Honey Bee Defenses

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Abstract

Honey bees play a crucial role in the global agriculture industry. Their pollination is liable for crop values of over 15 billion dollars, but within the past century, honey bees have been plagued by a mysterious complication: Colony Collapse. Many different blights have become well known destroyers of hives across the globe, but little can be found as cause or a cure to the bizarre disorder. This daunting calamity is defined by a bee colony with no living adult bees and no carcasses in the hive; however, a living queen, growing larvae, and oftentimes adequate stores of honey are still present. No single scientific cause for Colony Collapse has yet been proven, so if the cause and cure cannot be found, what can be done to save the colonies? Centuries ago, the methods that bee keepers use today to treat bee hives were not available. How then did they manage to keep their bee hives alive? Through understanding hives, identifying bee behavioral patterns, and the cycles of certain attackers, the hives could be kept alive if these patterns were identified. While bee hives did not always survive, mostly due to generic issues or effects of winter, fewer harmful chemicals were used and crops were produced more naturally. Now, in the 20th century the bee care industry is battling the balanced use of chemicals wontedly distributed in-hive for mite prevention, and unwantedly in the urban and farmland ecosystems.

Keywords: Honey Bees, Bee Defense, Pollination

Introduction

Bees of numerous species greatly impact plant pollination and are recognized worldwide for their contributions to human consumables. The bees' frequent flower visiting habits, as well as the hairs all over their bodies which enable the bees to collect and distribute pollens, make them excellent, proliferate, and well-known benefactors to many plants that are not wind-pollinated (Batra 1995). Researchers collected data from 200 of the most edible crop producing countries to estimate how much of an affect pollinators had on the global food sourcing. Of the top 115 crops the researchers used (i.e., only fruit, vegetables and seed productions) 87 of these leading international crops were dependent on animal pollination leaving only 28 that did not (Klein *et al.* 2007).

Foraging bees are most likely the only growth stage that the public will ever encounter; whereas, bee keepers watch over the bees in younger phases of development that serve the entire unit within the safety of the hive. Bees mature through several stages before death: egg, larvae, pupa and adult. Upon reaching the adult stage, they are then subjected to different natural chemical reactions in their own bodies that rise and fall with age. These hormone changes cause them to naturally modify their job roles within the hive. Without every kind of worker present in strong figures, the health of not only the rest of the hive would decrease, but the queen who gives way to the growth of the hive, would be intensely over-worked. If the queen is not functioning as she should, the entire hive could weaken within a matter of days. The queen serves a crucial role in the adult bees taking on their ever adjusting job roles within the hive (Kaatz *et al.* 1992).

As an adult, they begin their "careers" by cleaning old pupa hive cells and extracting or restoring any damaged comb structures. As they mature, they then progress from cleaning cells to feeding other larvae and fellow nest mates. The bees switch to these two roles at around the same time and in nearly equal measures, but those who remain as nest mate feeders tend to stay with that occupation longer in life than feeding larvae. At around 10 days old, the bees begin to transition then into the role of packing pollen for hive use. Near the last few days of their lives, bees finally take the job of foraging for nectar so all the other bees can continue their tasks (Alcock 2009).

Each of these developmental stages is susceptible to different kinds of colony harms. In the larvae stage, there are many things that hinder or completely stop hive growth. Diseases can spread throughout the hives travelling on developing bees in the combs and on fully grown adult bees. Fungal

infections can take over cells containing laid eggs and may contaminate anything it comes in contact with. It is often advised to burn and bury any piece of equipment that may have come in contact with some of the infectious material. Bees from one hive robbing another of their resources may also become a problem, but it's a simple fix. All the bee keeper needs to do is narrow the entrance hole of the hive that is being robbed so the bees inside can now protect the much smaller entrance.

The hive cannot function in a healthy manner if one or more of these issues arises. Many beekeepers today use toxicants (i.e., Fumigillin®, Terramycin®, Tylan®, etc.) to treat many of these devastating issues, while others prefer to use more homeopathic remedies. While modern medicine has advanced people's abilities to take care of many issues that previously were not seen to have been solvable, it is possible to deter wing-deforming mites, Verroa destructor, with the application of certain natural plant extracts.

Mites are difficult to purge from a hive once they have begun to hatch within a hive cell with a larva; however, if a bee keeper is able to notice its wing-deforming effects before it spreads throughout the entire hive, it is possible to drive their presence from the hives without putting the bees at risk of long-term poisoning to their own larvae. Acute toxicity found in bees wax from long-term or over-use of lab produced pesticides have been hypothesized as a contributor to the decline in overall hive health within the last twenty years. In recent trials, researchers found common pesticides used on crop fields may cause bees to become 'picky eaters'. With the lack of "proper food" available due to lack of interest in certain qualities, bee-to-hive communication for abundant food sources may become far more infrequent and difficult to find (Eiri and Nieh 2012).

Many common neonicotinoids (i.e., a class of neuro-active insecticides, chemically similar to nicotine) used in fields affect not only already grown forager bees, but also those in their younger days within the hive. While no conclusions have been made on one specific cause of Colony Collapse Disorder, many researchers have hypothesized that pesticides on crops as well as ones deliberately placed into the hive, have become a recent contributor to the ever-growing list of honey bee survival struggles (Keplar 2015).

Sub-lethal threats to honey bee hives have been linked to residual build up in honey comb often without notice of the bee keeper until it's too late. Many trials have been conducted on the toxicity of various pesticides. I am curious how commonly used pesticides may affect the various stages of development of the bees. Since a hormone change causes the bees to switch from pollen packaging to foragers, I am curious to see how each of these pesticides may affect the hormone level in each stage of development.

The residue levels of miticides intentionally placed in bee colonies have been found to migrate in increasing amounts from honey, to pollen, to comb. The honeycomb is the least renewable resource the bees have, and as a result of repeated exposure, can cause a "toxic house" syndrome to the hives. Of the hives that researchers from this specific study took samples from across the U.S.A., 79% of the hives suffering with high amounts of bee mortality showed corresponding high concentrations of miticide toxins in the beeswax housing (Mullin *et. al.* 2010).

New man-made hives require healthy bees, unused comb barrier walls (viz. these are purchased) and a well-developed, healthy queen. The bees bought from a farm or taken from another hive need to be acclimated to the pheromones of their own queen mother, and when being transported to a new location without their queen, the hive may collectively become more agitated and frantic about their work. When creating a new hive, it benefits the health of the entire colony to have a fully grown pre-ordered queen to establish within the hive as soon as possible. Queens are usually purchased from the internet or created by the worker bees. In cases with an already strong hive, but the recent death of the previous queen, it is possible to influence the bees in a colony to create a new queen (i.e., by giving a special shaped larvae cell "royal jelly", a natural nectar compound made by the bees specifically to grow queens).

Creating specifically shaped comb cells to encourage bees to make an already growing larvae into a new queen is one of the easier and least disruptive ways to introduce a new queen to a colony. This process requires an already fully functioning, well-established hive. When beginning a brand new hive with newly built frames, there are not many nursery frames that are useable for creating a new queen. Usually when starting a new hive, the best method is to introduce a bought queen from another farm to give the bees an opportunity to begin building their new hive with an already strong queen.

Before a queen can ever be shipped, the bees within a hive must be exposed to smoke so they can be easily moved and collected. A bundle of grasses is lit on fire and put in a container made for keeping a smolder, but not an open flame. The smoke is then used to send the bees into a frantic survival tactic. Upon smelling smoke, the bees turn to the hive and begin gorging on as much honey as they can. When the bees have been exposed to smoke, the bee keeper

is able to enter the hive and gather the specific bees he or she needs to fulfil an order. A queen, and several nurse bees that have just gorged on honey are put into a specific container and sealed off with a "candy plug," the purpose of which will be explained later.

The queen and the nurse bees packed in with her are set into a box with a wire mesh top. The box has three connected circular shaped compartments. One of the short ends has an entry/exit space in which is packed the "candy plug." Further within the box are two other segments where the queen and nurse bees mingle. The wire mesh top allows the queen's pheromones to be released within the hive giving the bees within an opportunity to get to know their new queen and accept her. The candy plug at the end is eaten away by the bees within the hive so that the nurse bees and queen within the box may be released naturally and slowly, giving as much time as the hive needs to adjust, although the candy plug is normally eaten within a few days. After the new hive is established, work continues as normal with the new queen they have adopted.

Methods

I am currently in the process of establishing two bee hives at the home of my professor and will soon tend to them as often as is permissible due to weather or as often as it will take to resolve any number of issues while still retaining the natural strength of the hive. I estimate that it will approximately take the spring semester and the summer of 2016 to establish my hives and learn how to become a very basic expert in bee keeping. I will be using bees transported from the beehives at our family farm as my starting colonies for the ones I will use in my sophomore year for experimental studies.

The two hives I will be establishing in my professor's home yard will have plentiful access to gardens, water supply, and all year forest and field foraging. My experiments will be testing the effects of various kinds of miticides on the bee's natural ability to survive. This includes the hive's fitness, the queen's ability to function properly, the healthy growth of the larvae and the foraging success of the older hive members. Miticides are typically crafted into a long strip that is attached to the top of the hive. The scent and the chemicals within the strip are transferred throughout the hive by the bees. In combination with other pesticides possibly used in crop fields or garden beds, the build-up of pesticides in the wax of the honey bee comb could amount to lethal quantities causing a decrease in hive growth as the larvae develop in these toxic combs.

Before beginning my experiments, I plan to have created suitable in-lab housing compartments for testing. At the moment, I expect this to consist of liter sized glass jars with fitting lids. Air flow capability will be ensured, as well as proper holes in the lid, or in the jar, for the insertion of feeding and watering tubes. The amount and type of feed provided will be measured equally for each temporary testing hive site. Within the jar, a section of comb will be placed for the bees to continue about their work. I do not estimate these preliminary tests taking longer than one week each. Adult bees of specifically selected age range and occupational duty will be placed in jars with those of similar age and dedicated task. I will select 15 bees from each of the ages I will specify on jar labels and house them in the temporary lab conditions.

After each jar is established, each jar will receive a small miticide strip placed at the top of the honey comb block. While the build-up of these chemicals in the honey comb leads to acute toxicity, for this particular study, I am interested in seeing what neurological effects these pesticides have on the adult bees in a short term trial. While some pesticides commonly sprayed on plants may turn bees into less opportunistic eaters, I am interested in seeing how miticides that are made specifically for beehives affect their responsiveness to food availability.

I will have separate trials established, so I may also collect data on the chemical concentration throughout a comb block by natural diffusion, possible bee transportation, specific placement, and other various factors. Since this smaller trial does not require as much maintenance (i.e., there may not be any bees involved in these trials) they will be conducted on the side and allowed to remain untouched for longer periods of time. I plan to study the miticide effects on the comb toxicity levels over greater lengths of time (i.e., trials may be run from the fall semester of sophomore year, through the summer, and possibly another school year). I am interested in observing truly long-term effects on these very susceptible bee hives.

My research will contribute to the necessary growing amounts of information on bees. Benjamin and McCullum wrote a book titled A World without Bees (2009) in which the data presented gave considerable light to the growing problem with the disappearance of bees. While many possibilities have been found for their rapid decline, one of the more popular hypotheses is that bee keepers are the ones delivering the most damage to their bee hives with the ever increasing number of chemicals introduced into the habitats (Oldroyd 2007). The research that I will be conducting has the potential to aid bee

keepers in understanding how long they can leave in these chemicals before toxicity takes place.

Progress to Date

My hives have been built and painted, and I will be receiving my bees later this month to put into my hives and establish the new colonies. I have been learning how to take care of bees off site at a regional bee keeper's farm, from whom I will also be receiving my bees from to begin my colony. Bees are very complicated and take time to understand, so even as I have not begun my own research yet, I've been pursuing learning how to take care of them regardless and researching methods of study. I have the materials I need and will begin testing as soon as I am confident in my skill to maintain the hives. My first tests will be separating out small factions from the hives as replication studies and counting inevitable mite exposure in untreated, powdered sugar treated, and essential oil treated colonies. For now, I want to see the success of these tests before I expose the environment to manufactured chemicals mentioned previously. At the end of the season, the colonies will be weighed to see which treatment promoted the best population growth ratio of the hive.

Conclusion

There comes a point, every once in a while, when it is necessary to completely destroy a harmful culture all at once and keep it away. I hope to provide insight to bee keepers so that they may be more mindful of how long they are exposing their hives to chemical agents rather than natural remedies. It may be healthiest for a hive to switch the kind of chemical used every year or so, or it may be best to use the chemical only when all other natural options are exhausted.

Bees are very resourceful creatures, but in humans' own acts to protect them, we may just be harming them even more. People have been striving to keep the bees alive and avoid Colony Collapse Disorder, but sometimes solutions we thought were helping, in the long term may turn and harm them even more. I plan to understand more about how these pesticides affect various stages of bee development, both hormonally and neurologically in adult bees. These trials will be used for further understanding the nature of bees and hopefully contributing in a natural way to the research being done in several universities to keep them safe.

References

Alcock, J. 2009 *Animal Behavior: An Evolutionary Approach*, Ninth Edition. Sinauer Associates Inc., Sunderland, MA.

Batra, S.W. Bees and pollination in our changing environment. *Apidologie*: 361–370.

Benjamin, A., and B. McCallum. 2009. A world without bees. Random House.

Eiri, D. M., and J.C Nieh. 2012. A nicotinic acetylcholine receptor agonist affects honey bee sucrose responsiveness and decreases waggle dancing. *The Journal of experimental biology*, 215(12): 2022-2029.

Kaatz, H. H., H. Hildebrandt, and W. Engels. 1992. Primer effect of queen pheromone on juvenile hormone biosynthesis in adult worker honey bees. *Journal of Comparative Physiology* B, 162(7): 588-592.

Klein, A.-M., B.E. Vaissiere, J.H. Cane, I. Steffan-Dewenter, S.A. Cunningham, C. Kremen. and T. Tscharntke. 2007 Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B: Biological Sciences:* 303–313.

Mullin, C. A., M. Frazier, J.L. Frazier, S. Ashcraft, R. Simonds, D. VanEngelsdorp, and J.S. Pettis. 2010. High levels of miticides and agrochemicals in North American apiaries: implications for honey bee health. *PLoS one*, 5(3), e9754.

Oldroyd, B.P. 2007 What's Killing American Honey Bees? *PLoS Biology*.