Assessing bumblebee colony development and natural variability using automated and manual monitoring

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BAYER

ID 67236

A Comparison of the Variability Across Bumblebee Colony Parameters Using Manual and Automated Methods: How Accurately Can We Measure *Bombus* Colony Development?

INTRODUCTION

Bumblebees are important pollinators of agricultural crops, therefore methods for the evaluation of effects of pesticides have been proposed in some regulatory schemes. Recently validated testing methods have been developed for individual bumblebees (OECD 246/247) but the development of methods that would allow the assessment of colony development has proven to be more challenging since existing data reveal a very high inter-colony variability. We have jointly been developing an approach to compare assessment methods:

Assessment/ parameter	manual	automated	Comparison done
Activity (in/out)	no	yes	-
Individual numbers	yes	yes	Complementary data
Individuals body size	no	yes	-
Pollen foraging	no	Yes	-

METHODS

Testing material and study set-up: Commercially available bumblebee colonies (Biobest) were each set in a housing, to which apic.ai monitoring systems were attached. Colonies were accessible and protected from weather conditions. The monitoring systems were the solar-powered and equipped with a radio device to be able to connect to the internet.

Timeline & treatments
In 2020, non treated colonies foraged freely. In 2021, 2 concentrations of a toxic reference were tested by feeding the colonies with spiked sugar solution in tunnels.

	Assessment period	Number colonies/ treatment
2020	09.05. to 30.06.20	N=4/ none
2021	14.05 to 21.06, respectively 20.07.21	N=6/ 2 colonies per treatment (Contr. T1-T2)

Manual assessments:
The development of the brood nest size was assessed two times per week based on the volume categorizing system by Sterk & Huverman.
Emerged young queens were collected 3 times per week individually. The weight of collected queens was registered. At the end of the trial, colonies were deep-frozen for a final evaluation (assessment of individuals/ development stage or caste).

Automated assessments:
Video footage was collected continuously throughout the study. It was analyzed after the study ended using neural networks trained to detect activity, size and pollen collection. The training of the algorithms as well as the accuracy determination were done using manually annotated videos.
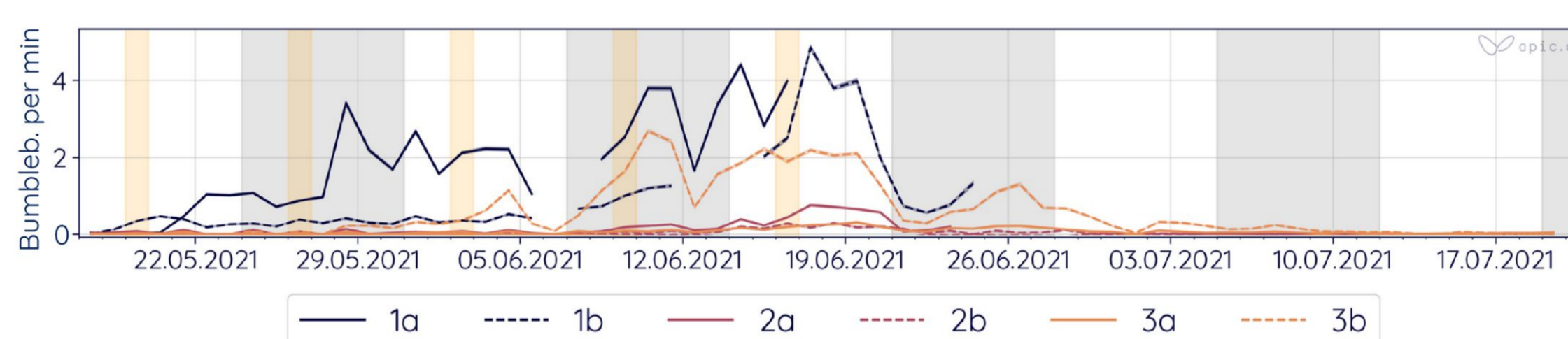
RESULTS

Activity
2020: Activity of bumblebees entering the colony. Light shades display the (low) uncertainty of measurements.
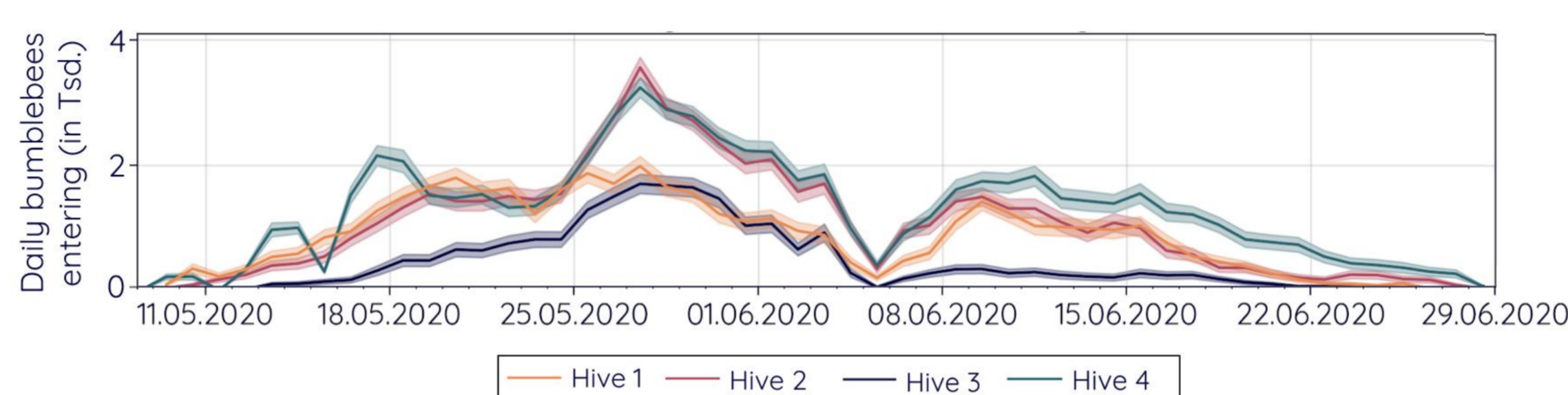
2021: Average minutely activity of bumblebees entering the colony. Light shades display (low) uncertainty of measurements. T1 =2a, 2b, lower concentration; T2 = 3a, 3b higher concentration; C = 1a, 1b control group.
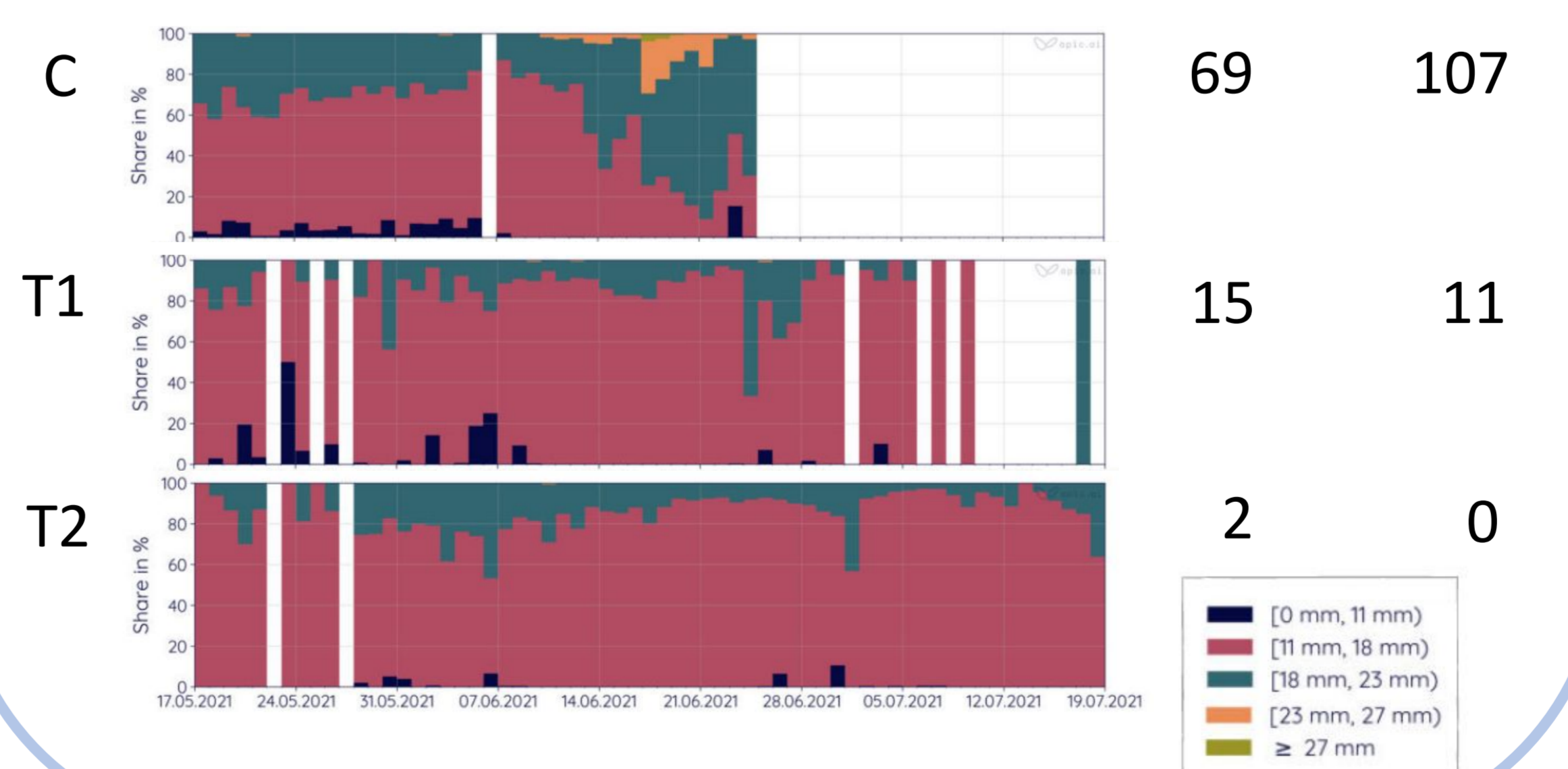

2021: Average minutely activity of bumblebees entering the colony. Light shades display the (low) uncertainty of measurements as well as in-group variability.
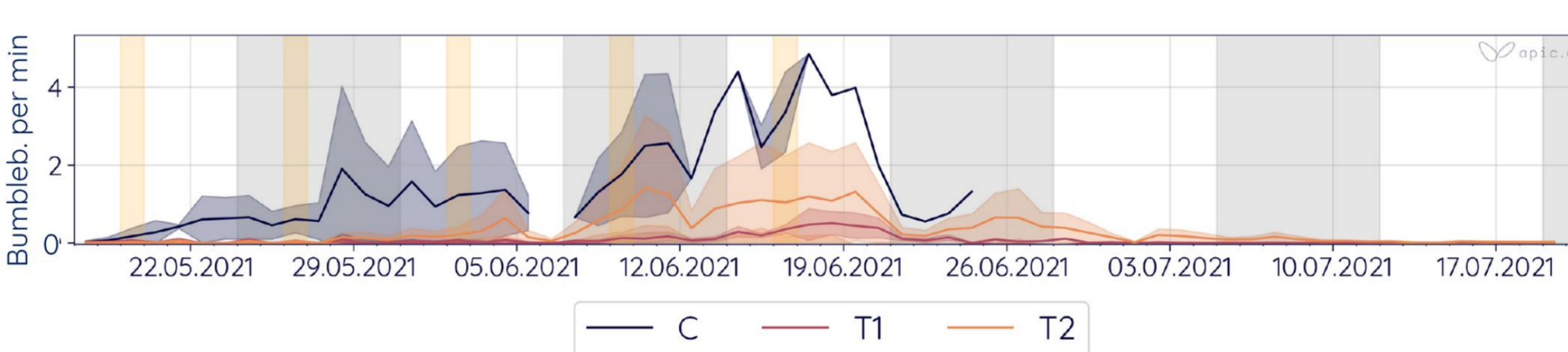
Body size distribution
Distribution of individuals clustered into size categories by median length. Only data from bumblebees leaving the hives was used.
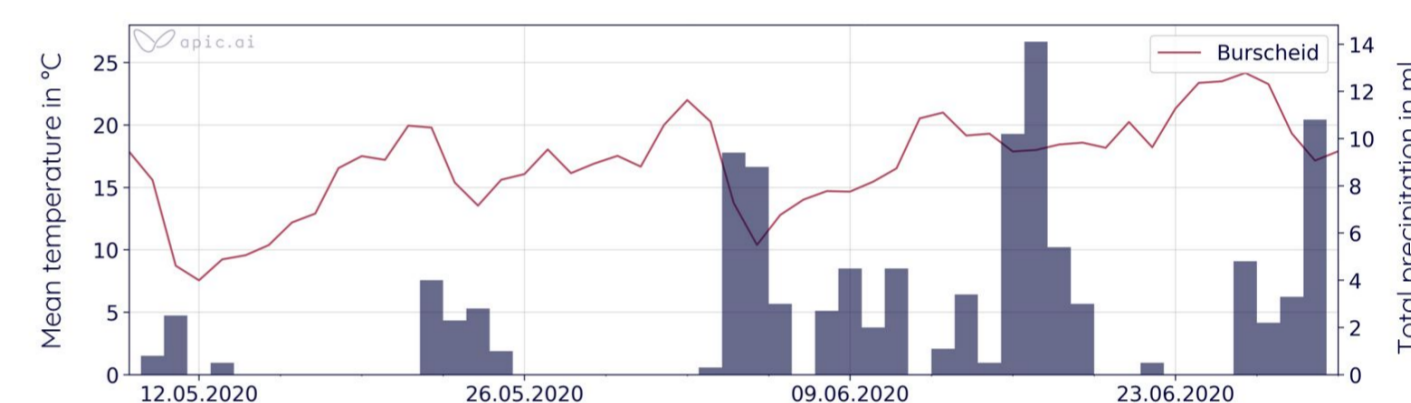
	Manually collected gynes	Number gynes at dissection
C	69	107
T1	15	11
T2	2	0

Size categories: [0 mm, 11 mm); [11 mm, 18 mm); [18 mm, 23 mm); [23 mm, 27 mm); ≥ 27 mm
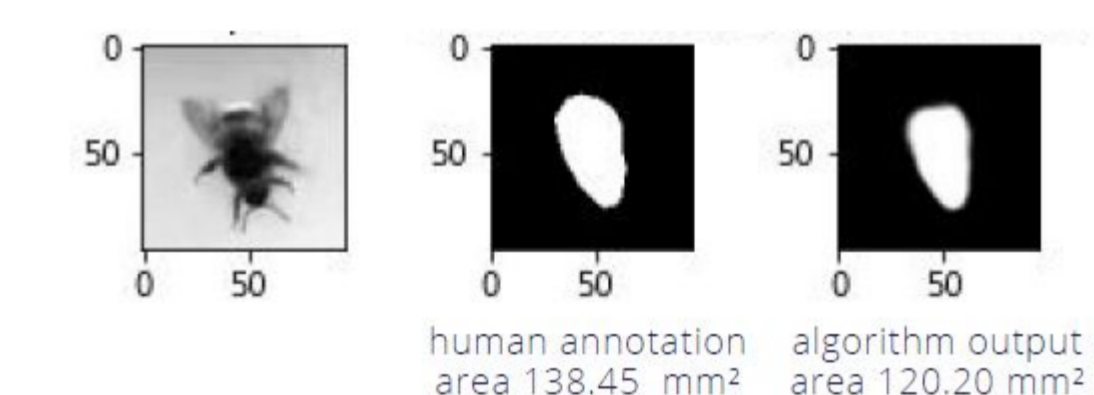
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Study details 2020

Weather conditions (OpenWeatherMap – Location Burscheid, Germany)

Exemplary comparison of algorithm output and human annotation for the visual determination of bumblebee size.

human annotation area 138.45 mm²

algorithm output area 120.20 mm²

Study details 2021

Accuracy of apic.ai data
Activity: Average uncertainty of measurements (CI 95% percentile) was less than 5.9 bumblebee movements per day.
Size: The algorithms bumblebee length estimation has an uncertainty of ± 9.2 % (95% CI).

Size assumptions

< 18 mm are assumed to be workers or drones.
11-23 mm are assumed to be drones.
>23 mm are assumed to be queens.

CONCLUSION

- The inbound and outbound activity of individual colonies can be measured accurately. These data combined with the body size distribution could be used to identify in a semi-quantitative way the development of individual colonies (i.e. presence of queens).
- The development of colonies even under the same conditions can vary greatly as observed with colonies not exposed to a stressor in 2020 and with the variation observed in colonies of T2 (2021 data)

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