Quantification of pollen intake as a behavioral endpoint for foraging activity in ecotoxicological risk assessment

Frederic Tausch, Matthias Diehl and Katharina Schmidt
apic.ai GmbH. Rintheimerstraße 31-33, 76131 Karlsruhe, Germany

apic.ai

Introduction

As of the publication of EFSA's *Guidance on risk assessment on bees* in 2013, it has not been possible to include sublethal effects in ecotoxicological risk assessment. Therefore, risks in lower tier studies may be underestimated (EFSA 2013, p. 10). It was recorded, that in order to include them, a quantitative link had to be made between sublethal effects observed in lower tier studies and those in colonies in the field. (EFSA 2013, p. 99).

- Exposure to plant protection products as well as possible repellent effects are currently assessed by manually counting the number of bees on flowers per m² in set time intervals (EPPO 170). This is time-consuming and labor-intensive.
- Detailed information on pollen foraging behavior is scarce, especially over long periods. It can be obtained with pollen traps, through expert observations or manual colony assessments. These either have low resolution regarding time of foraging, short collection periods and possible bias or include intrusive actions which influence bee behavior.

Objectives

Validate if artificial intelligence based hive monitoring can generate the data necessary to enable the inclusion of foraging behavior as a sublethal end point in ecotoxicological risk assessment. Success criteria was defined:

- Continuous data, not just snapshots of a few minutes.
- Data of different hives must be comparable regarding time of day collected.
- AI-generated data must be manually checkable to validate the results.
- Data collection must be scalable to allow assessments of large numbers of hives.
- Enable the assessment of both the absolute amount of pollen collected and the share of foragers which carried pollen into the hives.
- A high resolution of data, which enables detailed insight into changes within minutes, hours and days as well as long-term trends.

Materials and Methods

Oomen study design with eight hives for ten consecutive days. Four were fed 500 g of 50% sugar solution with 200 µg imidacloprid/ kg. The control group of four hives was fed an equal amount of sugar solution. A total of 72 days was monitored.

Each hive was equipped with a visual monitoring device of apic.ai (see figure 1), which recorded all bees entering and leaving. The videos were later analyzed using machine learning methods in a three-step-process (see figure 2).

Figure 1: The AI based monitoring devices.

Figure 2: Video analysis process using different machine learning methods.

Pollen collection can be quantified with the help of artificial intelligence (AI) based visual hive monitoring.

Results and Discussion

- The success criteria was met for the analysis of the Oomen study. Behavioral differences could be observed between treated and control group (see figure 3, 4).
- During the exposure period the daily mean number of bees entering their hive was 54.879. Among these a mean number of 4.477 bees carried pollen. The confidence interval had a range of ± 315 bees, which is 7 % of bees carrying pollen. The statistical error depends mostly on the total foraging activity and the share of pollen foragers.

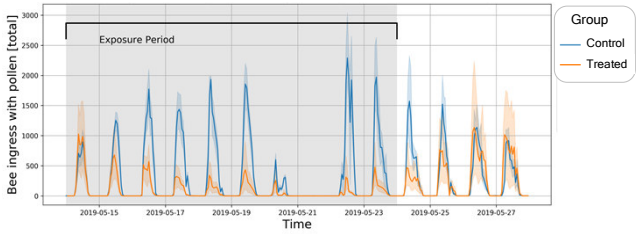

Figure 3: Amount of pollen collected hourly during and after the exposure period.

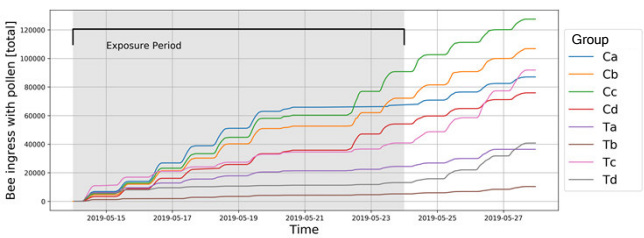

Figure 4: Cumulated amount of pollen collected during and after exposure period.

Conclusion and Outlook

- AI generated data on pollen foraging may be used to measure secondary assessment endpoints, alternatively to methods described in EFSA GD (2013) p. 220.
- The technology could be used to collect data on exposure and possible repellency in the crop instead of counting bees on flowers as described in EPPO 170 (see figure 5).
- In future research the data could be used to study how pollen collection correlates with colony development, queen health or external factors (see figure 6).
- Foraging success could be used as an indicator for the level of availability of feed in the surrounding during field studies and for the identification of temporary shortages.

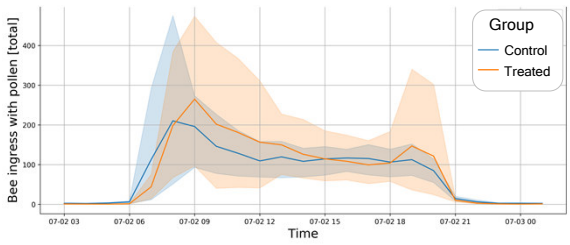

Figure 5: Amount of pollen carried into the hive per hour on exemplary day (July 2nd).

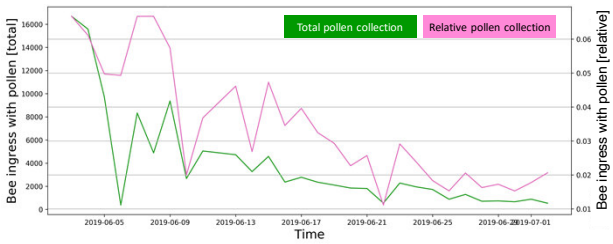

Figure 6: Daily collected pollen following queen loss in total and as a share of all bees entering the hive.

European Food Safety Authority, 2013. EFSA Guidance Document on the risk assessment of plant protection products on bees (Apis mellifera, Bombus spp. and solitary bees). EFSA Journal 2013;11(7):3295, 266 pp., doi:10.2903/j.efsa.2013.3295.

OEPP/EPPO, 2010. EPPO Standards PP1/170 (4) Efficacy evaluation of plant protection products. Side-effects on honeybees. Bulletin OEPP/EPPO, 31, pp.313-319.

Presenter: Katharina Schmidt
Contact: katharina.schmidt@apic.ai

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