

Student Poster

MACHINE LEARNING-BASED BIOACOUSTIC DETECTION OF ROBBER BEES



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WHAT?



Some stingless bee species (such as *Melipona quadrifasciata*) respond aggressively to robber bee incursions.



• Cleptobiotic bees •

Robbers of food from other colonies.

• A threat to meliponiculture •

Reducing productivity and weakening hives.

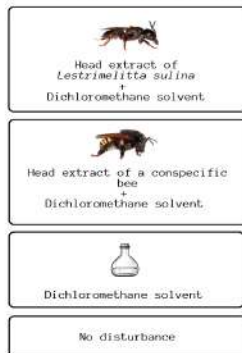
• Defensive behavior •

The *Melipona quadrifasciata* tactic •
Sheltered alongside other species due to its defensive responsive when robber bees are around.

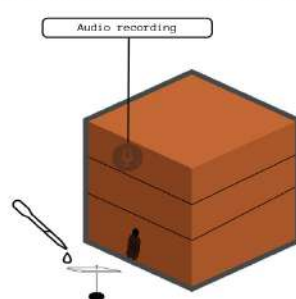
- This tactic isn't always enough •
Attacks can still break through.

What if we could detect the presence of robber bees rapidly to prevent damages?

HOW?



1 TREATMENT SETUP:
Control and test stimuli.



2 HIVE EXPOSURE AND RECORDING:
Presenting treatments and capturing bee responses.



3 ACOUSTIC FEATURE EXTRACTION:
Deriving MFCCs from audio samples.



4 MACHINE LEARNING CLASSIFICATION:
Training and testing the model.

THEN?

Highest classification performance:

Robber bee exposure (F1 score = 0.96)

Moderate detection:

Conspecific exposure (F1 score = 0.71)

Lower detection:

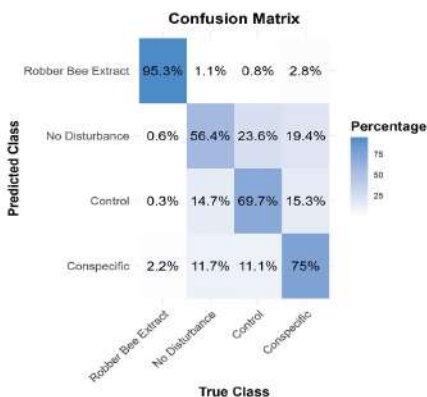
No-disturbance (F1 score = 0.61) and positive control (F1 = 0.67)

- The KNN model achieved high performance in identifying the exposure of the hive to robber bee extract, with minimal misclassification.
- The model distinguished the Conspecific stimulus, revealing a different, though less pronounced, sound modification compared to the other classes.
- The rate of confusion between the Control and No Disturbance classes, along with their individual accuracy rates, indicates that the solvent does not have a very prominent discernible acoustic effect on *M. quadrifasciata* bees.

NEXT?

Increase the number of monitored hives and develop a device for rapid alerts, enabling beekeepers to take protective measures (e.g., closing hives) to prevent damage.

Watch a short video about some aspects of our research:



PP-301 [Beekeeping Technology and Quality]

Machine learning-based bioacoustic detection of robber bees

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Most stingless bee species forage on flowers to obtain nectar and pollen, except some genera such as the cleptobiotic bees *Lestrimellita*, which steal food resources from other colonies. In Brazil, beekeepers know that some stingless bee species exhibit a defensive behavior as robber bees are attacking nearby colonies. One of these species is *Melipona quadrifasciata* in which its colonies are commonly integrated into meliponaries alongside other stingless bee species as a protective measure. However, this strategy is not always effective, as the defensive response does not completely prevent attacks. In this context, it is known that the defense responses of stingless bee species are triggered by pheromones in cephalic glands of both their nestmates and the robber bees. Additionally, studies in precision beekeeping have demonstrated that coupling audio analysis with machine learning techniques can detect behavioral changes in bee nests. In this study, we hypothesized that exposure to the contents of the cephalic glands to *M. quadrifasciata* triggers the defensive response of such bees against robber bees and that this response could be detected through acoustic analysis. To test this, we exposed a hive of this species to four treatments: (i) no disturbance (control), (ii) exposure to the solvent dichloromethane alone (positive control), (iii) exposure to the head extract of a conspecific bee diluted in dichloromethane, and (iv) exposure to the head extract of *L. sulina* using the same solvent. We recorded the hive's response, selecting five-minute segments from each condition, and extracted 12 Mel-frequency cepstral coefficients from 1,200 samples per treatment using the `melfcc` function from the `TuneR` package. The dataset was split into training and testing subsets to train a k-nearest neighbors (neighbors: 20) model using the `knn` function from the `class` package in R. The model achieved the highest F1 score when classifying responses to robber bees head context exposure (0.96), followed by conspecific exposure (0.81), while the no-disturbance (0.61) and positive control (0.67) treatments had lower scores. These results demonstrate that presence of cleptobiotic bees can be rapidly detected using the tested techniques, advising beekeepers to implement protective measures, such as closing hives, to mitigate attacks.