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# Using Video Footage for Observing Honey Bee Behaviour at Hive Entrances

Elizabeth Crawford , Sonja Leidenberger, Niclas Norrström and Mats Niklasson 

Video recording is a common method to study animal behaviour. In honey bee studies, short video-recordings are often used to learn more about a behaviour, but rarely used for their quantification. Standard methods for observing bee behaviour involve behavioural assays or direct observation of a limited subset of marked bees within an observation hive. This means that behaviour at the hive entrance may be overlooked. Here we describe a 4-camera set up for the study of behaviour at hive entrances. With minimal disturbance, we were able to record and quantify all previously described behaviours (9 in total - including self-grooming in drones) on and around the hive entrance. We briefly discuss the general feasibility of video footage and the relative frequency of each observed behaviour. Our conclusion is that video footage is a useful and perhaps overlooked method for unbiased quantification and comparisons of bee behaviour at the hive entrance. With this paper we are publishing some example short video-recordings as online [supplementary material](#) for educational purposes.

## Common Methods for Studying Honey Bee Behaviour

Honey bee behaviour at the hive entrance is classically studied by behavioural assays, whereby researchers induce a behavioural response by disturbing the hive (Scheiner et al., 2013). Studies of natural bee-to-bee behaviour using non-invasive methods are rare. The two standard methods for observing and quantifying 'natural' behaviour involve making regular, frequent observations of a single marked bee over the course of its lifetime, or marking many bees and observing a random subset of these bees less frequently. These studies are usually conducted in observation hives under

controlled laboratory conditions (Scheiner et al., 2013). Video-recording has been used within observation hives to study colony interactions (Seeley, 1995), but this typically focuses on one behaviour or function (e.g., brood-care, hygienic behaviour).

While these standard methods for observing behaviour provide important insight into activities within the hive, they probably cannot accurately represent all behaviours which would occur naturally at the hive entrance. Thus, many behaviours which naturally occur in response to abiotic and biotic stimuli e.g., weather or natural threats (robber bees, predators) can be misrepresented.

Direct observation is not a suitable method for quantifying multiple behaviours at the hive entrance, as activity occurs too quickly to be documented as it happens. However, video cameras can be set-up at hive entrances and left to record continuously for a period of time in order to record multiple behaviours simultaneously for review and quantification at a later stage. Here, we report a video footage method for studying bee behaviour at hive entrances. We tested and evaluated the method on 16 hives with three *Apis mellifera* subspecies and one hybrid in southern Sweden. The experimental design of this study was intended for a 3-year multi-subspecies comparison (Leidenberger et al., 2019). To our knowledge, this is the first study to quantify all bee behaviours occurring simultaneously at the hive entrance by manually reviewing video recordings.

## Our Video-Recording Study

The apiary was established in Summer 2019 at Nordens Ark, Southwestern Sweden. The sixteen beehives in the apiary

housed four colonies of three different subspecies of *Apis mellifera* (*A.m carnica*, *A.m ligustica*, *A.m mellifera*) and the hybrid 'Buckfast' (Norrström et al., 2021). Wooden posts were planted into the ground at a distance of 200 mm from the centre of the hive entrance.

In Summer 2021, we recorded one hour of video footage per subspecies and hybrid every day for forty-five days. In total, 180 1-hour films were recorded at hive entrances ( $4 \times 1 \text{ hour} \times 45 \text{ days} = 45 \text{ hours}$  per subspecies). At the beginning of each filming session, one tripod (type: Gorilla pod) and video-camera (type: Ricoh WG-60 Model R02090) were attached to the wooden post outside one colony per subspecies (Figure 1). A different colony from each subspecies and the hybrid was filmed every day on rotation. The cameras were positioned so that the hive entrance and landing board were visible on screen (Figure 2). The diagonal length from the centre of the camera lens to the centre of the hive gate was on average 274 mm. All four cameras were started within 15 seconds, and stopped after 60 minutes. Recording period (morning/afternoon/evening) and specific hour of recording was randomly selected each day, for a total of fifteen days of each recording period. 1-hour recording times were randomised within recording periods as follows; Morning 0700–1100; Afternoon 1200–1600 and Evening 1700–2200. Filming only took place in daylight so that all behaviours could be observed clearly in video-recordings.

The 1-hour films were reviewed to quantify all previously-described behaviours observed on and around the hive entrance (Table 1). To quantify entrances and exits of worker bees and drone bees, a 2-minute period was randomly selected for observation using an online random number generator.



Figure 1. Camera set-up at hive entrance.



Figure 2. Screen captures from the same second of four videos simultaneously recorded at 18:00pm, 18<sup>th</sup> August 2021. Clockwise from top left; Buckfast, *A.m carnica*, *A.m ligustica*, *A.m mellifera*. Some notable observations include undertaking behaviour (top left), self-grooming (top right) and many guard bees (bottom left).

To quantify all other behaviours, a 5-minute period for observation was randomly selected. In total, 21 hours of footage were reviewed – 15 hours’ worth of 5-minute clips and 6 hours’ worth of 2-minute clips. We reviewed the same time period for each set of simultaneous video-recordings.

Quantifying Bee Behaviours

We were able to record entrances and exits, as well as a total of 9 behaviours (Table 2), where self-grooming was recorded both in workers and in drones. Not unexpectedly, the number of observations of the 9 different behaviours varied greatly, sorting them into 3 groups; 1. dominating behaviour (foraging); 2. common behaviours (self-grooming, guarding, pollen-foraging) and 3. rare behaviours (defence, air circulatory fanning, resin-collecting, Nasonov pheromone fanning and undertaking) (Tables 2 and 3).

With video-recording we could differentiate between workers returning with pollen, and those without. This can also be done by Artificial intelligence (AI) which can detect and quantify bees that are carrying pollen (Tausch et al., 2020). Using the AI method to count pollen-foragers and foragers would have significantly reduced manual reviewing time and labour in our study. Alternatively, various automated bee counting devices exist to estimate the number of bees entering and exiting the hive (Odemer, 2022). However, we wanted to quantify all behaviours using

Table 1 Guide for behaviours observed on and around the hive entrance.

Behaviour:	Described by:	Brief description:
Allo-grooming	Moore et al., 1995	Worker bee grooming another bee with legs, proboscis or mandibles
Defence	Butler and Free, 1952	Worker bee stinging, biting, grasping, pushing or dragging a robber bee or invading hornet
Fanning (air circulation)	Lindauer, 1954	Worker bee stationary, fanning wings with abdomen raised upwards
Fanning (projecting Nasonov pheromone)	Avitabile et al., 1975; Winston, 1987	Worker bee stationary, fanning wings with abdomen raised upwards, last segment of abdomen pointed downwards, pale yellow-orange Nasonov gland exposed
Foraging	Seeley and Kolmes, 2010	Worker bee returning to hive without pollen or resin (assumed to have been foraging for nectar/water/propolis, or returning from orientation flight)
Guarding	Butler and Free, 1952; Free, 1955	Worker bee touching returning bees with their antennae
Pollen-foraging	Seeley, 1985	Worker returning to hive with pollen in corbiculae (pollen baskets) on legs
Undertaking	Trumbo et al., 1997	‘Undertaker’ workers dragging dead bee out of the hive
Resin-collecting	Meyer and Ulrich, 1956	Worker returning to hive with shiny resin in corbiculae (pollen baskets) on legs
Self-grooming	Peng et al., 1987; Boecking et al., 1993	Bee cleaning self with legs, proboscis or mandibles



**Table 2.** Total number of observations in 15 hours of reviewed footage of behaviours quantified using 5-minute clips (Key: Fanning (AC) is air circulatory fanning, Fanning (P) is Nasonov pheromone fanning).

Behaviour	Total observations	Observations per minute
Foragers	17880	19.9
Self-grooming (workers and drones)	2951	3.29
Guard Bees	2407	2.67
Pollen-foragers	1355	1.51
Defence Cases	79	0.0878
Fanning (AC) cases	61	0.0678
Resin-collectors	49	0.0544
Fanning (P) cases	11	0.0275
Dead bees removed	4	0.00444

**Table 3.** Total number of observations in 6 hours of reviewed footage of variables quantified using 2-minute clips.

Behaviour	Total observations	Observations per minute
Worker Exits	8473	23.5
Worker Entrances	8274	23
Drone Exits	144	0.4
Drone Entrances	108	0.3

the same method of manual quantification to ensure that all values are comparable. Additionally, few bee counters generate precise data due to the lack of a standardised method for validation (Odemer, 2022).

Video-recording is probably the only possible method for quantifying natural bee-to-bee guarding behaviour which has not been influenced by human disturbance. It has not been widely documented that drone bees practice grooming behaviour (Pritchard, 2016), however, we observed multiple instances of this in our video-recordings (included in total quantification of self-grooming behaviour).

A further advantage of a video-recording is its potential to reveal many possible relationships between individual behaviours, thus it is possible to investigate task allocation trade-offs between subspecies. The behaviours which were rarely observed in our study ( $n < 100$ ) (Table 2) are not, to our knowledge, currently quantifiable using AI. Increasing the length of the film clips used to review these rare behaviours could potentially provide a more comprehensive insight into these types of behaviour. However, as these behaviours were observed less than once per 10-minutes, the reviewing time and thus labour would have to increase

significantly. We believe that the 2-minute clips and 5-minute clips were adequate for quantifying all behaviours.

## Future Potential

Investigating multiple behaviours simultaneously is the only way to fully capture group behaviour of honey bees. The key strength of video-recording is that it causes little disturbance, which allows an accurate representation of natural bee behaviour. We were able to quantify the response of all visible bees to natural threats from robber bees and predators. This is not possible using behavioural assays, which evaluate defensive behaviour from a 'human-to-bee' context after deliberate disturbance. Here, we evaluated natural bee-to-bee defensive behaviour (guarding and active defence) over a long period.

Further benefits are that video-recording is relatively low-cost and weather insensitive, and that it requires little labour to collect a large amount of data, but, manually reviewing video recordings is labourous. It is possible that future developments in AI could minimise human labour and assessment bias while achieving the same results as manual review. There are multiple studies currently piloting AI which can detect motion patterns of individual bees in order to detect bee poses (Pereira

et al., 2019; Tausch et al., 2020). AI is also currently used in combination with video to track bee flight paths at the hive entrance (Magnier et al., 2018). However, AI is not currently employed to recognise all behaviours of individual bees at the hive entrance. Therefore, manual observation of video-recordings is currently still the most accurate unbiased method for quantification of bee behaviours. While this method is often overlooked in favour of genetic studies or behavioural assays, we propose that video-recording is underestimated as a valuable tool for studying bee behaviour.

## Geolocation Information

(Lat/Long 58.442481°N and 11.437202°E).

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## Supplementary Material

Supplementary Videos 1–9 are available via the 'Supplementary' tab on the article's online page (<http://dx.doi.org/10.1080/0005772X.2022.2106739>).

## Disclosure Statement

The authors report there are no competing interests to declare.

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