minutes that many bees that were outside and resting on the hive walls or the landing board were ventilating by vibrating their wings.

Normally, bees perform this ventilation instinctively inside the hive after dusk, which aids in the evaporation of the high moisture content of the nectar collected during the day, essential for its conversion into honey. This external ventilation was likely triggered by the darkness during the total eclipse, which may misleadingly signal the end of the day for the bees.

It is hypothesized that the eyes of bees function as an accurate biological light meter (too). Using a lux meter, it might be possible to measure the light intensity at which they leave the hive and the light intensity at which they stop foraging.

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