Potential Solutions to Honey Bee Decline: Hygienic Behavior

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Background

- Honeybees are declining throughout the world
- Colony Collapse Disorder
  - Complex
  - Many factors compounded over time
  - Media hype

Factors Contributing to CCD

- Decreasing green space
  - Bee nutrition
    - Bees need a variety of pollen and nectar sources
    - Flowers staggered all season long

Factors Contributing to CCD

- Increased pesticide use
  - 46 pesticides found in pollen from beehives
  - 20 found in wax samples
    - Insecticides, Herbacides, Fungicides, Insecticide metabolites
  - Samples contained avg. 5 pesticides
  - Fluvalinate found in 100% of wax samples
    - Labeled “highly toxic” for honey bees
- Frazier et al., 2008, American Bee J.

Factors Contributing to CCD

- "In the past, pesticide poisoning of honey bees has been associated with lethal exposure and the obvious symptom of a pile of dead bees.. . . We are becoming increasingly concerned that pesticides may affect bees at sublethal levels, not killing them outright, but rather impairing their behaviors or their ability to fight off infections."
- Frazier et al., 2008, American Bee J.

Factors Contributing to CCD

- Depressed honey market
- Increased profit in pollination
  - Increased movement for pollination leads to disease transfer
  - “Shipping bees for pollination is like sending your kids to school,” said one beekeeper, “They come back with whatever disease is going around.”

Factors Contributing to CCD

- Pathogens and diseases, which have been here a while, are playing on bees' weakened state
  - Varroa mites
  - Acute & Israeli Acute Paralysis Virus
  - *Nosema spp.*
  - Foulbrood and chalk brood

Varroa mites

- (*Varroa destructor)*
- Attach to bee larvae and parasitize bees, living on the outside of the bee's body.
- Relatively large compared to the bee, about 1/6th of the bee's body weight.
- Possible vector for other diseases

http://www.ec.gc.ca/EnviroZine/images/Issue33/bee_varoa_mite_large.jpg

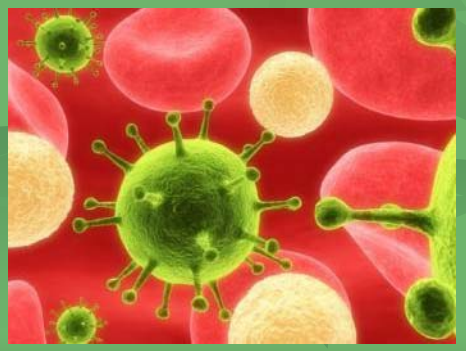
Varroa mites

- To eliminate varroa mites, beekeepers sometimes put insecticides in the beehive
- Insecticides weaken bees to attack by other diseases
- Varroa mites are becoming resistant

http://www.utahcountybeekeepers.org/Images/varroa2.jpg

Acute Paralysis Virus
Israeli Acute Paralysis Virus

- Contribute to Colony Collapse Disorder of varroa mite-infested colonies.
- Varroa mite is a possible vector for these viruses and it also weakens bees and makes them more susceptible to it (Bakonyi et al., 2002).



Nosema spp.

- 47% of all colonies have *Nosema*
- *Nosema* causes complete disappearance of mature bees in the hive
- Honeybees generally clean
  - Defecate outside the hive
  - “Hold it” until a warm day in winter

Nosema

- Intestinal gut parasite
  - Multiplies in bee guts, breaks through the bee gut wall and makes bee susceptible to other problems
  - If bee does defecate in the comb, other bees clean the comb and get it
  - Nurse bees cannot produce brood food
  - Adult bees have a decreased ability to digest
  - Forage too early in the winter and die

Nosema

- Beekeepers breed for resistant *Nosema* when they give blanket treatments without sampling.
  - Ex) Fumagellin

Foulbrood and Chalkbrood

- Spore-forming bacterial diseases which infect honeybee brood (Hansen and Brosgaard, 2003)
- Foulbrood can weaken or kill a colony in one season
- Honey bee larvae infected with foulbrood become a stringy mass of material that later dries and carries the spores that may infect other larvae.

www.usda.gov

http://www.geocities.com/vernadakis_nick/melissa/foto/4/foulbrood.sized.jpg

Spores

- Spores can be stored in old wax combs
- Important for beekeepers to remove old wax combs from hives every 5 years
- Otherwise, comb can become toxic to bees (Spivak, 2009)
- This practice “cures” foul brood and chalk brood

What are beekeepers doing to combat CCD?

- Innovative beekeepers . . .
- Leave enough honey/pollen for bees to eat over the winter
  - Many remove all honey and feed sugar syrup to bees for winter
  - Honey meets bee nutritional needs better than sugar syrup
    - Honey more complex than sugar syrup
  - Honey has pH 3.2-4.5, sugar syrup has pH 6
  - Diseases of concern live better in a higher pH

Innovative beekeepers. . .

- Follow the following treatment steps:

1. ID clinical symptoms of disease
2. Are there management practices that can prevent disease spread?
3. Are there bees that are resistant to disease?
4. Use chemical treatments as a last resort.

- Usually missing # 2-3

Innovative beekeepers. . .

- Breed for survivors
  - More resistant to disease
  - Ex) Tracheal mite
- Developing resistant lines of bees
  - Hygienic Behavior

Hygienic Behavior

- Trait researched at the University of Minnesota
  - Marla Spivak, Gary Rooter
  - Developed Minnesota Hygienic Line
- All beekeepers have some good hygienic colonies
- Encourage them to breed for more!

Original Goals for MN Line

1. Make sure hygienic trait has no negative fitness affects on colonies
2. Encourage beekeepers to select for this trait from many tried-and-true bee stocks
3. Open breeding system

MN Line Criteria

- Produces a lot of honey
- Survives a MN winter
- Builds up well in the spring
- Gentle
- Hygienic

Brood Cells

- Queen bee lays eggs in individual honeycomb cells (1,200/day or 200,000 eggs/season)
- Eggs develop into larvae in the cell
- Called “Brood”
- Worker bees feed brood until they emerge as immature (flightless) bees
- If there is a disease in the hive, it will attack brood

Hygienic Behavior

- A colony exhibits hygienic behavior when
  - Worker bees detect and remove ≥ 95% of diseased/damaged brood
  - Dispose of it outside the hive
  - Clean up the cell

Hygienic Behavior

- Detection and removal of diseased brood
  - Before disease forms infectious spores
  - Before mites are mature enough to begin laying eggs
  - (Park et al., 1938; Woodrow, 1942; Rothenbuhler, 1964)

Hygienic Behavior

- “We have known for over 50 years that hygienic behavior is the main defense mechanism against American Foulbrood and chalkbrood. Why are we still using antibiotics and chemical solutions?”
- –Dr. Marla Spivak

Why?

- It is easier to add a chemical than to maintain breeding practices.
- Mites quickly develop immunity to chemicals. We are breeding for very hardy mites.

How does it work?

- Hygienic workers sense chemicals not released by healthy brood
  - Ex) In chalk brood, phenethyl acetate is perceived by bee antennae
- Not all bees can detect this
- Some bees within a hive are cleaner than others (like people)

Genetics

- Hygienic behavior is a recessive genetic trait
- Beekeepers can select for this trait and make their hives more resistant!
- Queen must mate with 10 out of 20 hygienic drones for workers to exhibit hygienic traits
  - Queens usually mate with drones from nearby colonies

Testing for hygienic behavior

- Freeze kill 100 cells of bee brood on a frame of bees
  - Liquid N and a PVC pipe
- Mark the killed area
- Look at the killed area 48 hours later
- Bees are considered “hygienic” if they remove >95% of the brood on two consecutive tests

http://www.honeybeeworld.com/diary/images/hygiene2.jpg

Propolis

- Propolis: a complex plant resin that protects plants against bacteria and other microbes when new leaves are coming in
  - Poplar, Birch, and Alder families
- Bees collect it and return with it to the hive
- Bees put a propolis lining around the lining of trees

Propolis

- 2005 study in *J. Ethnopharmacology*
- Propolis is active/affective against HIV-infected cells
- Propolis is a very complex compound,
  - Components difficult to isolate
  - Human medical researchers haven't done more research (yet)

Propolis

- Spivak et al., *American Bee Journal*, 2008
- Bees do not have antibodies
  - Can have direct response to pathogen, but not immunity
- Treated hives with propolis coating
- Found bacterial load was lower in propolis-treated colonies than control.
- Found that when colonies are diseased and propolis is present, bee immune systems are still quieter than without propolis.

Propolis

- Plan:
  - Use honeybees to screen chemical fractions of propolis to determine which are active against bacteria and viruses.
  - Apply results to human medicine.

References:

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