Evaluation of bee counters - a new protocol for measuring the accuracy of daily losses

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BACKGROUND

To assess daily honey bee losses, an accurate bee counting system is needed. The challenge of determining daily losses in an automated manner with an accuracy suitable for regulatory risk assessment has not yet been accomplished. While many counting systems exist, there is a lack of sufficient evaluation of their suitability for this task.

None of the evaluation methods found in the literature is able to exclude malfunctions of the bee counter and to quantify the remaining errors as daily loss uncertainties. Even with the only standardized approach to date (Robbers Test, Fig. 1), we cannot detect faulty counters. A robust assessment protocol is needed to test the accuracy of existing counters and identify those suitable for regulatory risk assessment.

NEW APPROACH

The accuracy of a counter depends on the difficulty of the measurement condition, i.e. the number of flights or the " crowdedness " at the entrance. We differentiate between scenarios with a varying degree of difficulty, which are more or less prone to error. Each day is composed of different scenarios in different parts.

A larger proportion of more difficult scenarios, e.g. due to flight-friendly weather, will more frequently lead to measurement errors than a rainy day, which may be comprised of particularly easy scenarios.

By modeling the performance of the robbers test based on the measurement conditions, the expected measurement errors for a given day can be predicted based on their difficulty. The following nine-step procedure implements these ideas:

ROBBERS TEST

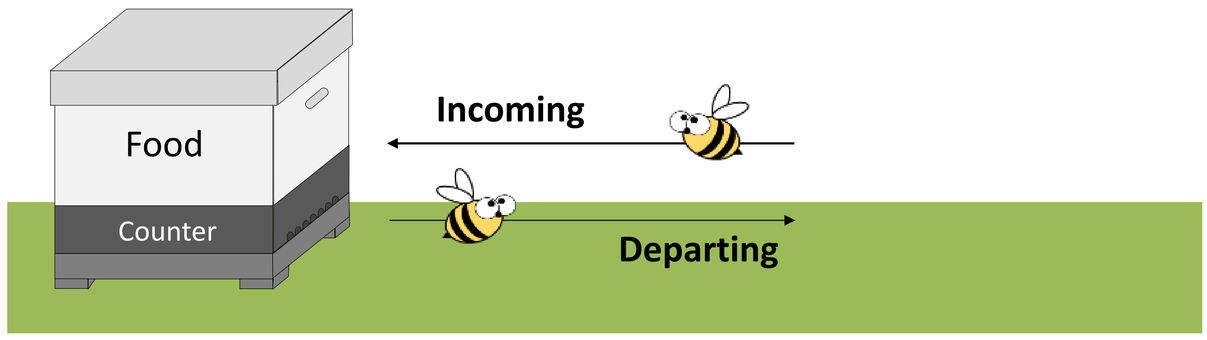

Fig. 1: In the Robbers test after Struye, the counter is placed at the hive entrance of an empty hive in the field. The hive contains a food source (honeycomb, sugar water). Now the in and out flights are measured, where the balance must be zero at the end of the day. Deviations from zero are interpreted as a percent error (PE) of the device.

✓ 1. Identify performance factors

Example: Crowding and infrared lighting have a negative effect on counting accuracy and represent performance factors.

✓ 2. Derive scenarios

Example: “Few bees moving slowly under infrared lighting” is considered to be a scenario.

✓ 3. Annotate scenarios

Example: For each scenario, 10, 20, or 30-s videos are annotated manually by a well-instructed person as ground truth.

✓ 4. Scenario evaluation-by-observation

All annotated videos are processed with the counting system and compared with the ground truth.

✓ 5. Rate scenario difficulty

The scenario that achieved the best result in the previous step is assigned difficulty level zero, the worst result is assigned difficulty level one.

✓ 6. Robbers tests

Robbers tests are carried out during several days.

✓ 7. Difficulty of robbers tests’ measurement conditions

For each robbers test, the measurement conditions are evaluated.

✓ 8. Model accuracy based on the difficulty of the measurement condition

There should be a positive correlation between the difficulty of the test day and the accuracy of the bee counter.

✓ 9. Plausibility check

The measured loss should be compared with the loss expected from a reference source.

We published this protocol in *Computers and Electronics in Agriculture* (Borlinghaus et al. 2022). See the link below.

OUTLOOK

High-quality data on honey bee background mortality are currently unavailable due to a lack of methodology to generate them. With the here presented evaluation for daily loss measurements, a protocol was introduced that should be suitable for determining the accuracy of electronic bee counters under field conditions in a standardized way.

The protocol combines existing approaches into a new, harmonized method that can be performed regardless of how the bee counter operates. The thorough evaluation is time-consuming but only needs to be done once for a bee counter system. The work thus makes innovations in practice measurable and creates the basis for comparability of bee counting systems, enabling faster progression of the sector. Hence, it should be possible to advance the field by developing counters that meet or even exceed scientific and regulatory requirements.

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