Investigating the Biological Impacts of Radio Spectrum

The bee project group

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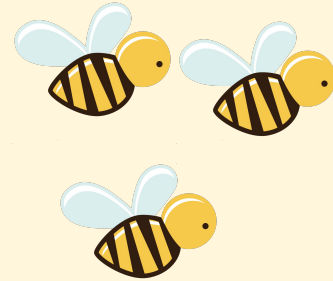**Graduate Student:**

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Advisors:

Richard Martin & Richard Howard

Website: https://www.orbit-lab.org/wiki/Other/Summer/2020/Bees

Objectives

- Bees use Earth's magnetic field for navigation and orientation.

- We seek to explore if the bees can detect dynamic signals!

Our approach

- Expose bees to static and dynamic magnetic (B) fields
  - Static fields first, then test RF

- Positive and negative reinforcement learning
  - Sugar water (reward) while RF is ON
  - Bitter water (punishment) while RF is OFF

- In-the-wild experiment
  - No capture/release
  - Not in controlled lab environment

System Components

- Low frequency and high frequency field generators
- Camera system
- Electrical control system
- A solar power unit, survives field conditions
- Real time field measurement

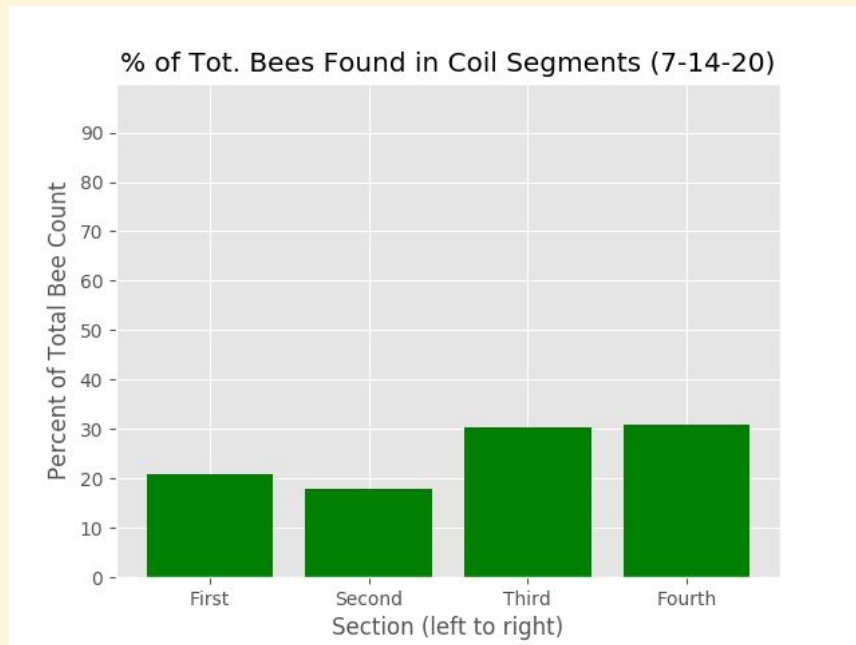
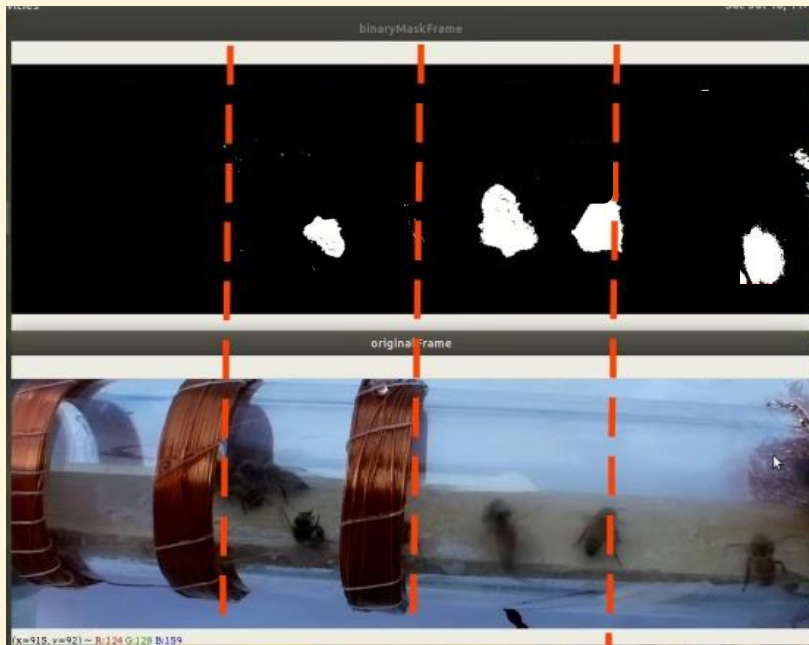RF Feeder Components
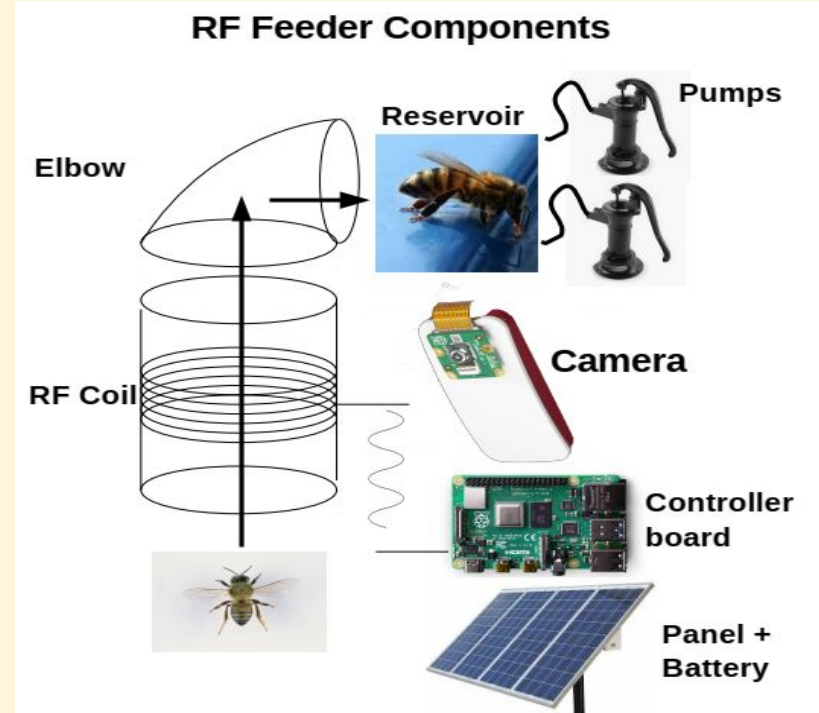
Field Generation

- Static:
  - 700 turn bunched solenoid (4X175 turns)
    - Allows easy tracking of bees
    - Magnetic field is still fairly uniform
- RF (dynamic):
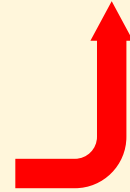 - Small helical coil under static coils
  - Initial testing to be at 1MHz.
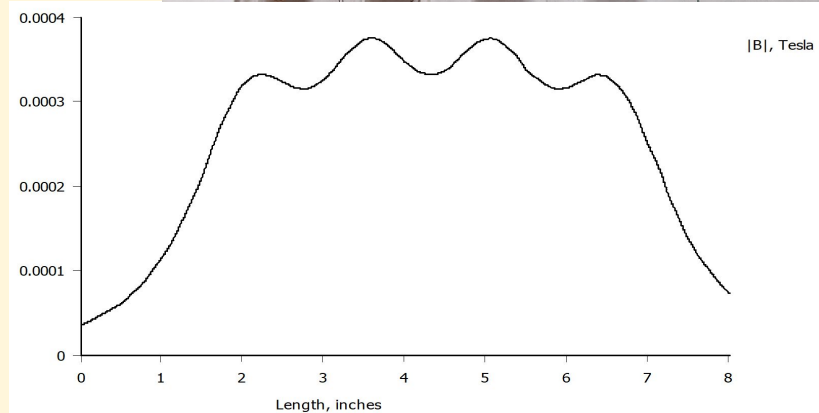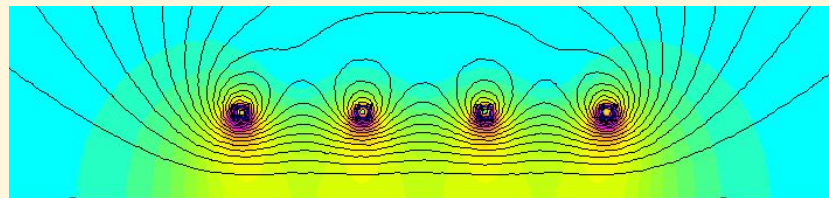
Counting Bees:

Split tube into 4 virtual sections.

% of Tot. Bees Found in Coil Segments (7-14-20)

Tracking Bee Movement:

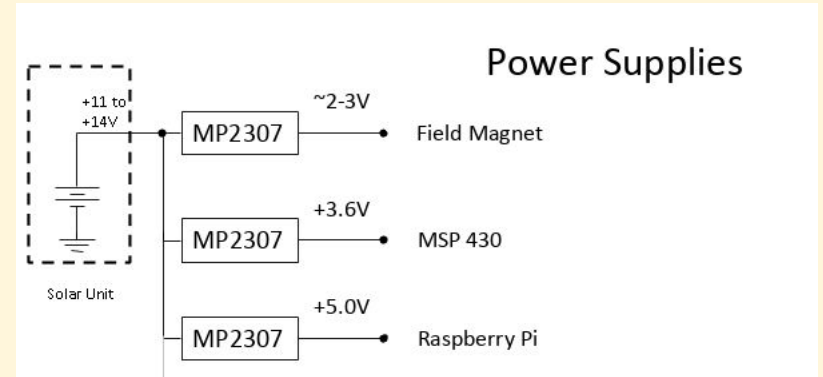Analyze patterns in response to radio waves.

2mm x 2mm Marker Code

Electrical Control System

- Pump/drain sugar/bitter/rise water (12V)
  - Pumps and trap door
- Raspberry Pi (5V)
- Field Coil (3.3V)
- Measure ambient light to detect day/night
- Control two relays for the static field coil

Power Supplies

+11 to +14V → MP2307 → ~2-3V → Field Magnet

MP2307 → +3.6V → MSP 430

MP2307 → +5.0V → Raspberry Pi

Solar Unit

PCB Design:

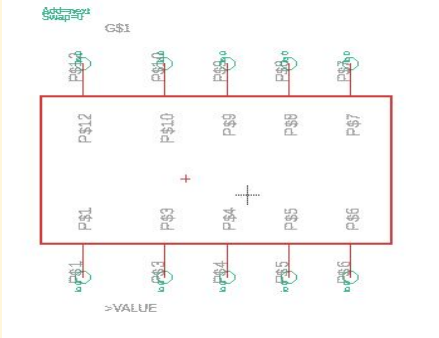## Relay Connection & Customized Library
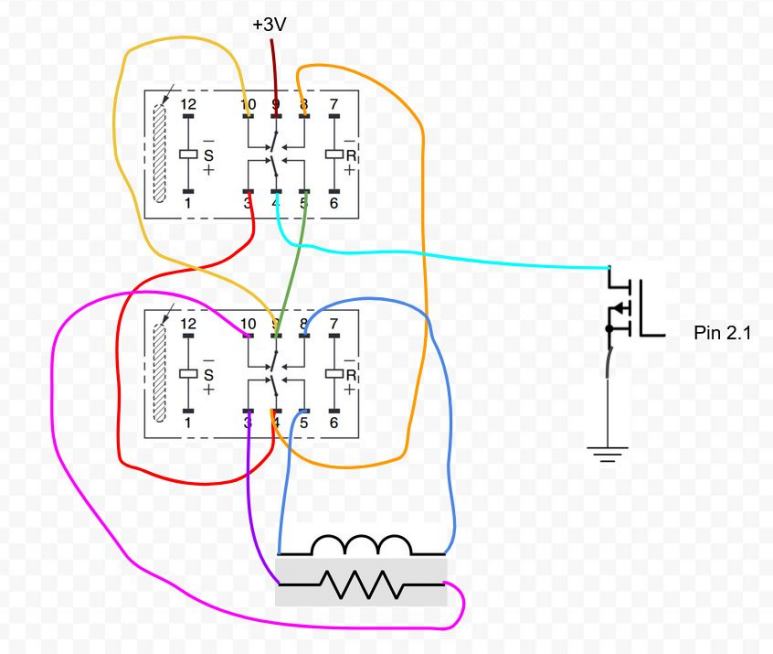
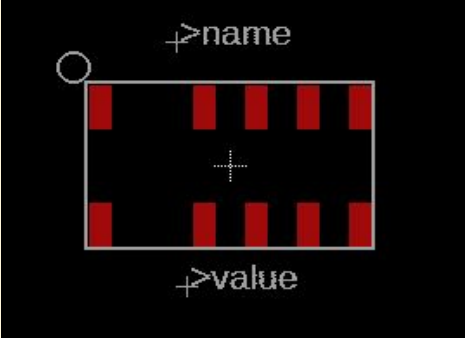Figure 1: Relay Connection

Figure 2: Symbol in Schematic

Figure 3: Footprint in Board View

Resources From & Built Based On

Relay Documentation:
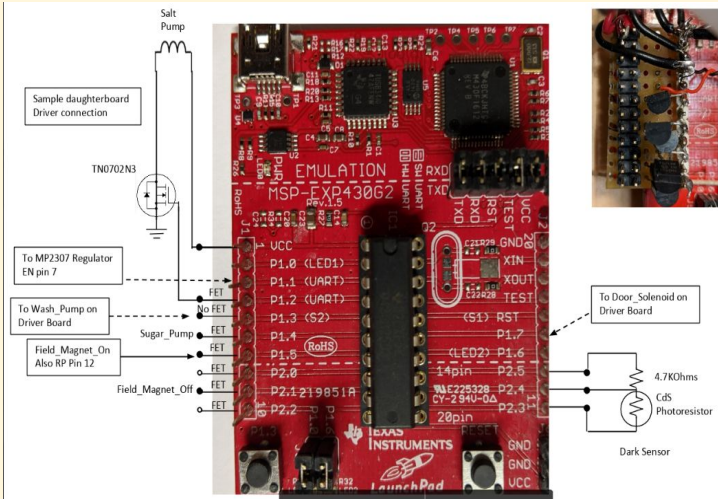https://omronfs.omron.com/en_US/ecb/products/pdf/en-g6s.pdf

PCB Design using EAGLE

Figure 1: Control Layout
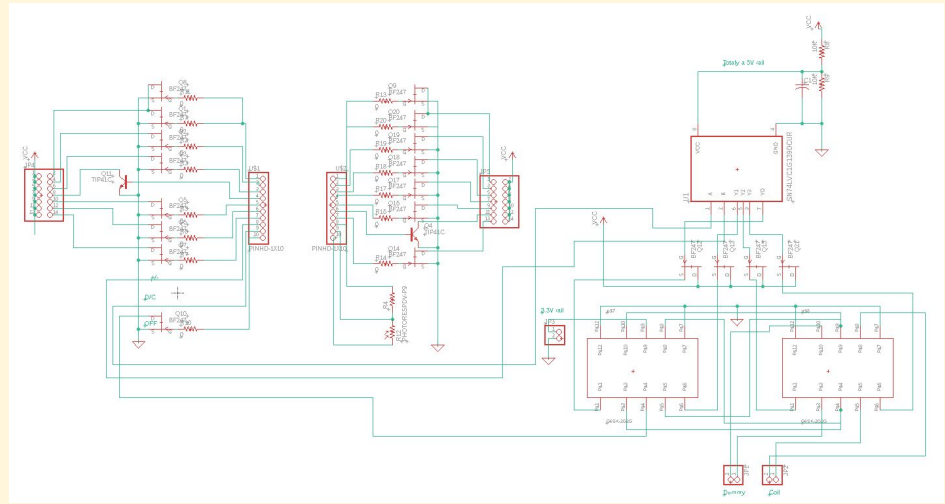
Figure 2: Version 2.1

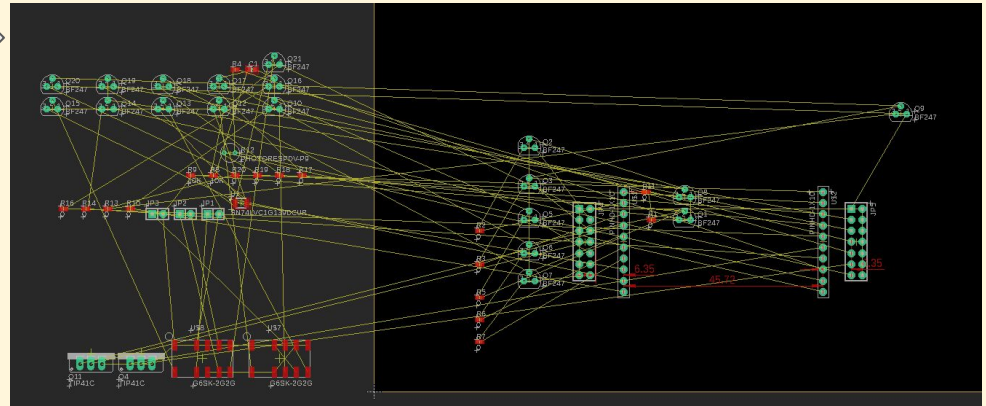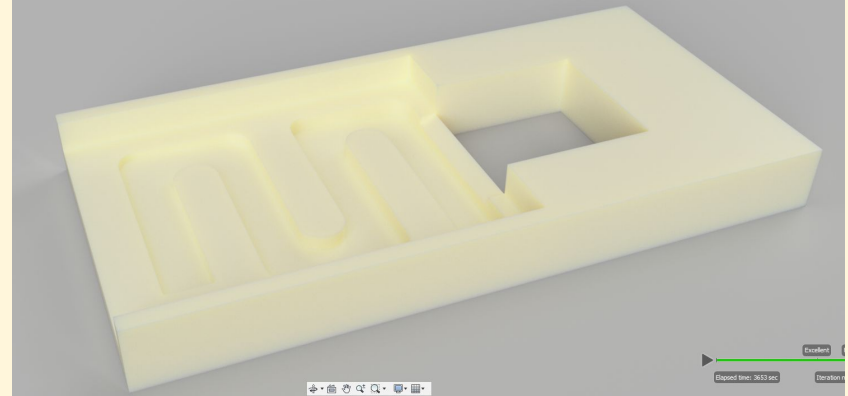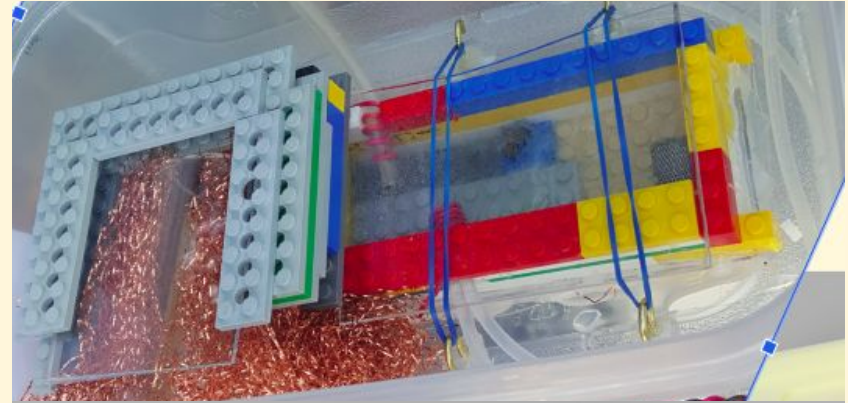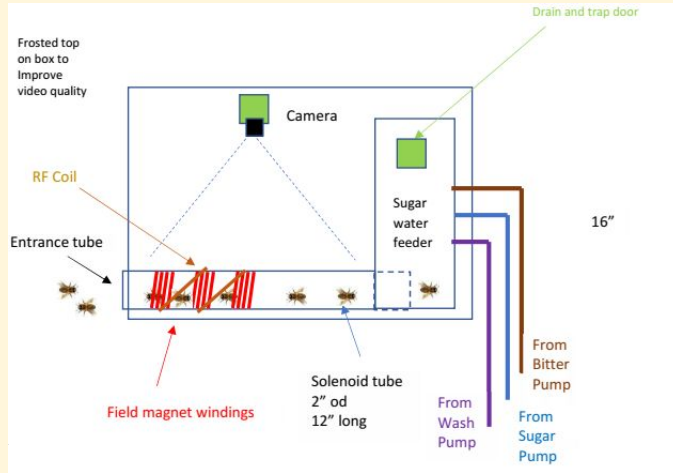

Figure 3: Version 2.1 Board View
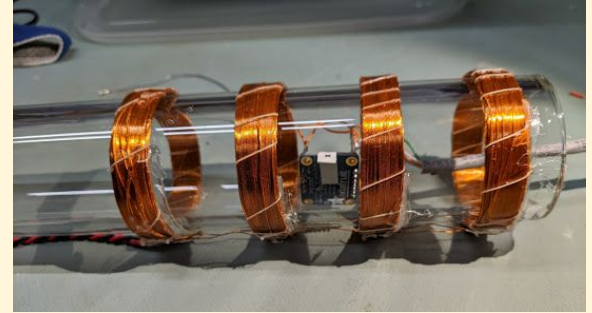
3D printing feeder design

- The current design is lego
- 3D printed design will be watertight
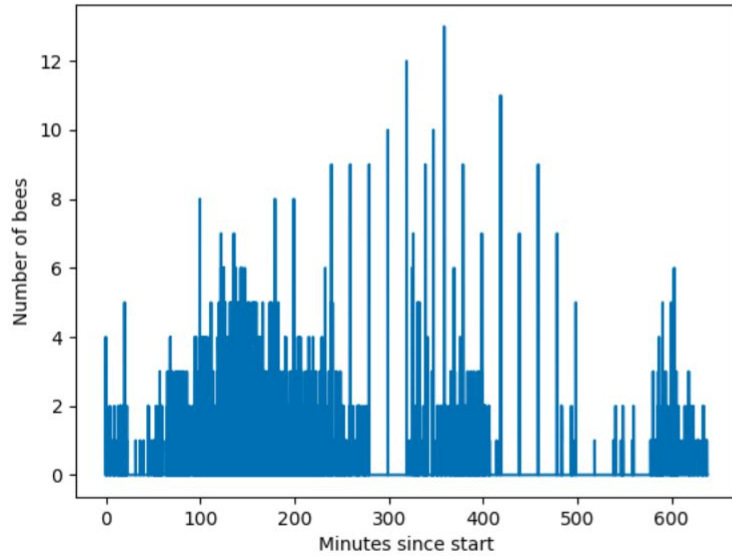- More bee friendly feeder structure

Magnetic field sensing

- We use PIP-Tag and a magnetometer to measure the magnetic field strength.

- Data is transmitted wirelessly.
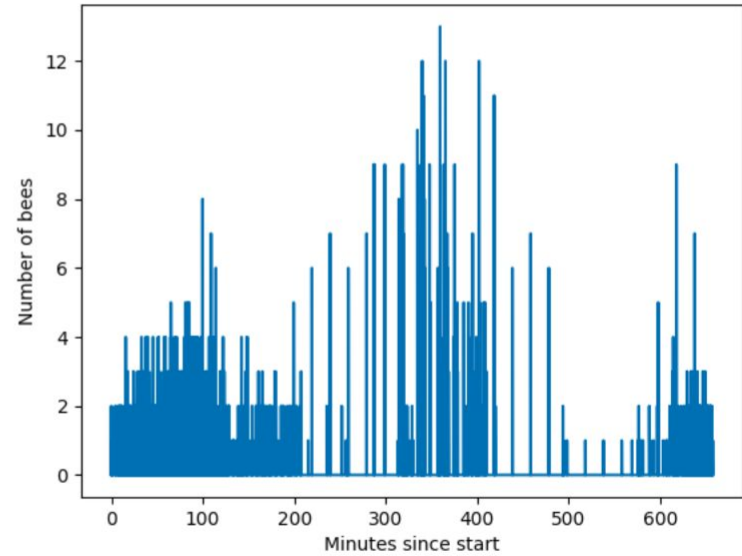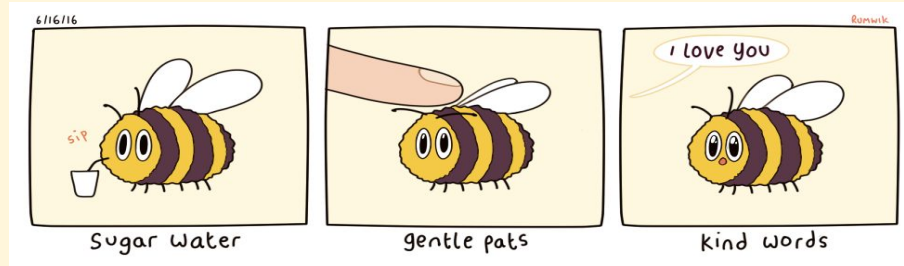
- Data can be viewed in real-time.

Recent Findings

Future Work

This project is not over! Field work will continue at least until the first frost.

Questions?

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Previous Studies

- Training a few marked honeybees using unnatural punishments, e.g. an electric shock.

- A few bees (in a lab) were exposed to observe their proboscis extension reflex (PER) after associating field exposure to food