HONEY BEES, COLONY COLLAPSE DISORDER, AND WILD POLLINATORS

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Pollination is an essential first step in the production of a wide variety of our fruits and vegetables. An estimated 35% of the global production of plant-based food comes from crops that benefit from animal pollination. In other words, one third of our diet is dependent on animal, mostly bee, pollination. Crops such as blueberries, cranberries, squashes, pumpkins, watermelons, kiwis, passion fruit, strawberries, citrus, peaches, cherries, apples, cacao, and even coffee require insect pollination for successful fruit production. Bees are by far the most important pollinators in agricultural settings and contribute between $5.7 to $19 billion per year to the United State economy and $217 billion per year globally. The most widely-used bee for crop pollination is the European honey bee, *Apis mellifera*. Unfortunately, honey bees have experienced significant declines in North America over the past 50 years. Honey bee declines generated significant media coverage in 2007 with the onset of what was described as "colony collapse disorder" (or CCD). As recently as Feb, 2013, reports of additional significant losses of honey bee colonies in the US (and even massive die-offs of bumble bees) again raised concerns over the impacts of honey bee losses on agricultural production in the US.

In this talk, I will present information on the history, symptoms, and possible causes of CCD in honey bees as well as recent results from my laboratory at Cornell on the relative contribution of wild native bees to apple pollination.

What Causes colony collapse disorder?

In February, 2007, a number of major media outlets reported on significant losses of honeybee colonies, especially those managed by "migratory beekeepers", across the United States. Initial reports referred to a "mystery disease" that was behind the losses and scientists across the country began a search for the causes. What was described at that time as "colony collapse disorder" became a major media focus. Symptoms of CCD included abandoned colonies with only a few workers and the queen. The majority of workers appeared to have left the colony or died. Mortality reached 80-90% in some apiaries. A number of factors were hypothesized to have caused CCD, including cell phones, agricultural pesticides, previously undetected pathogens, in-hive chemicals (primarily miticides), genetically modified crops, and the stresses of long-distance transport of colonies for crop pollination (or "migratory beekeeping"). While some of these have since been proven incorrect, such as cell phones and genetically modified crops, there is a growing consensus that die-offs of honey bees can be attributed to a combination of pathogens (including viral, bacterial, fungal, and microsporidian pathogens), parasites, such as Varroa mites, tracheal mites, and small hive beetle, the lethal and sublethal effects of pesticides, monoculture, and finally, the stresses placed on colonies used in "migratory beekeeping".

While sudden and catastrophic losses of honey bee colonies may sound frightening, historical a records from as far back as the Middle Ages indicate that CCD-like events have been observed in the past. Reports of catastrophic honey bee losses have been recorded in historical documents from 992 (Ireland), 1443 (Ireland), 1906 (Isle of Wight), 1903 (Utah), and as recently as 1995 in Pennsylvania. In each of these cases losses were far greater than the typical 30% loss expected by beekeepers over the winter. In the case of the 1906 report, all the colonies on the Isle

of Wight disappeared! This is not to say that what we are experiencing in North America is not significant. It is only to say that honey bees may be prone to these catastrophic declines on occasion.

Native Bees for orchard pollination

While scientists will continue to explore the causes and possible remedies for diseases in honey bees, another approach is to explore what role native, wild bees might be playing in crop pollination. We know that bees are an extraordinarily diverse group. There are over 20,000 species known worldwide, 4000 in the US, and an estimated 450 species in NY State alone. We know from previous studies that wild bees are diverse in orchard habitats and that they can be effective pollinators of many flowering trees, such as cherry, plum, pear, and apple. My laboratory began investigating the role of native bees in apple pollination in 2009 and since then we have surveyed over 30 orchards ranging from Ithaca to Lake Ontario. We have learned number of important things about native bees and their importance in apple pollination:

1. Native bee diversity and abundance – we have detected over 90 species of native bees in apple orchards during full bloom. A single orchard can have as many as 40 native bee species visiting apple. In many orchards that we have surveyed native bees outnumber honey bees, suggesting that, if abundance is related to pollinator importance, native bees are contributing significantly to apple pollination. Native species include ground-nesting (mining) bees, above-ground stem nesters, below-ground cavity nesters, carpenter bees, and even cleptoparasitic bees. Our studies have more than doubled the number of native bee species that were previously reported in NY apple orchards.

2. Native bee pollinator effectiveness – in carefully controlled field experiments we have shown that native bees can deposit as much as four times more apple pollen than a honey bee on a per-visit basis. Native bees are "honest" pollinators in that they land directly on the reproductive parts of the flower (anthers and stigma). Honey bees often visit flowers exclusively for nectar and thus contribute little to flower-to-flower pollen transfer. Native bees carry apple pollen loosely scattered over their thorax and abdomen, making them highly effective pollen vectors.

3. Native bees and apple seed and fruit set – based on careful experiments over the past three years we have found that seed set in apples is positively correlated with both native bee abundance and diversity, while seed set appears independent of honey bee abundance. What this means is that we could detect with our experiments a significant contribution from native bees to apple seed and fruit set, but we were unable to detect an effect of honey bees on apple seed set. Studies in other crop systems are finding the same result – honey bees seem to have a limited impact on agricultural productivity.

4. Drivers of native bee abundance and diversity – based on careful, standardized surveys of native and managed bees across 24 orchards in Central NY, we found that there were two primary factors that promoted native bee diversity and abundance. More natural habitat in and around orchards contributes to more native bees and a more diverse native bee fauna. Reduced pesticide levels (especially reduced fungicide levels) lead to increased native bee abundance and diversity. One of the most striking (and perhaps relevant) results we have obtained is that

fungicides commonly applied in apple orchard management may have a much more significant (negative) effect on native bees than we had previously realized.

Overall conclusions – native bees are contributing significantly to apple pollination! Our results indicated that at some sites and under some conditions growers should be able to reduce their reliance on honey bees. Our mail and phone surveys of apple growers suggest that this is already taking place. More and more apple growers are reducing their reliance on honey bees, especially when orchards are small (<100 acres) and surrounded by natural habitat.

There are a number of steps an orchard manager can take to enhance and support a diverse native bee fauna in and around their orchards.

- First, provide increased nesting resources for wild bees. Strategies can include installing commercially available "trap nests" in the orchards to promote mason bees, leaving stone walls intact for bumblebees, leaving dead trees and other standing wood for carpenter bees, creating nesting sites for ground nesting bees by tilling a corner of the orchard and leaving the soil unpacked.
- Second, maintain natural habitat (including hedgerows, small wood lots, forest edges, wind breaks, meadows) in and around orchards. These areas can serve as source populations for wild, native bees visiting apples.
- Third, leave unmanaged (abandoned) orchards intact. These habitats provide important floral resources for wild pollinators of apple with low levels of pesticide exposure. We find some of our highest native bee diversity and abundance in abandoned orchards adjacent to managed orchards.
- Finally, minimize pesticide (especially fungicide) exposure to wild bees. If possible, spray at night or early in the day, when bees are least likely to be active.

Based on our five years of survey work on native bee diversity in central New York, I am now fairly certain that I can identify orchards where honey bees are essential and orchards where native bees are most likely providing all the pollination services needed for successful apple pollination. However, my laboratory can only survey 20-25 orchard per year and these sites are all located within driving distance of Ithaca. If I could enlist orchard managers to collect data on the abundance of native bees and honey bees in their orchards, we could then develop recommendations on how best to manage your pollination needs. I would like to develop a simple, standardized protocol for you to count honeybees and native bees over a 15-minute time period during the peak of apple bloom. If we could have you enter these observations into a centralized database via a simple, easy-to-use website (or, even better, an iPhone app), we would be able to make specific recommendations on best practices for orchard pollination. Based on your observational data we would be able to recommend that you either do or do not bring in honey bees for apple pollination. This project would have a number of benefits for you as apple growers, including reduced costs associated with honeybee rentals, and could also become an important example of "citizen science" in the interest of scientifically-based pollinator management.