Honey Bee Diseases and Pests

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About Capital Bee Supply
Manufacturers and Purveyors of Fine Beekeeping Equipment

Honey bee immune system

<table>
<thead>
<tr>
<th>Components</th>
<th>Innate immunity</th>
<th>Adaptive Immunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Physical and chemical barriers</td>
<td>1. Humoral immunity (B cells, which produce antibodies that neutralize pathogens)</td>
<td></td>
</tr>
<tr>
<td>2. Phagocytic leukocytes</td>
<td>2. Cell-mediated immunity (T cells, which initiate immune response and destroy infected cells)</td>
<td></td>
</tr>
<tr>
<td>3. Dendritic cells</td>
<td>3. Natural killer cells</td>
<td></td>
</tr>
<tr>
<td>4. Natural Killer cells</td>
<td>4. Membrane proteins (complement)</td>
<td></td>
</tr>
<tr>
<td>5. Phagocytosis, phagosomes, phagolysosomes</td>
<td>5. Effector T cells</td>
<td></td>
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</table>

Activity
Always present

Response and potency
Immediate response, but has a limited and lower potency
Slower response over 1-2 weeks, but is much more potent

Specificity
General: can recognize general classes of pathogens (i.e., bacteria, viruses, fungi, parasites) but cannot make fine distinctions
Recognizes highly specific antigens

Course
Attempts to immediately destroy the pathogen,

Memory?
Yes — “memory cells” “remember” specific pathogens upon re-exposure to the same pathogen.
HONEY BEE DISEASES, PESTS AND PARASITES

Diseases by life cycle impact

<table>
<thead>
<tr>
<th>Brood Diseases</th>
<th>Adult Bee Diseases</th>
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<tbody>
<tr>
<td>American Foul Brood (AFB) - bacterial</td>
<td>Nosema (apis and ceranae) - protozoa</td>
</tr>
<tr>
<td>European Foul Brood (EFB) - bacterial</td>
<td>Bee paralysis virus</td>
</tr>
<tr>
<td>Chalk brood - fungal</td>
<td>Deformed wing virus</td>
</tr>
<tr>
<td>Sacbrood - viral</td>
<td>Kashmir bee virus</td>
</tr>
<tr>
<td>Stonebrood - fungal</td>
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</tbody>
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Disease and Pest Detection

- Use your senses
  - Learn the look, smells, sounds and actions of a “normal” hive
- Observe your hives on a regular basis
  - Do full inspections only as needed
- Clean your hive tools
  - Arm and Hammer Soda Washing Crystals or similar and a dash of liquid soap
    - Soda crystals are highly alkaline (pH 12 to 14)
What healthy brood looks like

Good…maybe a little on the “dry” side

What capped brood should look like

How a healthy bee looks and acts
Bacterial Diseases
• American Foulbrood
• European Foulbrood
• Powdery Scale – kills larva
• Septicemia – impacts bee connective tissue
• Spiroplasmosis – impacts hemolymph

American Foulbrood
Affects about 1.8% of colonies in Wisconsin
That doesn’t seem like many but this is a serious disease spread very easily and at some time or other beekeepers will experience it.

American Foulbrood - Cycle
• American foulbrood (AFB) is a brood disease of honeybees caused by the bacterium Bacillus larvae – discovered 1910
• Young larva ingest the bacterial spores when fed by nurse bees.
• The spores then germinate and begin to grow rapidly. Death to the larva usually occurs as the pupae stage is reached.

American Foulbrood - Symptoms
• Larva that die turn a coffee brown and begin to melt down into a gooey mass.
• Housecleaning bees then try to remove the dead larva and in the process become contaminated with the bacterial spores that are now dormant.
• The house bees then carry the spores to other bees, and the spores end up either in the honey stores or are fed again to new larva. Thus the disease is spread within the colony rather rapidly.
American Foulbrood - Spread

- Robbing is one of the ways that American foulbrood is spread.
- Robbing bees will take back contaminated honey to their own hives which will result in larva being fed with spore laced honey.
- The disease will spread to many colonies within several miles from the infected hive.

American Foulbrood - Testing

- One way to test for this disease is to place a thin stick, twig, straw into a cell with this coffee brown gluey substance. Stir and draw the thin stick out. If the gluey substance sticks and ropes, it is most likely AFB.
- You can also take a sample of comb from this frame and have your bee inspector send it in for confirmation of AFB.
- Holst Milk Test

Holst Milk Test

- Suspend a suspect scale or a smear of a diseased larva in a test tube or glass vial containing 3 or 4 ml of 1-percent powdered skim milk in water.
  - Carmel colored larvae or resulting scale
  - Put sample in vial, put some water in the vial; add skim milk until the water is cloudy.
  - Can also use small bathroom cups w/ ½” of skim milk in bottom
    - 2% milk – add 25% water
    - Whole milk – dilute w/ 50% water
Holst Milk Test

• The tube or cup is then incubated at 37° C (98.6F).
  – Can put the tube in a cup of warm water to incubate.
• If AFB is present, the suspension should clear in 10 to 20 minutes; occasionally can take longer if the temps are lower.

American Foulbrood - Treatment

• If diagnosed as AFB, some will suggest treating the hive with Terramycin or Tylan.
  – This is an issue now since these are only available through prescription and/or VFD

• This must be used and consumed by the bees at least 4 weeks prior to a honey crop.

• These only mask the disease. The spores are not killed and can re-infect the hive.
  – Puts you on the “treatment train”

American Foulbrood - Treatment

• Burn  ..........  This is the only way to effectively destroy the disease. Other chemical treatments only mask the symptoms and it can return at a later time.
• Some bees have built up a resistance to AFB.
• Strict disinfection (hive, equipment, buildings, soil, shoes)
European Foulbrood - Symptoms

- European foulbrood (EFB) is a brood disease of honeybees caused by the bacterium *Melissococcus pluton*.
- Larvae are most susceptible to infection when they are less than 48 hours old, and usually die while still in the coiled state.
- Poor nutrition and severe stress, for example insecticide poisoning, often cause this disease to break out.
- The larvae first turn yellow then brown in color. The disease is usually noticed in early spring, and to a lesser extent in autumn.

European Foulbrood - Spread

The bacteria multiply vigorously in the gut of larval bees which have been given food contaminated with *M. pluton*.

As with American foulbrood, EFB can also be spread by:
- bees robbing infected hives
- transferring infected honey supers and combs to clean hives
- using contaminated beekeeping equipment
- feeding infected honey and pollen.

European Foulbrood - Treatment

- Good beekeeping hygiene will keep this disease in control, however, if a hive should be found with EFB it is important to prevent any robbing of the hive and frames from this hive should not be transferred to any other hive.
- Treatment with terramycin – A colony recovers rapidly. The effect of EFB is to reduce a colonies bee population and thus reduce a honey crop. Also consider re-queening if the bees are not cleaning up the disease.
Fungal Diseases

- Chalkbrood
- Stonebrood

Chalk-brood

- A fungal disease caused by Ascosphaera apis – discovered early 1900s
- Found throughout the United States. It is a disease of stress in the early spring (wet springs) to early summer
- Severe cases can be found in the comb later in the year.
- Often the bees will try to remove the mummy larva.
- These mummies can often be seen at the entrance of the hive.

- Affects 2.5% of colonies in Wisconsin
- Fungus will compete with the larva for food, ultimately causing it to starve. The fungus will then go on to consume the rest of the larva’s body, causing it to appear white and ‘chalky’
Chalk-brood - Treatment

There is no chemical approved treatment for this disease.

- The best management plan would be to:
  - strengthen a weak hive with more brood and bees,
  - replace the queen (literature indicates that it might be genetic characteristic) with a queen of known hygienic behavior.

- To avoid spreading chalk-brood, you can avoid using pollen from a chalk-brood hive for supplemental feeding and avoid mixing frames of comb from a chalk-brood hive with other hives you may have.

Stone brood

- Stone brood is caused by a fungus Aspergillus fumigatus, Aspergillus flavus
- Causes mummification of the brood of a honey bee colony – looks similar to chalkbrood
  - Infects the larvae after capping
  - Infected larvae are yellow-green to gray-green mummies
  - Larvae form a black ring around the “neck” and become gray to black and hard to crush.
- The fungi are common soil inhabitants and are also pathogenic to other insects, birds and mammals.
- Can be spread in moldy hay

Protozoan Diseases

- Nosema Disease
- Amoeba Disease – impacts malphigian tubes
- Other Protozoa – impact midgut
  - Gregarines
  - Flagellates

Nosema apis and Nosema ceranae

- The most common adult bee disease.
- N. ceranae has overrun N. apis in European honeybees.
- A microsporidia (spore and protozoa) that infects the gut of the bee.
- 30 million spores in a single bee after 2 weeks of infection.
- Can kill an overwintering colony.
- Researchers studying Nosema’s suspected interaction with viruses and varroa mites.
**Why Nosema matters so much...**

- Greatly reduces the lifespan of all castes of bee. (by 50%)
  - Thereby reduces honey yield (40%)
  - Causes early queen supersedure
  - Delays growth of bee population by reducing functioning of food brood gland of nurse bees
- Disruption of hormonal development, causing bees to age faster and forage earlier in lifecycle.
- Disruption of digestive enzymes, causing starvation.

**Nosema symptoms**

- Unable to fly or only short distances
- Trembling, stumbling, dragging legs on bottom board
- Feces on combs, top bars, outside walls
- K-wing deformity
- Not eating syrup when fed
- Abandoning colony leaving queen and few workers

**Nosema Control and Treatment**

- Good wax rotation practices
- Clean water
- Young queen
- Sunny site, shielded from wind but with adequate winter ventilation
- Adequate or emergency pollen, honey, or heavy sugar syrup (2:1)
- Clean comb; sterilize soiled comb with 10 % bleach and/or replace; some use acetic acid vaporization
- Reduce stress - no moving
**Nosema Chemical Treatment**

Fumagillin (commercial Fumagilin-B)

- Fed as a medicated syrup in fall and spring
- **Must not be used during nectar flow**
- Current dosing level effective for N. apis.
- Check web for studies of effective doses against N. ceranae – **lots of debate about effectiveness against N. ceranae**

Fumagillin-B is permitted by the Certified Naturally Grown program.

**Dysentery**

Result of poor food, fermented food, syrup with impurities; and long (usually late winter) periods of confinement in humid conditions.

Signs: Sluggish bees, swollen abdomens, and yellow/brown fecal staining on hive walls

Treatment: Provide winter exit; provide fresh heaviest syrup possible; clean or replace soiled comb

**Viral Diseases**

- Sacbrood
- Chronic Bee Paralysis
- Filamentous Virus
- Acute Paralysis Bee Virus and Kashmir Bee Virus
- Deformed wing virus

**Sacbrood**

- Sacbrood is caused by a virus Morator aetatulas – discovered 1917
- May appear at any time during the brood-rearing season
- The fungus starts in the soil, and any litter, and can go up through the crop, which the brood consume. The fungus is ingested into the brood during feeding, and then effects its guts, and soon, engulfs the body.
Sacbrood - Identification

• About the time the cell is sealed, the larva dies from the virus.
• When it does, the head end turns up like the end of a canoe, and remains in that position. The pearly white color of the larva darkens and the skin becomes tough.
• At this stage, the larva, which resembles a liquid-filled sac, can be removed from the cell intact; hence the name, sacbrood. The dead larva continues to dry and harden until the dried-down scale is almost black. The head end is usually the darkest. Scales of larvae dead of sacbrood can be removed easily.

Sacbrood - Treatment

• No treatment available – use good beekeeping practices

Deformed wing virus

Bee paralysis virus

• Symptoms include trembling motion of the wings and bodies of adult bees, who are unable to fly, and crawl along the ground or up plant stems, often clustering together.
• Bees will generally become hairless as well
**Varroa History – know thy enemy**

- *Varroa jacobsoni*
- **1904** - first descriptions as an ectoparasite of the eastern honeybee (*Apis ceranae*)
- **1950s** - Movement of *A. mellifera* by humans into areas where *A. cerana* is endemic in the 1950’s enabled *V. destructor* to transfer to *A. mellifera* (mainland Asia)
- **1987** - *V. destructor* first found in the US in Wisconsin
- **2000** – discovery that *Varroa jacobsoni* is a complex of two different subspecies that parasitize eastern honeybees
  - *Varroa jacobsoni*
  - *Varroa destructor* – females are larger and less spherical than *V. jacobsoni*

*V. Jacobsoni and V. destructor are reproductively isolated*
Varroa History – know thy enemy

• *A. mellifera* did not evolve with varroa and as a result has very limited mechanisms to cope
  • *Apis cernae*
    • has shorter worker brood cycle (18 days)
    • so mites only reproduce in drone brood (22 days)
  • exhibits hygienic behavior
  • Carries another mite that is even more destructive than varroa
  • *Tropilaelaps clarae*
    - absolutely fatal if introduced in *Apis mellifera* colonies
    » Requires year round brood production for survival

Pettis varroa video

• Video of mites
• Sample jar of mites
• Sampling device
Testing for Mites

• Powdered sugar roll or alcohol wash
  – Sample size: 300ish bees (1/2 cup)
  – Perform test, count mites, compute mites per 100 bees
    • E.g. 6 mites per 300 = 2 mites per 100 = 2%
  – Double this number (maybe triple when brood rearing is at peak)
    • Why?
      – Your counting mites on adult bees (phoretic mites) not the mites in brood. 50% or more of the mites could be in with brood (at peak brood rearing it is 33% adult:67% brood)

Why powdered sugar works for testing mite loads

• Powdered sugar clogs the mite’s ambulacrum with dust. The ambulacrum of adult female Varroa is a claw-like form (sclerites) used for grasping the hairs of bees. The claw-like sclerites of the ambulacrum enable mites to move rapidly on adult bees and other substrata.

• Stimulates the bees’ grooming behavior.

• Dust on the mite’s body may stimulate it to release from its host to groom itself.
  – An aside - One of the first products used to control Varroa was Sineacar, a mixture of powdered sugar (98.2%) and chloropropylate and bromopropylate (1.8%)
  – The idea of using a powder to dislodge is also how oxalic acid powder was discovered as a potential mite treatment (1989)

Treatment thresholds

• Varies by information source
  – 8% to 12% - thought to be the economic threshold when treatment is absolutely necessary

  – Some argue lower values – 6% or less

  – Some argue the threshold changes by the season with a lower tolerance in the spring such as 2% and then higher in summer
Variable thresholds for sugar roll

<table>
<thead>
<tr>
<th>Colony Phase</th>
<th>Acceptable (further control not needed)</th>
<th>Caution (Control may be warranted)</th>
<th>Danger (Control promptly)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Dormant&quot; with brood</td>
<td>&lt;1%</td>
<td>1-2%</td>
<td>&gt;2%</td>
</tr>
<tr>
<td>&quot;Dormant&quot; without brood</td>
<td>&lt;1%</td>
<td>&lt;2-3%</td>
<td>&gt;3%</td>
</tr>
<tr>
<td>Population increase</td>
<td>&lt;1%</td>
<td>&lt;2-3%</td>
<td>&gt;3%</td>
</tr>
<tr>
<td>Peak Population</td>
<td>&lt;2%</td>
<td>&lt;3-5%</td>
<td>&gt;5%</td>
</tr>
<tr>
<td>Population Decrease</td>
<td>&lt;2%</td>
<td>&lt;2-3%</td>
<td>&gt;3%</td>
</tr>
</tbody>
</table>

Using drone brood monitoring to decide appropriate level of control to apply – less reliable

<table>
<thead>
<tr>
<th></th>
<th>Proportion of infested drone pupae</th>
</tr>
</thead>
<tbody>
<tr>
<td>April, May, June</td>
<td></td>
</tr>
<tr>
<td>&lt;1% (1 mile in 50)</td>
<td>Less than 2% No action</td>
</tr>
<tr>
<td>&lt;1% (1 mile in 30)</td>
<td>Less than 3% No action</td>
</tr>
<tr>
<td>&lt;1% (1 mile in 20)</td>
<td>Less than 5% No action</td>
</tr>
</tbody>
</table>

Treatment Options

- Varies by beekeeper’s philosophy and management requirements
  - Integrated Pest Management
    - Screened bottom boards (maybe 2-3% reduction)
    - Drone brood removal (requires constant management)
    - VSH, etc. genetic lines
    - Nectar flow or syrup to stimulate hygienic behavior
    - Small cell (lots of debate over how well this works)
  - Soft Chemicals
    - Organic acids – formic, oxalic
    - Essential Oils – thymol, eucalyptol, menthol
  - Synthetic Chemicals
    - amitraz, fluvalinate, cuomaphos

Number of registered treatments

- US – 11 unique products (EPA registered)
  - A couple no longer manufactured
  - 8 registered products in WI
- Europe – 13 unique products collectively
  - Apistan, Apiguard, Apilife-VAR, Checkmite+, MAQs, are common between US and Europe
  - Oxalic acid is only authorized for use in Austria, Italy, Hungary and Spain but is generally tolerated in the remaining 25 EU countries
- Canada – 8 unique products
How the treatments work
- The most commonly used synthetic Varroa treatments are based on amidines, organophosphates, pyrethroids or carbinols and all affect the nervous system of the mite (and bees too) in one way or another.
  - The “trick” – need concentrations high enough to damage or kill mites but not so high as to significantly damage bees.

THE SYNTHETIC CHEMICALS

Apivar (Amitraz)
- Chemical class: amidine
- Mode of action: antagonistic effect on octopamine receptors of the nerve cells.
Apistan (Fluvalinate)
- Chemical class: pyrethroid
  - *Penetrates cuticle of the insect*
    - Mode of action: prevents the closure of the sodium channels

Checkmite+ (Coumaphos)
- Chemical class: organophosphate
- Mode of action: inhibits Ach channel

THE ORGANIC ACIDS
- MAQs (Formic Acid)
  - Chemical class: organic acid
  - Mode of action: fumigant – vapors from the product kill mites through respiratory inhibition
    - (messes up the citric acid/glycolsis cycles in cells which is necessary for cell "respiration")
HopGuard (Potassium salt of Hop beta acid)

- Chemical class: potassium salt
- Mode of action: contact – mode is not completely understood

Oxalic Acid

- Chemical class: organic acid
- Mode of action: contact or fumigant – mode is not completely understood
  - It is thought that vapors may enter through the soft pads of the mite’s “feet” and travels to their circulatory system. It is also thought that it could damage the mite’s mouth

ESSENTIAL OILS

Apiguard (Thymol)
ApiLife Var (Thymol, eucalyptol, menthol)

- Chemical class: essential oil
- Mode of action: fumigant; kills the mites by disrupting their cell membranes and general cellular processes rather than being highly specific to nerve channels.
Handout

- Varroa sampling and threshold discussion

Tracheal Mites

- **Acarapis woodi**
- Impacts 0.2% of colonies in WI
- Discovered in mid 1880’s. It was first identified as the Isle of Wight Disease. This mite has become well established in the United States except Hawaii. These mites can be observed under a microscope. They are found in the tracheae of adult honey bees.

Tracheal Mites

- Highly infested hives usually die in the fall or winter. One may find few bees in a dead hive.
- This is contrary to starvation when most of the bees will be on the face of the comb -- dead. Early detection is important. If the beekeeper notices a rapid decline in population, the situation is already out of hand.

Small Hive Beetle

- **Arthina tumida**
- Impacts 2.5% of colonies in WI
- The Larvae may be mistaken for wax moth larva but they do not spin cocoons as the wax moth larva and leave a slime trail within the hive.
Many types of "pill bugs" in Wisconsin (nitidulidae)

Small Hive Beetle Known Locations

Adult bees avoid the light, and feeds on honey and pollen. They carry pollen from flower to flower.

Eggs hatch in 3-4 days, and larva remain inside the cell. Larvae feed on the honeycomb and convert it into silk and wax. Larvae pupate in a "puparium" and emerge as adults.

Larvae are serpentine in shape and can be up to 2 inches long. They may damage the honeycomb by chewing or digging, and can cause a decrease in bee colony strength.
Hive beetles

- Are attracted to
  - Rotting fruit (e.g. cantaloupe)
  - Pollen patties
- Can survive 5 days without food in summer temperature and much longer in equipment containing honey and pollen
- Can spread in swarms
- Can fly – how far is debated but further than honeybees can fly.

Hive beetle control options

- In hive traps
  - Oil filled traps
  - Dryer or Swiffer sheet traps
- Bottom traps
  - Oil filled trays in screened bottom boards
Wax moths

- There are two types found in the United States:
  - *Galleria mellonella* L. - the Greater Wax Moth
    - More destructive and more common comb pest of the two
  - *Achroia grisella* F. - the Lesser Wax Moth.

Both will do considerable damage to bee hives that are in weak condition and to stored comb in supers. It is the wax moth larva that are a serious problem in warm weather and dark conditions. They can do a lot of damage in a very short period of time.
Lesser wax moth
Smaller, lighter color

Wax moth control

- Wax moths attack weak hives. Strong hives will keep them under control.
- Wax moths do not like light. Exposing equipment to light will deter moths.
- Storing honey supers “wet”
- Using biological control such as Bacillus thuringiensis (BT-401, Certan, Xentari)
Wax moth control

- Using a moth fumigant in stored equipment
  - Currently paradichlorobenzene (PDB) is the fumigant of choice.
  - It can be purchased from bee supply dealers or at hardware and drug stores everywhere.
  - Be sure you purchase 100% PDB and not the other common moth fumigant naphthalene.

Integrated Pest Management (IPM)

IPM: To significantly reduce or eliminate the use of pesticides while at the same time managing pest populations at an acceptable level. IPM is performed in three stages:

- Prevention
- Observation
- Intervention

IPM PRACTICES

IPM Examples

- Screened bottom boards for Varroa trapping and monitoring (2-3% reduction)
- Powdered sugar dusting to control Varroa
  - (very mixed results on effectiveness)
- Drone trapping method of Varroa control
- Chickens in apiary to control small hive beetle
- Proper location and orientation of hives
- Provide clean and consistently available water source
- Hive entrance reduction when appropriate
- Frame/Comb replacement schedule (5 year schedule)
**IPM Examples**

- Clean/sterilized tools and equipment
- Proper storage of frames and combs
- Use of physical barriers, traps and deterrents
- Maximize distance between hives when possible or practical
- Genetic resistance and selection
- Locating hives out of sight from road traffic
- Hives raised off ground
- Vented cover for increased hive ventilation
- Feed sugar water and pollen patties when appropriate to reduce stress
- Use enclosed feeders to reduce robbing

**Questions**

**Contact Information**

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