

The Days the Bees Stopped Buzzing

New Mexico

Supercomputing Challenge

Final Report

March 27, 2009

Team 8

Albuquerque Institute for Math and Science

Team Members:

Stefan Klosterman

Pablo Canseco

Erik Johnson

Jordan Medlock

Teacher:

Philip Watje

Mentor:

n/a

Abstract

A simulation is developed to examine if the neonicotinoid imidacloprid (IMD) is a possible cause of the colony collapse disorder (CCD) in bee populations. The simulation is made in Star Logo. It emulates the behavior of scout bees finding flower fields, returning to the hive, and telling the workers how to get to the field to bring food back to the hive. Randomly infected and uninfected fields are simulated to determine whether or not an encounter with infected fields can cause a hive to be destroyed. Simulation results support the hypothesis that IMD may be responsible for CCD.

Table of Contents

Abstract	2
Table of Contents	3
I. Introduction	4
II. Background	4
III. Problem Definition	6
IV. Method	6
V. Results	8
VI. Conclusion	8
References	8

I. Introduction

Colony Collapse Disorder (CCD) is a condition that strikes certain bee colonies, the cause is unknown, but it causes bees to leave the colonies and never return. One of the most popular theories is that a neonicotinoid called imidacloprid (IMD) is causing bees to forget their way back to the hive. Consequently, the worker bees wander and never return to the hive causing the hive to collapse from a lack of food.

The following report concerns simulations performed in an effort to examine the effects of beehive encounters with fields dosed in the neonicotinoid IMD. The simulation looks at the number of infected versus uninfected fields in the region of a beehive and the potential for its collapse from IMD or related pesticides. Findings indicate that the potential for widespread use of the pesticide IMD to be a potential cause of CCD.

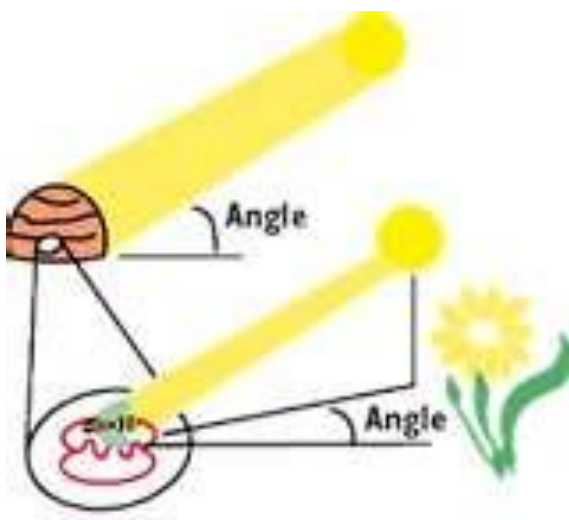
The rest of this report begins with background concerning CCD and the neonicotinoid IMD pesticide theory from open literature research. Next, the problem statement is presented followed by a section outlining the method of approach used to investigate the question posed by the problem statement. Simulation results are given from which conclusions are made. A summary concludes the report.

II. Background

During the months of October, November, and December 2006, an alarming number of honey bee colonies began to die along the East Coast of the United States. West Coast beekeepers are also beginning to report unprecedented losses [1]. The phenomenon, now known as colony collapse disorder (CCD), affects 26 states and parts of Europe. Though the cause is not known, several theories have been formed; including viruses, stress, and neonicotinoids[4].

Neonicotinoids are a class of insecticide that acts on an insect's nervous system. One insecticide in this family, imidacloprid, has been noted to have adverse effects on a bee's navigational system[6].

The method a beehive uses to find food starts out with the hive sending scout bees. The scout bee, with a lifetime range of 800km^[3], flies outwards from the hive until they find a flower field. Though it is not known how, a bee always knows its position relative the sun, the scout bee uses this to remember the path it took to get from the hive to the flower. The scout bee goes back to the hive and relays the directions they remembered to the worker bees in the hive via the waggle dance. In the waggle dance, the bee follows a figure eight pattern, the bee ‘waggles’ forward and the circles either right or left back to the starting position and repeats this process (see Figure 1).



(Figure 1)

The speed that the bee ‘waggles’ forward indicates the speed that the bee flew to get there and how long, turning either left or right after the ‘waggle’ means the bee should turn the corresponding direction. After receiving the directions from the scout bee, the worker bees follow the path until they reach the field. After gathering nectar from the flowers, the bee then flies the same path in reverse to get back to the hive.

Imidacloprid’s effect on the bee’s nervous system has been noted to make bees forget their way back to the hive. This leads to the bees not being able to find their way back to the hive causing them to die. This causes the beehive to collapse from a lack of worker bees to gather resources for the hive.

Symptoms of CCD [1]:

- 1) In collapsed colonies
 - a. The complete absence of adult bees in colonies, with no or little build-up of dead bees in the colonies or in front of those colonies.
 - b. The presence of capped brood in colonies.
 - c. The presence of food stores, both honey and bee bread
 - i. which is not immediately robbed by other bees
 - ii. when attacked by hive pests such as wax moth and small hive beetle, the attack is noticeably delayed.
- 2) In cases where the colony appear to be actively collapsing
 - a. An insufficient workforce to maintain the brood that is present
 - b. The workforce seems to be made up of young adult bees
 - c. The queen is present
 - d. The cluster is reluctant to consume provided feed, such as sugar syrup and protein supplement

III. Problem Statement

Can a field sprayed with IMD in a beehives range cause the hive to collapse?

IV. Method

The star logo simulation is designed to emulate the behavior of scout and worker bees of a typical beehive (see Figure 2). When the program is initiated, the computer randomly generates five fields, either one or two of which are infected. The program also generates a central hive that contains resources used to produce more bees, and send bees out to discovered fields.

The method a beehive uses to find food starts out with the hive sending scout bees. The scout bee flies outwards from the hive until they find a flower field. Though it is not known how, bees always know their position relative the sun, the scout bee uses

this to remember the path it took to get from the hive to the flower. The scout bee goes back to the hive and relays the directions they remembered to the worker bees in the hive via the waggle dance. In the waggle dance, the bee follows a figure eight pattern, the bee ‘waggles’ forward and the circles either right or left back to the starting position and repeats this process. After receiving the directions from the scout bee, the worker bees follow the path until they reach the field. After gathering nectar from the flowers, the bee then flies the same path in reverse to get back to the hive.

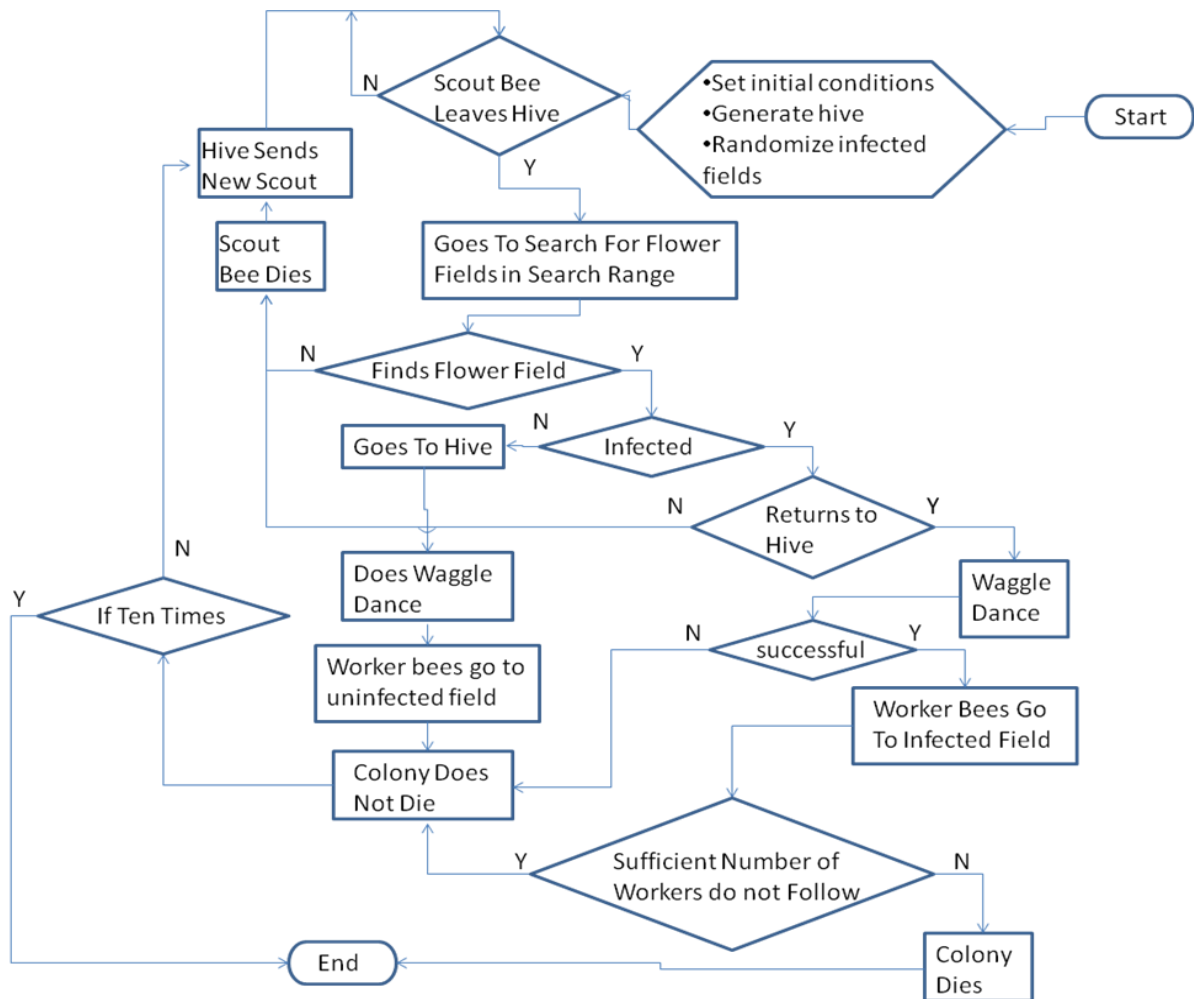


Figure 2: Simulation Flow Chart

Results

Almost every time the simulation was run, the hive collapsed when it encountered the IMD infected field, except for the rare occasions that the hive encountered enough uninfected fields before a wave of scouting bees discovered the infected field, we believe there is a slight margin of error that may cause some tests to be invalid, but can be ignored because we disregarded the abstract results. The colony never survived when two fields were infected with IMD.

Conclusion

Based on the results of our program, a field infected with IMD is enough to cause the beehive to collapse, in running the program we have noticed that the lack of sense of direction (of the bees) causes them to fly around blindly until they die, rarely making it back to the hive. We believe that IMD is a very likely cause of CCD based off of our simulation.

References

1. <http://maarec.cas.psu.edu/pressReleases/FallDwindleUpdate0107.pdf>
2. <http://www.ombwatch.org/node/3773>
3. <http://gears.tucson.ars.ag.gov/beepop/life.html>
4. <http://www.ars.usda.gov/News/docs.htm?docid=15572>
5. http://www.kellysolutions.com/erenewals/documentsubmit/KellyData%5CND%5Cpesticide%5CMSDS%5C228%5C225-588%5C225-588_ARMORTECH_IMD_75_10_1_2008_11_22_07_AM.pdf
6. <http://encyclopedia.thefreedictionary.com/Neonicotinoid>