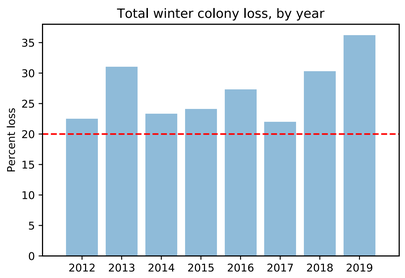
Drivers of Honeybee Colony Population Outcomes

PJ Wilkens

Crisis of honeybee colony loss



Introduction

Total annual losses of honeybee colonies in regions with developed beekeeping communities have been consistently increasing for decades, now >20%/winter

There is significant concern over the sustainability of existing stocks and their ability to meet the demand for crop pollination

The increasing colony loss is likely due to many factors, including parasites, pathogens, pesticides, habitat loss, poor beekeeping practices, etc.

Currently available hive sensors don't track representative data to allow for real-time predictive modeling of population outcomes

In order to develop the appropriate sensor technology to enable the development of predictive beekeeping tools, **it is essential to determine the factors and qualities of honeybee colonies that drive population outcomes**

Methodology

Build a behavioral model of the internal colony dynamics of Apis mellifera mellifera beehives

Test model against empirical results for validation

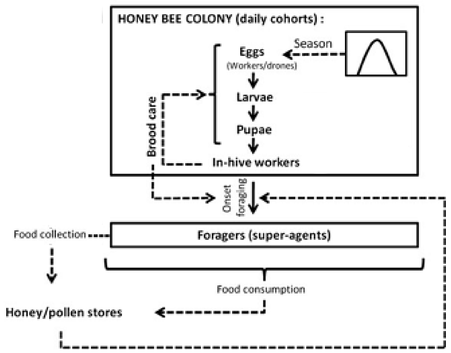
Complete a sensitivity analysis on the model to identify which input parameters have the greatest effect on 3 key hive population outcomes:

- **Peak adult bee population**
- **Peak brood population**
- **Population of adult bees during winter**

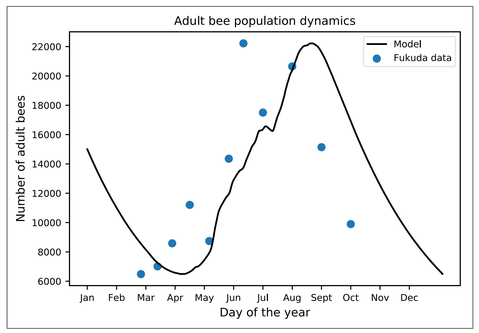
To simplify the initial state of the modeled beehives, for all simulations, we assume:

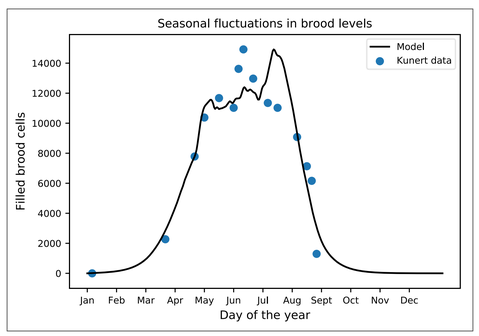
- Hives are started on January 1st when packaged bees are installed with beekeeper provided sugar and the queen begins laying
- No inclement weather to affect foraging
- There is no beekeeper or pest intervention after the first day

Model and validation



Developed following the core feedback loops, functions, and assumptions of the Beehave Colony Dynamics and HoPoMo models



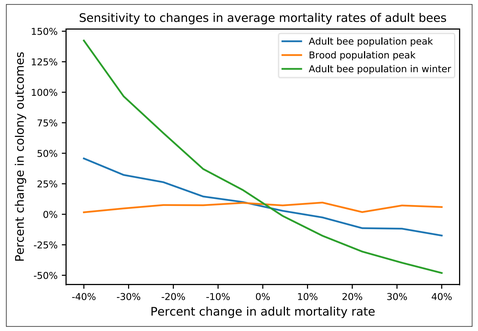


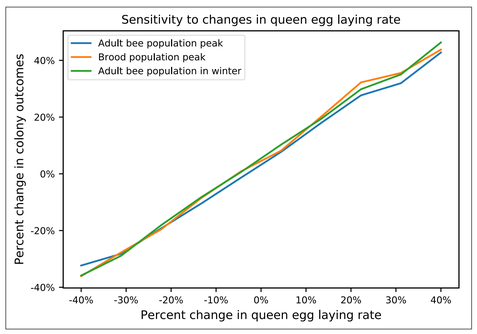
For both adult bee and brood populations, the model directionally agrees with literature data, but available literature data is scarce and does not include information on many inputs that are essential to the model, such as queen egg laying rates and weather data, preventing direct comparison

GitHub link: https://github.com/PJ-Wilkens/computationalPhysFinal.git

Results of sensitivity analysis

Queen egg laying rate and adult bee mortality rates were the most influential input parameters across population metrics





Results

Since queen egg laying rate and adult bee mortality rates were determined to be the most influential parameters on population outcomes, developing methods to track these values is crucial

Collecting this relevant data will also allow us to further validate and refine our model

Bibliography

Becher, M., Grimm, V., Thorbek, P., Horn, J., Kennedy, P., & *Osborne, J.* (2014). **BEEHAVE: a systems model of honeybee colony dynamics and foraging to explore multifactorial causes of colony failure**. Journal of Applied Ecology, 51(2), 470–482. https://doi.org/10.1111/1365-2664.12222

Becher, M., Osborne, J., Thorbek, P., Kennedy, P., & *Grimm, V.* (2013). **REVIEW: Towards a systems approach for understanding honeybee decline: a stocktaking and synthesis of existing models**. Journal of Applied Ecology, 50(4), 868–880. https://doi.org/10.1111/1365-2664.12112

Fukuda, H. (1983) The relationship between work efficiency and popula-tion size in a honeybee colony.Researches on Population Ecology,25,249–263.

Khoury DS, Barron AB, Myerscough MR (2013) Modelling Food and Population Dynamics in Honey Bee Colonies. PLoS ONE 8(5): e59084. https://doi.org/10.1371/journal.pone.0059084

Kulhanek, Kelly. *Bee Informed*, BIP, 1 Dec. 2019, research.beeinformed.org/survey/.

Kunert, K., Crailsheim, K., 1988. Seasonal changes in carbohydrate, lipid and protein content in emerging worker honeybees and their mortality. J. Apic. Res. 27, 13–21.

Schmickl, T. & Crailsheim, K. (2007) HoPoMo: a model of honeybee in-tracolonial population dynamics and resource management.EcologicalModelling,204, 219–245.