

# 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, Herbicides, 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 1/6<sup>th</sup> of the bee's body weight.
- Possible vector for other diseases



[http://www.ec.gc.ca/EnviroZine/images/Issue33/bee\\_varoa\\_mite\\_large.jpg](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.usda.gov)



[http://www.geocities.com/vernadakis\\_nick/melissa/foto/4/foulbrood.sized.jpg](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  $\geq 95\%$  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.

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