BEST MANAGEMENT PRACTICES FOR HIVE HEALTH

A GUIDE FOR BEEKEEPERS

HEALTHY BEES · HEALTHY PEOPLE · HEALTHY PLANET™

HONEY BEE HEALTH COALITION™

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CHAPTER 1: INTRODUCTION

A well maintained apiary.
Photo Credit: James Wilkes

Every beekeeper should seek to have hives that are healthy and productive. Today, the many threats to honey bee health — including parasites, pests, disease, pesticides, and inadequate nutrition — make achieving this goal a major challenge. Successful beekeeping means closely monitoring bee health and taking proactive steps to protect them.

Over the years, a wide range of public and private organizations have developed Best Management Practices (BMPs) for the honey bee industry. Important work has been done by state governments, crop and grower organizations, universities (particularly extension services), state beekeeping organizations, and other stakeholders.

This guide collects BMPs from many sources into one document to make it easy for beekeepers to find practical information that they can use. Experts from within and outside the Honey Bee Health Coalition, including entomologists, small-scale and commercial beekeepers, apiary inspectors, and commercial bee suppliers, have reviewed the BMPs in this guide to make sure that they are accurate and consistent with the latest research findings.

WHAT IS A BEST MANAGEMENT PRACTICE?

A practice, or combination of practices, that is determined to be an effective and practical means of improving honey bee health and reducing risks to colonies. BMPs in this guide are specific steps and actions that beekeepers, managing at any scale from a single colony to commercial apiaries, can take to protect their bees.

Whether you are just starting out as a beekeeper or have years of experience, you'll find that this guide offers valuable BMPs on many topics, including:

- Safety
- Apiary and hive set up and maintenance
- Pesticide exposure
- Treatment of parasites and bee diseases
- Queen health, bee breeding and stock selection
- Bee nutrition

We thank the *Canadian Honey Council* and its authors for allowing us to use their document, *Canadian Best Management Practices for Honey Bee Health*, as the foundation for this publication.

GENERAL PRACTICES

In addition to using specific hive best management practices (BMPs), successful beekeepers also adhere to four broad practices.

COMMIT TO LIFELONG LEARNING

The first and most critical step in responsible beekeeping is a lifelong commitment to education. All beekeepers should have a solid understanding of honey bee biology and basic beekeeping methods. They also need to remain current on issues of colony health and management and stay informed of recommended changes in beekeeping practices. There are several ways to learn. These are essential for beginners, but still valuable, no matter how much experience you have.

Take a beekeeping course:

Many colleges, universities, and beekeeping associations offer introductory courses in beekeeping (often called a Bee Short Course). In many areas, master beekeeping programs are also available. These teach both basic and advanced skills.

Get a basic beekeeping book:

Several excellent books cover the basics of beekeeping. See the list provided in the Resources section of this chapter.

Join a beekeeping association or club:

Look for a club in your area that holds regular meetings where you can learn from expert speakers and club members. The Resources section at the end of this chapter includes links to directories of beekeeping groups.

Find a mentor:

Choose mentors carefully. Select someone in your area who has kept bees alive and healthy for years. There are multiple management systems and opinions on beekeeping practices, so it's often wise to learn from multiple people.

Attend field days:

At field days or open-hive events, the bees will be your ultimate "teachers."

Use the internet - carefully:

The internet offers a vast amount of information on bees and beekeeping. However, many sources are not always reliable nor accurate. Read all sources of information, including media reports, trade journals, science magazines, and scientific journal articles carefully and critically. Watch out for assertions that are not supported by evidence.

Bee field day.
Photo Credit: D.M. Caron

FOLLOW ALL LAWS AND REGULATIONS

Beekeepers need to comply with all homeowner association, local, state, and federal ordinances, regulations, and laws about beekeeping. State laws and local regulations have the greatest impact on most beekeepers.

CHECK BEFORE MOVING!

If you are transporting live bees, dead bees, or beekeeping equipment across state or international borders, you may need permits. Transportation of bees and equipment may be subject to Department of Transportation or other agency regulations. Check in advance before movement.

State laws

Almost all states have an apiary law that covers issues like inspection for honey bee diseases, registration, bee movement and entry regulations, permits and certificates, quarantines, and approved methods of treating diseased colonies. Some states have a fee associated with registration and inspection, though some beekeepers with a small number of backyard colonies are exempt.

A few states have special legislation for commercial beekeepers related to property taxation and right-to-farm or explicitly classifying beekeeping operations as livestock farming.

Local regulations

Some city, community, county, and state laws and regulations may ban beekeeping or have limits on beekeeping (setback distances, number of colonies, etc.). A few communities may explicitly permit beekeeping. Nearly all communities can regulate beekeeping via nuisance statutes.

Check state and/or local bee association websites for information about apiary rules and regulations. See specific state-by-state listing of contacts on the Honey Bee Health Coaltion website.

KEEP APIARY RECORDS

Beekeepers should maintain a record system of their hives, apiaries, locations, and seasons.

Items to record include:

- Colony temperament
- Queen "rightness"
- Diseases and pests
- Honey production
- Management actions performed

Both paper checklists and online tools are available to assist with record keeping. See the Resources section at the end of this chapter for links to record keeping tools.

Consider individually marking your hives and equipment and maintaining photographic evidence of apiary health throughout the year. Should anything happen, such as a pesticide kill, vandalism, or theft, photographic evidence could be valuable.

"Love the neighbor you have, not the one you wish you had."
– Wendell Berry

COMMUNICATE WITH NEIGHBORS

If your colonies are in a populated area, maintaining respectful communication with neighbors is essential. Many people are afraid of bee stings, especially if they or their children are often outside.

Good communication includes:

- Listening to neighbors' concerns and answering their questions.
- Inviting them to see your hives. A little bit of education about honey bees can help to reduce their fears.
- Discussing convenient times when you can check hives when neighbors will not be outside.
- Asking them to let you know when they are having barbeques, birthday parties, lawn maintenance or other outdoor activities so you can avoid hive activity.
- Giving them some honey.

RESOURCES

BEEKEEPING SCIENCE

The Council for Agriculture Science and Technology (CAST) publication *"Why Does Bee Health Matter? The Science Surrounding Honey Bee Health Concerns and What We Can Do About It"*
http://www.cast-science.org/file.cfm/media/products/digitalproducts/QTA20171_Bee_Health_565CB839D149E.pdf

BEEKEEPER TASKS AND DUTIES

Ohio State University's DACUM Research Chart for beekeepers
https://cpb-us-w2.wpmucdn.com/u.osu.edu/dist/a/836/files/2017/09/Beekeeper-Chart-final-2017-1dir7nb.pdf

HIVE MANAGEMENT RESOURCES

Canadian Best Management Practices for Honey Bee Health
http://honeycouncil.ca/wp-content/uploads/2016/12/ BMP-manual-for-honey-bee-health-Feb-2017-English.pdf

BMPs developed by the Managed Pollinator Coordinated Agriculture Program (CAP)
https://articles.extension.org/pages/33379/best-management-practices-for-beekeepers-and-growers

Honey Bee Health Coalition
https://honeybeehealthcoalition.org/hive-management-additional-resources/

BEEKEEPING ASSOCIATION/CLUB DIRECTORIES

https://www.mannlakeltd.com/beekeeping-education/beekeeping-directory

http://www.localhoneysources.org/content/State_Beekeeping_Associations.phtml

http://www.beeculture.com/directory

BEEKEEPING BOOKS

Top Titles:

Honey Bee Biology and Beekeeping, Dewey M. Caron and Lawrence John Connor (2018)

The Beekeeper's Handbook, Diana Sammataro and Alphonse Avitabile (2011)

The Hive and the Honeybee, published by Dadant & Sons (2015)

The ABC & XYZ of Bee Culture, A. I. Root and others (latest revised edition)

Beekeeping for Dummies, Howland Blackiston (2017)

The Buzz about Bees: Biology of a Superorganism, Jürgen Tautz (2008)

Honeybee Democracy, Thomas Seeley (2010)

The Backyard Beekeeper: An Absolute Beginner's Guide to Keeping Bees in Your Yard and Garden, Kim Flottum (2018)

Natural Beekeeping: Organic Approaches to Modern Apiculture, Ross Conrad (2013)

The Bees in Your Backyard: A Guide to North America's Bees, Joseph S. Wilson and Olivia Messinger Carril (2015)

First Lessons in Beekeeping, Keith S. Delaplane (2007)

Find new and newly revised beekeeping books and other informational materials in Bee Culture Magazine (A.I. Root Co.) and American Bee Journal, through bee supply companies, and from specialty publishers like Wicwas Press and Northern Bee Books.

LAWS AND REGULATIONS

State and Federal Beekeeping Resources
The contacts and resources at the following link have been compiled for you by the Honey Bee Health Coalition. The websites or people you visit and contact may provide contradictory information. Please use your own judgment, and seek multiple sources of information prior to decision making. In addition to the federal and state resources contained below, please also seek out local resources and bee clubs and associations.
Honeybeehealthcoalition.org/federalstateresources

Oregon State University Extension Service manual (EM 9186) on avoiding nuisance complaints in residential areas
https://catalog.extension.oregonstate.edu/em9186

Apiary Inspectors of America – State Laws
https://apiaryinspectors.org/state-laws/

RECORDKEEPING

Checklists:

Dadant:
https://www.dadant.com/catalog/m01940-hive-inspection-sheet-notepad

Bayer Bee Health (includes instructional video)
https://beehealth.bayer.us/who-can-help/beekeepers/healthy-colony-checklist

Eastern Missouri Beekeepers Association
https://www.formsbank.com/template/110857/eastern-missouri-beekeepers-association-hive-inspection-sheet.html

Southern Adirondack Bee Association
http://sababeekeepers.com/HiveInspection.html

Online recordkeeping tool:

HiveTracks offers an interactive personalized recordkeeping system available online for a monthly fee
https://hivetracks.com

Many beekeeping books and manuals discuss the essentials of good recordkeeping.

CHAPTER 2: PREPARATION AND PERSONAL SAFETY

An assortment of beekeeping equipment.
Photo Credit: Bee Informed Partnership

Bee safety starts with proper preparation. Here are the minimal Best Management Practices (BMPs) all beekeepers should follow for personal safety.

GENERAL PREPARATION

EMERGENCY PLAN

All beekeepers should have an emergency plan written out and posted in a convenient location. The emergency plan should include, but not be limited to, physical injury, internal (heart, respiratory, or digestive) condition, and a plan for a sting emergency. Know where the closest medical facility is and map out a route to the facility. Have your cell phone on your person (not in your vehicle or sitting on a hive) and know how to describe the location of your apiary to an emergency service (911) dispatcher. If you are working alone at the apiary, let someone know where you are going and when you expect to be back.

FIRST AID KIT

Keep a first aid kit in your vehicle, stocked with antihistamine, pain relief, antiseptics, bandages, gauze pads, etc. Also keep first aid items in the honey house and storage facilities, and clearly label their locations.

HYDRATION

In hot weather, make sure you hydrate prior to working bees. Once you suit up and have a veil in place, stopping to drink water can be bothersome. Supply your workers and yourself with enough water for frequent breaks and for washing hands after inspections.

ERGONOMIC SAFETY

When inspecting heavy hives, beekeepers bend, lift, and twist. Bend and lift with your knees, not your back, as much as possible. Avoid lifting and twisting with heavy supers if possible. Consider using a back brace or knee support when inspecting hives. To ease back and knee fatigue, sit or kneel when doing inspections. Simple warm-up exercises prior to bee activities help to keep backs and knees in better shape and muscles toned. Hand strength and dexterity are important.

EQUIPMENT SAFETY

Be sure you and your employees or helpers understand the safe operation of honey house and beekeeping management equipment.

- Post safety precautions prominently, and indicate emergency procedures clearly.
- Clearly label emergency shut-offs of power and water.
- Train operators in safety, proper equipment use, and how to keep equipment in top repair. Review annually before use.
- Be careful around electricity (honey is a good conductor), and avoid open flames around beeswax (it has a low fire flash point).
- Keep floors and surfaces reasonably clean of wax and honey to minimize potential falls and to limit attraction of vermin.
- Have a flow plan for movement of full supers — entry to extraction to removal of empty supers — as well as handling of liquid honey and beeswax cappings.

Beekeeping tool box.
Photo Credit: Mann Lake Bee Supply

TOOL BOX

Keep the following items handy for hive inspection activities:

- Cold smoker
- Smoker starter fuel
- Hive tools
- Hammer and nails (and metal frame tab fixers)
- Spare matches in waterproof container
- Queen cage
- Marking pens
- Field notebook and other recordkeeping tools
- Fire extinguisher
- EpiPen®

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Veil: Always wear a veil, even if you are approaching a hive for simple, quick tasks.

Clothing: Wear clothing that covers all skin. Periodically inspect bee clothing for tears or openings.

Gloves: Wear gloves to protect your hands and wrists to avoid stings. Tight fitting gloves are best because they allow you to move nimbly within the hive and avoid crushing bees.

Footwear: Boots or work shoes are recommended when working with bees to protect your legs and ankles. Tuck coveralls or pants into footwear or close pant legs with strapping to keep crawling bees out.

Body Odor: Scents in perfumes, shampoos, soap residues, cologne, etc. can attract or irritate bees, which are highly sensitive to scents. Do not apply anything with a scent.

PERSONAL PROTECTIVE EQUIPMENT WHEN HANDLING PESTICIDES OR CHEMICALS

Additional PPE is required when handling Varroa mite treatment chemicals and other pest controls. Mite treatments are pesticides, and there is a legal requirement to follow all label instructions.

- Before using any chemical, always check or recheck the label to identify what specific protective clothing or equipment is required and direct employees to do likewise. This includes specific gloves, eye protection, and respirators.
- Do not eat or smoke when actively mixing or using treatment chemicals, and keep your hands away from your mouth and face.

TOOL SAFETY

SMOKER

Always use a smoker to control the bees during an inspection.

Don't over smoke (i.e. lightly apply just a few puffs prior to opening the hive, and continue lightly once the hive is opened and the frames are separated). Smoking is not intended to subdue but to change behavior.

An active smoker during an inspection.
Photo Credit: D.M. Caron

Follow these safety precautions:

- Practice fire safety when lighting and using your smoker, especially when dry vegetation might be close to your working area. Some fuel sources, such as fuel pellets, can fall out of the smoker nozzle and ignite dry ground litter.
- Hot smokers can burn clothing or skin. Smokers with wire guards keep heated surfaces away from clothing, skin, and flammable fuels.
- Use a hook to hang the smoker from an open hive, so it is always readily available. Avoid setting a hot smoker on surfaces; the bottom plate of a smoker often gets very hot.
- The hinged top of a smoker needs to fit snugly. Smokers build up creosote, so periodically remove it with a wire brush.
- Close hot smokers with a cork or stopper to conserve unspent fuel for reuse another time.
- When moving between bee yards, enclose the hot smoker in a metal box, such as a surplus army ammunition box or a commercial smoker enclosure device, for safe transport. Don't leave smokers on open truck bodies.
- When emptying a smoker at the end of a day's work, be sure that the fire is completely out and ashes are fully extinguished.

TOOL SANITATION

Always keep tools clean by removing all of the propolis and wax using a chlorinated scrubbing cleanser. You can also use fire or rubbing alcohol to further sanitize a tool that has been cleaned. Heat the hive tool to a high temperature with a portable torch or by flames in the smoker. Use caution when handling heated hive tools.

Sanitizing hive tool with portable torch.
Photo Credit: Canadian BMPs for Honey Bee Health

MEDICAL RISKS

BEE STING REACTIONS

About 5 percent of our population is allergic to honey bee venom. However, how people with allergies respond to stings varies. We think of allergic response as anaphylaxis, leading to inability to breathe and possible death. The statistics demonstrate 1 percent of children and 3 percent of adults have endured such reactions.

If you get stung:

- Scrape the stinger out as soon as possible.
- If you start having a reaction, take an antihistamine or use an EpiPen®. Proceed directly to a medical facility if the reaction continues or after using an EpiPen®.

Sting in skin.
Photo Credit: D.M. Caron

If you know you are allergic to bees, consider extra precautions, including immunotherapy and keeping an EpiPen® handy at all times.

EpiPen 2-Pak.
Photo Credit:
www.EpiPen.com

TICKS

Ticks are increasingly becoming a problem because they can vector Lyme Disease and Rocky Mountain Spotted Fever. Beekeepers need to inspect their bodies and hair after being in beehives to locate ticks before the ticks become embedded.

AFRICANIZED HONEY BEES

The Africanized honey bee strain is a cross between African and European honey bees. Africanized honey bees are generally much more defensive and more easily disturbed. Guard and hive bees attack sooner, pursue longer distances, and remain alerted longer. If these bees attack an unprotected person, it can be extremely dangerous. States with high populations of Africanized bees include Arizona, Arkansas, California, Florida, Georgia, Louisiana, New Mexico, and Texas. Other warm climate states are at risk for the spread of Africanized bees on a seasonal basis.

Africanized bees often establish feral nests in natural or man-made cavities. Beekeepers are on the front lines in the efforts to reduce the impact of Africanized bees.

To prevent infiltration by Africanized bees:

- Mark all queens with paint or numbered tags.
- Regularly check hives.
- Don't let swarms move into empty hives.
- Properly store all bee equipment.
- Watch out for parasitic swarms (Africanized bees can invade a colony of European honey bees and take over the nest).

To control Africanized bees:

- Requeen any unusually defensive colonies.
- Contact your state apiary inspector so they may take a sample.
- Cull suspected Africanized bee populations with soapy water in a spray bottle rather than an aerosol insecticide.
- Educate the public about the benefits of honey bees and how to avoid contact with Africanized bees.

KEY POINTS TO REMEMBER

- Create detailed emergency plans before an emergency.
- Understand proper use of personal protective equipment.
- Use tools safely, and disinfect them frequently.
- Be prepared for bee stings, and make a specific plan in case of an allergic reaction.
- Monitor your apiaries for infiltration by Africanized bees.

RESOURCES

GENERAL INFORMATION ON BEE STING REACTIONS AND ALLERGIES

Mayo Clinic
https://www.mayoclinic.org/diseases-conditions/bee-stings/symptoms-causes/syc-20353869

WebMD
https://www.webmd.com/allergies/understanding-bee-sting-allergies-basics

GENERAL RECOMMENDATIONS ON BEEKEEPING EQUIPMENT SAFETY

Guidelines from Indiana University
https://protect.iu.edu/environmental-health/occupational-safety/beekeeping.html https://

Dickinson University
www.dickinson.edu/download/downloads/id/6877/the_hive_s_beekeeping_safety_guidelines.pdf

Illinois extension has guidelines for hosting visitors (especially youth) around bees
https://web.extension.illinois.edu/cook/downloads/69336.pdf

Consult bee supply catalogues/websites for the latest in PPE (Personal Protective Equipment).

MANAGING AFRICANIZED BEES

States with high populations of Africanized bees (AR, AZ, CA, FL, GA, LA, NM, and TX) have state and bee association websites with information on handling Africanized bees. The Florida, Texas, and North Carolina websites are particularly informative:

Florida
http://sfyl.ifas.ufl.edu/natural-resources/africanized-honey-bees/

Texas
https://txbeeinspection.tamu.edu/public/africanized-bees/

North Carolina
https://content.ces.ncsu.edu/africanized-honey-bees-prevention-and-control

CHAPTER 3: APIARY AND HIVE MAINTENANCE

A well maintained apiary.
Photo Credit: Bee Informed Partnership

Establishing and maintaining clean, safe apiaries and properly using and maintaining bee equipment helps to sustain healthy bees and reduce the risk of pests and diseases. Proper maintenance of beekeeping equipment should include renewing or replacing comb and hive materials susceptible to contamination, especially drawn brood combs.

ESTABLISHING SAFE APIARIES

There are many criteria to consider for apiary location, but it is not essential to find a site that fits every one because bees can thrive in many environments and conditions.

Components of a well maintained apiary.
Photo Credit: James Wilkes

CHOOSING A SITE

Desirable Features	*Features to Avoid*
• Vehicle access in all seasons • Dry locations with morning sun exposure • Access to clean water • Access to abundant, non-contaminated forage and for future expansion • 4 feet (120 centimeters) of clear, level space around hives in every direction for ease of working • Secluded from public attention	• Low-lying areas • Areas prone to flooding • Cold, damp air pockets • Locations without adequate work space around hives • Locations with high traffic (vehicular or pedestrian)

How Many Colonies?

Ideally, except for holding yards, an apiary should house only the number of colonies that can be sustained by nearby floral resources. Bees often forage up to 2 ½ miles (4 kilometers); from the colony, covering more than 12,000 acres (4,856 hectares). It can take several years to determine the carrying capacity of such an area.

Be alert to the environments near your apiary. Observe the flowering plants. What's blooming at what times of year? Consult experienced beekeepers for their perspectives.

- ***Urban and suburban areas*** may be rich with flowering shrubs and plants, but there may also be significant competition for forage if there are many nearby beekeepers.
- ***In rural areas*** the amount of resources will relate to how intensively the surrounding area is used for agriculture and the type of agriculture in the area. For example, thousands of acres of nearby corn will not provide much nectar.
- ***Forests*** may or may not provide adequate forage, depending on the types of trees and shrubs that flower within the forage area.
- ***Public lands*** (utility/gas lines, parks, federally managed lands, etc.) may exclude bees, but they can be highly desirable as sources of uncontaminated forage resources.

Take all these factors into account when deciding where and how many hives to place in a yard or apiary away from your residence.

Quarantining Bees

It is a good practice to initially isolate colonies from an established apiary site when adding a new colony or testing new control materials or management.

Moving suspect colonies from an apiary to a quarantine (hospital) yard to isolate them from other colonies allows further observation and management.

- ***Check colonies*** for a couple of brood cycles if disease might be suspected.
- ***Evaluate the bees*** for defensiveness over several inspections.
- ***Isolate colonies*** if you are seeking to manage American foulbrood (AFB) by any method other than immediately getting rid of the colony once AFB has been independently confirmed (see Chapter 6).

Confirm effectiveness of pest and disease controls by running parallel control colonies, ideally in the same yard under the same conditions, except for your tests.

Protecting Apiaries

Wind, grazing livestock, wildlife, and vandals can cause stress on the colony and contribute to unnecessary equipment wear and damage.

Shrubs, bushes, or other vegetation on the perimeter of the apiary provide a visual screen and protection against wind. Fencing can exclude wildlife, livestock, and vandals. Fencing should include locked gates in remote areas for security. In areas where bears are present, an electric fencing system is a prerequisite to preventing them from damaging colonies.

Bear fencing protecting overwintering colonies. Photo Credit: D.M. Caron

Siting Hives

Situate hives with morning sun exposure (south- or east-facing), if possible. Sun exposure may improve honey production as bees will begin flying earlier in the day and has been shown to reduce Varroa populations and disease conditions. Paint hives with light colors to reflect heat. In northern climates, darker protective sleeves can be added during the dormant season (winter), if necessary.

Within the apiary, site hives to reduce drifting between colonies. Bees can more easily return to their own homes when hives face different directions and are distinguished with different colors or geometric patterns on the front. Good apiary landmarks help as well.

Keep colony entrances and surrounding areas free of vegetation to provide good air circulation and reduce inhibition of flight and to help bees reduce moisture and circulate air within their hives. Avoid mowing that sprays grass clippings into hive entrances.

Hive Stands

Individual hives should be kept dry with a sturdy hive stand that keeps bottom boards off the ground. Replace solid bottom boards with screened bottom boards to aid in air circulation, allow debris to drop from the hive, and avoid moisture pooling at the hive bottom.

Hive stands must be stable enough to avoid moving hive parts and bumping or tipping hives during inspection. Look for stand designs that provide room to place smokers and other equipment nearby and space for removed frames. If possible, have a separate hive stand for each hive.

Use a hive stand that is a convenient height for you. If it's too low, you'll have to bend more; if it's too high, you may have to lift heavy honey supers over your head. Make sure the hive entrance is high enough off the ground so that skunks and other small animals can't get in.

A multi-hive stand (can be difficult to manage and are not recommended). Photo Credit: Unknown

A single hive stand on cinder blocks (recommended). Photo Credit: D.M. Caron

EQUIPMENT AND MAINTENANCE

Apiary and colonies in good repair. Photo Credit: D.M. Caron

PURCHASING EQUIPMENT

Purchase only new equipment from known, reliable sources to avoid introducing disease spores, toxins, and pesticide residues into your operation. Use caution if you buy used equipment, and make sure it is thoroughly cleaned. Avoid any suspect drawn comb. Inexperienced beekeepers should request assistance from more experienced beekeepers or state beekeeping specialists to help assess risks associated with used comb and equipment.

BUYER BEWARE

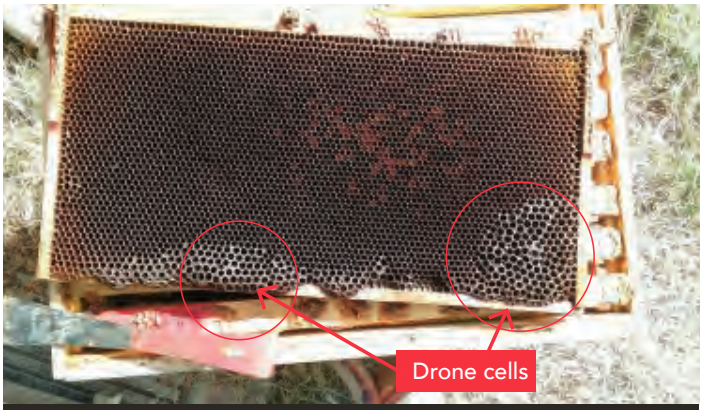
Purchase only new equipment from known, reliable sources to avoid introducing disease spores, toxins, and pesticide residues.

Discard Equipment, Wax, and Sugar Sources Properly

Avoid discarding frames or hive parts in the apiary. Debris on the ground invites hive beetles, ants, skunks, or other pests into the apiary. If conditions permit, have a burn pit or barrel in the apiary, or enclose old, unwanted frames in trash bags to carry to a burn pit or landfill. Avoid spilling sugar syrup or discarding burr or brace comb or drone brood sampled for mites in the bee yard. Bring a receptacle to collect wax scrapings.

REPLACING COMB

Replace a portion of the darker frames from the brood chamber each year. Replace frames with new foundation or drawn comb from honey supers at nectar flow. Culling frames reduces colony exposure to pesticide residues, pathogens, and brood remains that accumulate in brood cell wax over time. This is particularly important in the prevention of American foulbrood (AFB) and nosema infections. New frames can help slow the development of antibiotic resistance in AFB and miticide resistance in Varroa mites by removing low levels of such contaminants captured in the wax of brood cells.



Dark comb with heavy drone cell presence. Photo Credit: D.M. Caron

The best practices for most colonies are as follows:

- Replace frames at a rate of two to four frames per colony per year (about 20 percent per year). Replacement of older, darker comb is easiest during initial spring cleaning of colonies or with removal of deadouts.
- Replace older frames with thick, dark comb and comb with more than 10 percent drone cells. Such frames in the lower box are often without brood during early spring colony inspection and most likely will contain few cells of pollen or honey.
- Ideally, no brood frame in the hive should be older than five years. A simple frame dating or marking system helps in this maintenance activity.
- In areas where comb drawing is more difficult due to reduced or unpredictable nectar resources, the comb replacement rate may be reduced to one or two combs per hive annually.
- New beekeepers should hold off on comb replacement until they find dark comb (when a frame held up to sunlight does not show light penetrating) or when drone cells exceed 15 percent of comb content.

HANDLING HONEY

Refrain from extracting honey from the brood chamber. It is OK to store such frames in a freezer for feeding bees to stimulate in spring buildup phase or to counter possibility of starvation. Extract honey from supers quickly after removing them from the hive. After extraction, store comb in a freezer or refrigerator to kill small hive beetles and wax moths.

Don't feed bees anything that could contaminate honey, such as mite treatments (see Chapter 5), except for formic acid. Antibiotics used to treat colonies should not be used when honey supers are on hives.

AVOID ROBBING BEHAVIOR

Robbing can lead to prolonged stinging behavior, movement of mites and disease pathogens from one colony to another, and undesirable distribution of drone and worker-forager bee populations. Robbing can begin when beekeepers manipulate hives during periods of reduced resource availability or drought or when a colony is weak. Strong, hungry colonies can target those less able to defend themselves, and with a robbing assault, less healthy, stressed colonies may lose necessary colony guard protection.

If conditions are conducive to robbing, consider the following:

- Inspect colonies and remove honey supers either at sunrise or at dusk, or delay until conditions improve.
- Reduce colony entrances to one.
- Minimize the time you spend in a hive during drought or reduced foraging conditions.
- You don't need to inspect the brood nest when supers are in place.
- Don't put "wet supers" (honey supers that have been extracted) in open stacks; place wet supers on individual hives later in the evening.

Robbing honey bees . Photo Credit: Unknown

KEY POINTS TO REMEMBER

- Establish the apiary at sites that are dry and have morning sun exposure, access to clean water, and uncontaminated forage.
- Site hives to reduce drifting between colonies. Distinguish hives with different colors or geometric patterns on the front.
- Use hive stands to promote air circulation.
- Keep the apiary clean and safely accessible.
- Consider use of a quarantine yard when moving new material into an apiary or for colonies with possible disease.
- Purchase new beekeeping equipment from known and reliable sources to avoid potential disease spores, toxins, or pesticide residues. Only purchase used equipment and comb with caution.
- Replace a portion of older, darkened combs with excess drone cells each year with fresh foundation or honey super comb.
- Use best practices in colony inspection to avoid causing robbing behavior.

RESOURCES

ADDITIONAL BMP GUIDELINES

Certified Naturally Grown (CNG) has a handbook that addresses beekeeping practices including apiary siting, cycling hive frames, and other bee health factors. Its recommendations serve as guidelines for beekeepers seeking CNG certification https://certified.naturallygrown.org/documents/Handbook2ed.pdf

Recent beekeeping books, such as those listed in Chapter 1, offer more suggestions on apiary site selection and hive siting within the apiary.

AVOIDING NUISANCE ISSUES WITH NEIGHBORS

Oregon State University's Extension Service manual (EM 9186) https://catalog.extension.oregonstate.edu/em9186)

Oregon Master Beekeeper Program http://www.cobeekeeping.org/resources/Documents/GOOD%20NEIGHBOR%20BEEKEEPING%20Dewey%20Caron%20(1).pdf

CARRYING CAPACITY

There is little research on carrying capacity. Some studies and programs have attempted to model in-hive (colony) performance, including:

DeGrandi-Hoffman, Gloria et al. "Population growth of Varroa destructor (Acari: Varroidae) in honey bee colonies is affected by the number of foragers with mites" Experimental & applied acarology vol. 69,1 (2016): 21-34. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4824817

Torres, David J et al. "Modeling Honey Bee Populations" PloS one vol. 10,7 e0130966. 6 Jul. 2015, doi:10.1371/journal.pone.0130966 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4493160

BEEHAVE, a computer model to from the University of Exeter (Matthias Becher, et. al.) that simulates the development of a honeybee colony and its nectar and pollen foraging behavior in different landscapes beehave-model.net.

Scientific Beekeeping http://scientificbeekeeping.com/whats-happening-to-the-bees-part-2.

National Beekeeper Survey of the Foraging Needs of Bee Colonies, North American Pollinator Protection Campaign (NAPPC) https://pollinator.org/assets/globals/NAPPC-National-Beekeeper-Forage-Survey.pdf

CHAPTER 4: MINIMIZING RISK FROM PESTICIDES

Large numbers of dead bees outside of well-established colonies in the summer may indicate a pesticide-related kill.
Photo Credit: Honey Bee Biology & Beekeeping

Use of pesticides is a fact of life across the U.S. landscape, in both rural and urban environments. Beekeepers face a range of potential issues when their bees are exposed to pesticides. Honey bees are generalist pollinators that can visit a substantial area around the hive, so it is critical that pesticide exposure to bees is minimal to reduce the likelihood for any unintended adverse effects. Pesticides (insecticides and miticides) are applied to manage pest insects/mites on both agricultural and urban/suburban landscapes, and may also be used by beekeepers themselves to control pests inside their hives.

UNDERSTANDING PESTICIDE RISK

Honey bees must leave their hives and forage for food, water, and plant resins. Because pesticides are widely used in various settings (e.g., agriculture, ornamental plants, residential, and in-hive beekeeper use), contamination to nectar and pollen can occur, resulting in some exposure to pesticides in beekeeping. Honey bees can also be inadvertently exposed to pesticides via accidental spraying of their hive, spray drift, or contamination of a water source.

The goal of risk assessment is to ensure that the levels of a particular pesticide in the environment are below the level known to cause an effect to pollinators. Any labeled product undergoes extensive testing to inform an assessment on the risk to pollinators. Risk from a pesticide to individual honey bees and to whole colonies is a function of both the toxicity and the level of exposure of bees to a particular pesticide.

RISK = TOXICITY AND EXPOSURE

Toxicity is a function of the chemical and physical characteristics of the pesticide compound and how it affects bees. The EPA requires acute and chronic toxicity data on adult and larval honey bees during the registration process.

Exposure is influenced by the application rate, number of applications, mode of application (i.e. foliar, soil drench, or seed coatings), timing of application (e.g. pre-bloom application interval, time of day), rate of degradation, and a variety of environmental factors, such as weather and soil type.

Individual forager bees exposed to acutely toxic pesticides may die before returning to the hive. Foragers that survive initial exposure may transport the pesticide back to the colony in contaminated pollen or nectar or on their body hairs. A pesticide may also get stored in bee bread (stored pollen) or be absorbed by the beeswax comb and potentially extend the duration of exposure.

ADVERSE IMPACTS FROM PESTICIDES

It is important to be able to recognize the symptoms caused by a pesticide incident. Pesticides may interfere with individual bee behavior, shorten bee longevity, disrupt the age distribution and sequence of individual work duties, increase individual susceptibility to pests and diseases, and affect immune systems.

In addition to interference with individuals, pesticides may disrupt social functions of the colony when exposure occurs above levels known to cause an adverse effect. Pesticide exposure may dramatically slow colony development. Loss of forager bees may lead to decreased forager activity and reduced food in the colony. In response, the queen and drones may be affected, leading to potential impacts on reproduction. Such effects may be magnified during the build up phase (spring), when colonies need to develop rapidly, or during the decrease phase of fall preparations for winter, when it is critical that a colony produces sufficient numbers of winter bees.

A hive that has run out of honey can look like a pesticide kill with a mound of dead bees in the front or center of a hive or, as in this picture, on the frame.
Photo Credit: D.M. Caron

An example of a bee kill likely to have been caused by pesticides.
Photo Credit: Ellen Topitzhofer

Carefully observe colonies to verify behavioral changes or poor queen or colony performance.

Exposure to pesticides may make a colony more susceptible to other stressors, such as Varroa mites, disease, and poor nutrition, or may exacerbate problems in colonies already suffering from the impacts of these other stressors. By the same token, other stressors can reduce the capacity of bees to tolerate pesticides.

Two or more pesticides mixed in the same tank may interact to produce varying negative effects on bees. Beekeepers should stay current as science evolves. Seek advice from your local extension service and apiary inspector as questions emerge.

A weakened colony may exhibit several signs of stress:

- Dying bees.
- Low foraging activity.
- Poor (non-uniform) brood pattern.
- Large amounts of entombed pollen cells.
- Stress-related diseases (idiopathic brood disease (IPBD), European foulbrood (EFB), chalkbrood, etc.) that are normally not an issue for strong healthy colonies.
- Erratic movements and excessive grooming that limit bee foraging success and render bees more vulnerable to predation.

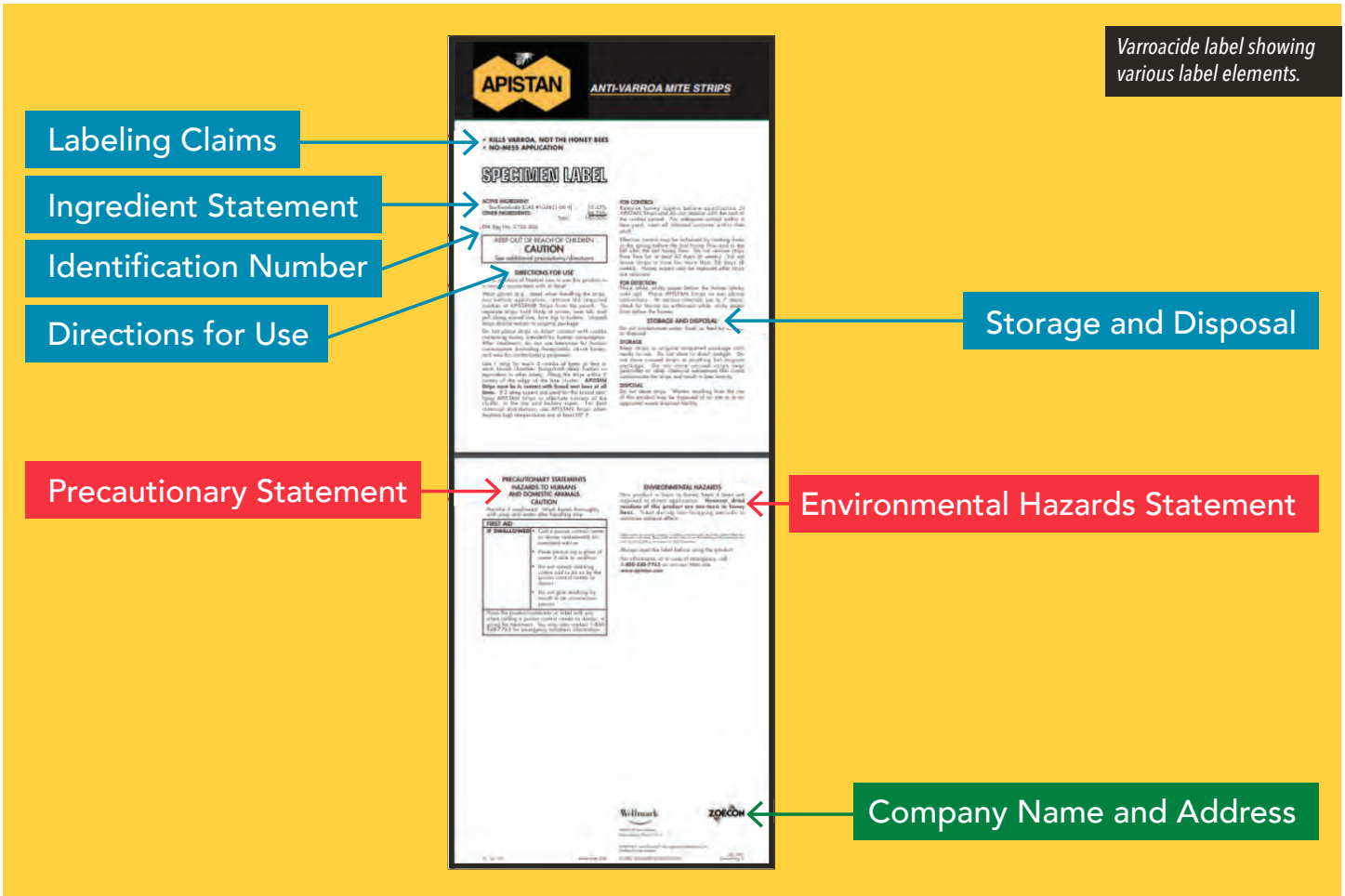
THE LABEL IS THE LAW

All pesticide users have the legal responsibility to follow the pesticide label to ensure that the use of a pesticide will not result in an adverse effect to humans or honey bees or an unreasonable risk to the environment. Misuse or "off-label use" (use not in accordance with the label) of a pesticide is a violation of federal and/or state law. If you are applying any product to control pests, ensure that it is a currently labeled legal product.

Many state agriculture departments have more information to help facilitate dialogue between beekeepers and pesticide applicators in order to reduce exposure to pesticides. This may include a colony registry program and/or access to FieldWatch® to help make applicators better aware of apiary sites.

A pesticide label consists of various sections:

- The Ingredient Statement contains information on the active ingredient.
- Specific language of the Environmental Hazard section protects non-target organisms; these advisory statements are based on the environmental fate and toxicity data for the active ingredient(s).
- Specific language to protect applicators can be found in Precautionary and First Aid Statements.
- Directions for Use (DFU) contains mandatory restrictions on how the pesticide must be used under specific circumstances.



Varroacide label showing various label elements.

HOW TO AVOID EXPOSURE

Beekeepers should maintain open communication with growers and pesticide applicators near their apiary sites throughout the growing season with the goal of limiting pesticide exposure to their honey bee colonies. Discussions should cover the importance of adequately protecting all pollinators. All three parties must be involved to prevent bee kill incidents while using pesticides to protect against crop losses.

To protect their colonies, beekeepers can:

- Communicate about apiary locations with growers, neighboring landowners, and pesticide applicators.
- Identify apiary sites by hive registrations.
- Many states have a "Field Watch®" program that allows pesticide applicators to view a registry of bee colony locations prior to a crop protection treatment.
- To the extent possible, place bees in areas where incidental exposure to pesticides is minimized. Place hives away from fields and with buffer area between the field and apiary.
- Post the beekeeper's name and contact information near apiary.
- Notify grower as soon as possible if any problems occur.
- Paint hives white or a conspicuous color.
- Move colonies before a pesticide application.
- If feasible, restrict colony flight at application time with wetted coverings. Confinement under elevated temperatures or for more than a few hours is not advised.
- Provide supplemental water free of contaminants if you suspect pesticides have contaminated other water sources.
- Keep current with changing pest management approaches, new products, and wide-scale public agency efforts to control pests of human health interest, such as disease -carrying mosquitoes. Your local bee club can help identify these risks and represent beekeepers' interests with municipal pest control efforts.

PAIRING BEEKEEPERS AND GROWERS

The Honey Bee Health Coalition's ***Bee Integrated Demonstration Project*** brings together beekeepers and producers to show how a suite of best practices for pollinator forage, Varroa management, and crop pest management can be implemented together in agricultural landscapes to improve grower-beekeeper communications and support honey bee health. See the Resources section at the end of this chapter for more information.

Hives placed near a flowering radish crop. Improper colony placement and failure to remove colonies promptly at the end of flowering may lead to pesticide loss. Photo Credit: Andony Melathopoulos

To reduce pesticide exposure to bees, beekeepers can also communicate the following to growers and applicators:

- Comply with pesticide label requirements rigorously.
- Follow the best management practices in state and tribal managed pollinator protection plans.
- Alert nearby beekeepers in advance when a pesticide application is planned.
- Spray pesticides when temperatures are cooler or apply early or late in the day to avoid times when bees are actively foraging.
- Avoid spraying flowering weeds upon which bees forage.
- Mow flowering weeds near the crop prior to an application or reduce them in some other manner, so bees will not be attracted.

PNW Guide

MSU Guide

HELPFUL PUBLICATIONS

The Pacific Northwest Extension (PNW) publication 591 ***How to Reduce Bee Poisoning from Pesticides*** will help educate both beekeeper and applicator. It includes a section on what might be discussed relative to pesticide choice and use.

The Michigan State University guide, ***Minimizing Pesticide Risk to Bees in Fruit Crops***, is aimed at a grower audience.

CONSIDERATIONS TO REDUCE RISK FOR BEES PROVIDING POLLINATION SERVICES

If bees are placed in the field or orchard for pollination services, it is important to remove colonies as soon as pollination is complete. This helps reduce potential exposure to pesticides, which may be applied post-bloom and which often have much higher toxicity to bees than those allowed during bloom. Discuss with growers the importance of giving beekeepers enough warning to remove colonies in a time-efficient manner. Growers may be unaware of the heavy demands of hive transport and availability of transport vehicles. Consider including provisions addressing beekeeper removal of hives in contract agreements.

In between pollination contracts, beekeepers should provide their bees access to favorable pesticide-free pollinator habitats to mitigate pesticide exposure and to ensure the diverse nutritional needs of bees are met. Such relief, sometimes called "time out," is important to commercially managed bees, which may have provided multiple pollination services during the year that may have resulted in low nutritional availability and increased pesticide exposure. When beekeepers providing pollination services have long-standing relationships with growers, beekeepers could encourage grower participation in conservation programs that provide cost-sharing to establish and maintain flowering pollinator habitats adjacent to crop plantings.

Spray drift or direct spray application may kill bees. Photo Credit: USDA

REPORTING PESTICIDE INCIDENTS

Beekeepers are encouraged to report all pesticide incidents suspected to have harmed the health of their bee colonies. The Honey Bee Health Coalition has developed a Quick Guide to Reporting a Pesticide-Related Bee Kill Incident which includes information on how to collect samples and provides contact information for EPA, state, and tribal lead agencies responsible for investigating pesticide-related incidents.

Because many pesticides degrade rapidly in the environment, professionals must collect samples from colonies suspected to have been affected by pesticide poisoning immediately after the suspected poisoning in order to verify exposure. Typically, state agriculture department officials or apiary inspectors will conduct such investigations.

It is difficult to prove a pesticide-related bee kill if the beekeeper cannot provide evidence of previously healthy hives. Keep good written and/or photographic records to support claims that bees were in good health prior to exposure.

This includes:

- Varroa counts with treatment records
- Hive number and population size (or # boxes)
- Queen status and age
- Indications of disease including virus signs
- History of apiary movements

Remember, beekeepers are also legally responsible for following label laws for pesticide use within the hive. A beekeeper filing a report may be subject to fines or sanctions if the investigation discovers violations of pesticide label laws by the beekeeper, themselves (e.g., off-label use of a pesticide to control Varroa mites).

See the Resources section at the end of this chapter for a link to pesticide information and reporting agencies in your state.

BEEKEEPER USE OF PESTICIDES

Beekeeper-applied pesticides also affect hive health, function, and mortality. Always apply pesticides used to treat parasites and diseases according to the label. Use of materials that are not labeled for in-hive use are illegal and may be detrimental to the colony and to human health when not used according to the label.

Avoid the overuse of chemicals and additives in the hive. Regularly remove and replace older, darker brood frames, as discussed in Chapter 3, to limit the buildup of chemicals within the hive.

Applying pesticide treatment of formic acid between brood boxes.
Photo Credit: Bee Informed Partnership

MANAGING MITICIDE RESISTANCE

Varroa mites reproduce rapidly, and new infestations may be introduced throughout the year. When challenged with the same pesticide repeatedly, the Varroa mite can develop resistance to that pesticide. Rotate your Varroa treatments according to Integrated Pest Management principles described in Chapter 5. Increasing dosage or use of more frequent applications of the same pesticide only hastens the evolution of such resistance.

A treatment failure may be the first sign of resistance, but can also be caused by other factors, including improper application, use of an outdated product, improper storage prior to use, or use of the product outside of recommended temperature and humidity regimes.

To reduce the possibility of treatment failure:

- Follow all label information regarding product storage.
- Follow all label information regarding application techniques and parameters (e.g., temperature, humidity, hive status).
- Sample bees for mites following treatment to evaluate pesticide efficacy.
- Maintain records on treatments applied and resulting effectiveness.

The Pettis resistance test can help beekeepers clarify if a treatment failure, or increasingly less effective mite control, could be due to increased mite resistance to the synthetic contact pesticides Apistan® (tau-fluvalinate), Apivar® (amitraz), and Checkmite® (coumaphos). This test will NOT work for organic treatments of acids or essential oils.

See the Resources section at the end of this chapter for a link to directions for conducting this test.

Insecticide damage to brood.
Photo Credit: Bee Informed Partnership

KEY POINTS TO REMEMBER

- Bees returning to the hive with contaminated food and water can expose the queen, the brood, and other workers to pesticides.
- Communication between growers and beekeepers is crucial to reduce the likelihood of adverse effects from pesticide exposure.
- Beekeepers are encouraged to report suspected pesticide-related incidents.
- Regularly clean and replace older frames to diminish chemical buildup within the hive.
- Read and follow pesticide labels.

RESOURCES

COMMUNICATION AND RELATIONSHIP BUILDING

Honey Bee Health Coalition's Bee Integrated Demonstration Project
https://honeybeehealthcoalition.org/bee-integrated-demonstration-project/

FieldWatch
http://www.fieldwatch.com/

UNDERSTANDING PESTICIDE RISKS

The Complex Life of the Honey Bee (PPP-16 Pol-9, 2017) from Purdue Extension
https://ppp.purdue.edu/resources/ppp-publications/the-complex-life-of-the-honey-bee

It discusses:

- Potential routes of exposure to pesticides.
- How pesticides may negatively affect bees.
- The U.S. Environmental Protection Agency (EPA) risk assessment process and information used to calculate risk estimates, referred to as risk quotients [RQs].

MINIMIZING PESTICIDE EXPOSURE

How to Reduce Bee Poisoning from Pesticides (publication 591) from Pacific Northwest Extension (Hooven *et al.*, 2013)
https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw591.pdf

Minimizing Pesticide Risk to Bees in Fruit Crops (publication E3245) from Michigan State University Extension
http://msue.anr.msu.edu/uploads/resources/pdfs/Minimizing_Pesticide_Risk_to_Bees_in_Fruit_Crops_(E3245).pdf

REPORTING PESTICIDE INCIDENTS

Honey Bee Health Coalition's Quick Guide to Reporting a Pesticide-Related Bee Kill Incident
https://honeybeehealthcoalition.org/quick-guide/

Local- and state-level pesticide incident resources provided by the National Pesticide Information Center (NPIC), a cooperation between Oregon State University and the EPA
http://npic.orst.edu/mlr.html

To report a pesticide incident, you can:

- Visit the NPIC Ecological Pesticide Incident Reporting web portal
  http://pi.ace.orst.edu/erep
- Call the NPIC reporting hotline
  1 (800) 858-7378
- Email the EPA at beekill@epa.gov

DETERMINING PESTICIDE TREATMENT FAILURE OR RESISTANCE

The Pettis Resistance Test - Easy-to-Use Bioassay to Spot Varroa Resistance
https://agresearchmag.ars.usda.gov/ar/archive/2005/apr/varroa0405.pdf

CHAPTER 5: INTEGRATED PEST MANAGEMENT AND VARROA MITES

Varroa mite on adult.
Photo Credit: Rob Snyder, Bee Informed Partnership

The modern approach to pest control is integrated pest management (IPM). IPM is a decision-making process that emphasizes use of more than one approach to pest control and seeks to integrate approaches in a multi-faceted way. Pest knowledge, monitoring, thresholds, and selection of compatible and complementary solutions are vital components of IPM.

This chapter discusses the concept of IPM and then how it is applied to Varroa mite control. Additional diseases and pests are covered in Chapter 6.

INTRODUCTION TO IPM

Long-term pest management acknowledges that eradication of a pest or pathogen is a biological impossibility. Beekeepers have a responsibility to sustain healthy honey bee colonies and to minimize colony pests and diseases. If you do nothing to treat hives, dying and dead hives become a threat to healthy neighboring hives. Good bee stewardship means establishing an integrated, preventative pest management strategy that is both economically and ecologically sound.

IPM solutions use multiple strategies rather than solely relying on a chemical approach. Management of pest populations can include habitat manipulation, physical/mechanical methods, cultural practices, genetics (e.g., selecting resistant queens), and enhanced biological control organisms.

WHAT IS INTEGRATED PEST MANAGEMENT (IPM)?

The Food and Agriculture Organization (FAO) of the United Nations defines IPM as "the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations, keep pesticides and other interventions to levels that are economically justified, and reduce or minimize risks to human health and the environment."

The four main components of IPM are:

1. Knowledge of pests and diseases and how they interact with the host (i.e. the honey bee)
2. Monitoring pest presence and abundance
3. Using pest thresholds to determine the need for and timing of treatment
4. Implementing appropriate solutions to manage pests and diseases

KNOWLEDGE OF PESTS AND DISEASES

The foundation of IPM is knowledge. Knowing what pests to look for and the risks they pose to honey bee colonies is crucial to managing pests and diseases effectively.

A beekeeper should be able to:

- Recognize the signs of pests and disease presence.
- Understand how pest and disease life cycles can harm colony health.
- Know how environmental and climatic factors — like season, hive location, and food resource availability — affect pests and diseases.

There is a compounding effect when more than one pest or disease is present. While any one pest or disease can be detrimental on its own, a combination of threats can be particularly damaging to bee health. Additional stressors such as pesticide exposure, poor nutrition, lack of access to clean water, hive transport, brood diseases, and other factors can diminish the ability of a bee colony to effectively resist the multitude of threats. When multiple pests and/or diseases are present, you may need to intervene sooner than you would for any single threat.

Stay up-to-date with changing scientific knowledge about pests, diseases, and treatment options. Rely on credible sources of information, such as state cooperative extension services, national beekeeping associations, industry publications, and peer-reviewed publications.

MONITORING

Monitoring (sometimes called sampling or scouting) is the detection and assessment of the significance of pest population levels. As pest populations increase, they can damage a colony, cause economic loss, and spread to other colonies.

CONSISTENT MONITORING

Use the same monitoring methods throughout the season, and keep a record of the results.

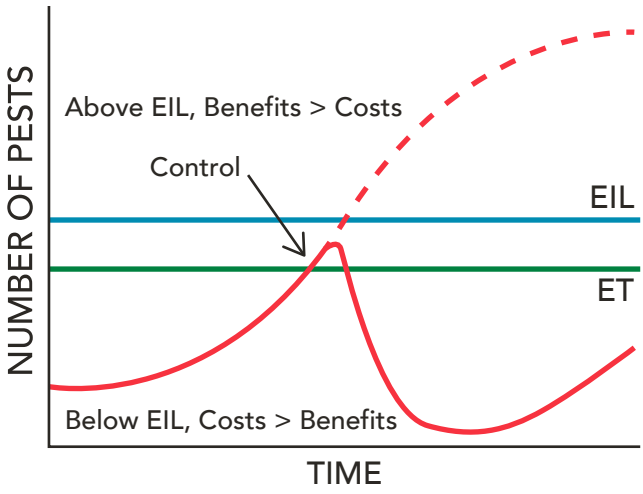
Monitoring helps:

- Determine the level of pest infestation (i.e., insects, mites, rodents, etc.) and disease.
- Determine whether intervention is necessary to prevent colony damage.
- Decide best timing to apply a treatment to reduce pest populations.
- Inform decision-making and avoid unnecessary (prophylactic) treatment.
- Determine what management methods to implement.
- Evaluate how well a treatment worked and if additional treatments may be necessary.
- Slow possible development of pest resistance to treatment chemicals due to unnecessary repeat exposure (treating only when necessary can increase the number of seasons a chemical can be used before resistance develops).
- Reduce possible contamination of hives and the environment by using unnecessary treatments.

Effective monitoring methods vary according to the pest or disease. In some cases, such as for wax moths and small hive beetles, visual inspection of bees, hives, or brood frames is the recommended method. For Varroa mites, proactive sampling methods, like the alcohol wash or powdered sugar shake of a 300-adult-bee sample, are required to accurately estimate pest population levels.

Collecting 300-adult-bee sample from brood frame. Photo Credit: D.M. Caron

Regular monitoring can track changes in pest population levels and indicate when they are above thresholds where treatment is needed. Keeping detailed records is very important when monitoring to help you to determine which management methods are most effective. It is important to monitor both before and after any treatment to determine the effectiveness of the treatment.



EIL: Economic injury level
ET: Economic threshold

WHAT ARE THRESHOLDS?

Thresholds are guidelines that assist the beekeeper in making decisions about when and what to treat. No threshold is absolute; it is a warning that intervention may be needed.

THRESHOLDS

Treatment thresholds have been established for various pests and diseases through research, inspection, and regular monitoring. They are not static and can change as new information becomes available.

Thresholds can be affected by time of year, environment, colony strength, and apiary management. For example, while a colony with brood and a colony without brood may have the same level of Varroa mites on adult bees, the colony with brood may have a much higher total Varroa infestation because many more mites may be located in capped brood cells.

For factual information on pest and disease thresholds that indicate treatment is needed, consult reliable sources, like:

- State extension services
- Major beekeeping associations
- Publications from the Honey Bee Health Coalition

SOLUTIONS

Implementing effective solutions when and where necessary is an integral part of an IPM approach. The focus is to manage the level of pests and diseases in the apiary, not to eradicate them. Effective IPM solutions minimize the spread of pests and diseases, reduce chemical exposure to honey bee colonies, maintain the health of the bees, and provide optimal living conditions within the management of a honey bee operation.

Solutions can include a combination of combination of cultural, mechanical, and genetic practices as well as chemical controls.

Cultural and Mechanical Practices

- Deal with sick hives promptly.
- Don't combine a sick colony with a strong one.
- Isolate sick or weak colonies.
- Use cultural management techniques to help reduce pest threats.
  - Screened bottom boards
  - Drone brood removal
  - Brood interruption methods
  - Darkened, old comb removal

Screened bottom board.
Photo Credit: D.M. Caron

Adding a drone foundation frame for drone trapping.
Photo Credit: D.M. Caron

Genetic Practices

- Employ young, healthy queens.
- Use tested, proven hygienic stock; buy queens and bees from a reliable source.
- Buy locally, if reliable sources are available that demonstrate desired characteristics.

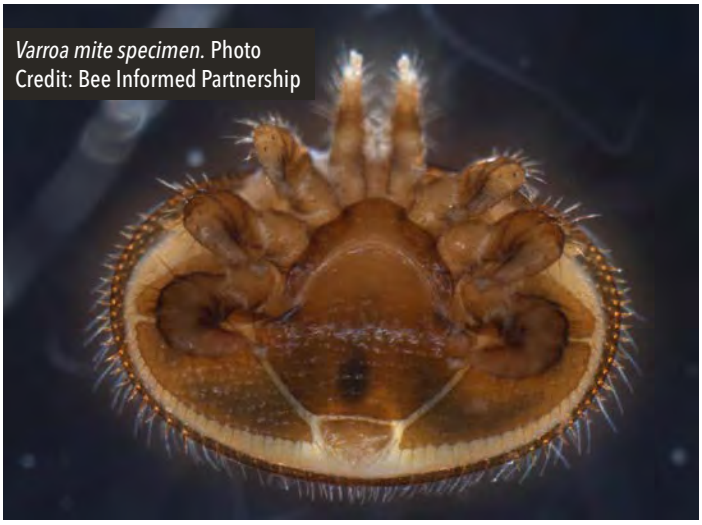
Chemical Controls

- Alternate between different chemical controls when possible; don't rely on any single product to continuously treat for a pest or disease.
  - Follow label directions; both over-treatment and under-treatment can lead to resistance. Failure to follow the label may also result in non-effective treatments.
  - Only apply treatments within the appropriate temperature range listed on the label.
  - Both synthetic and organic chemicals are available to treat many pests.

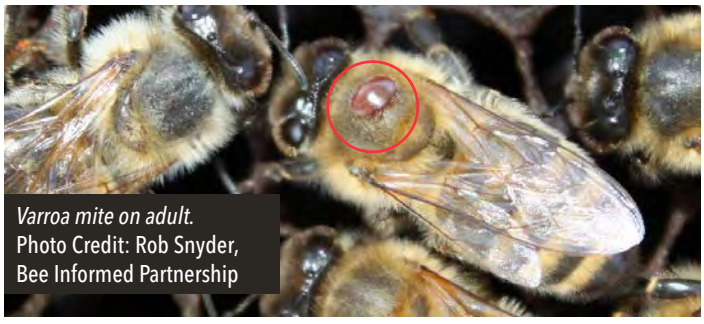
Selecting the most appropriate IPM solutions is based on continuous monitoring of pest and disease levels, both before and after treatments. Test for chemical resistance with synthetic miticides (e.g. the Pettis test for Varroa mite resistance – see the Resources section at the end of this chapter for a link to Pettis test instructions). Keep accurate records to help track changes, and identify trends in pests and disease populations.

MANAGING VARROA WITH IPM

Every honey bee colony in the continental United States and Canada either has Varroa mites today or will have them within several months. Varroa mite infestation represents one of the greatest threats to honey bee health, honey production, and pollination services. When honey bee colonies are untreated or treated ineffectively, colonies can fail, and beekeepers can incur major economic losses. In addition, colonies with high Varroa mite levels are a source of mites that can spread to other colonies, even in other apiaries, through drifting, robbing, and absconding activity of bees.



Varroa mite specimen. Photo Credit: Bee Informed Partnership



Varroa mite on adult. Photo Credit: Rob Snyder, Bee Informed Partnership

All beekeepers should remain vigilant to detect high Varroa mite levels and be prepared to take timely action to reduce mite loads. Effective mite control will reduce colony losses and avoid potential spread of infectious disease among colonies.

Using Apiuard to control Varroa mites. See tools document for how and when to use. Photo Credit: D.M. Caron

IPM is the most effective approach that beekeepers can take to manage Varroa in their colonies. The Honey Bee Health Coalition has developed two in-depth resources to help beekeepers monitor and treat Varroa. Both are available for free on the Coalition's website:

- The *Tools for Varroa Management Guide* explains practical, effective methods to measure and control Varroa mite infestations.
- A set of *How-to Videos* provides practical step-by-step demonstrations on monitoring and controlling varroa mites in your hives.

Consult these resources for accurate information on treating Varroa in your colonies. This chapter provides a brief summary of the information covered in these resources.

KNOWLEDGE OF VARROA

The Varroa mite, *Varroa destructor*, is a parasite that lives on the outside of its host. The mite feeds on the brood and adults of western (European) honey bees, *Apis mellifera*. When left untreated, colonies with high levels of Varroa may die within months. Varroa mites reduce overall colony vigor as well as transmit and enhance diseases, such as honey bee viruses. Varroa, which is present on all continents except Australia and Antarctica, is the most damaging honey bee pest and a major factor responsible for colony losses worldwide.

Varroa on pupae shaken from their cells.
Photo Credit: Bee Informed Partnership

Varroa mite on adult abdomen.
Photo Credit: Bayer

Adult Varroa mites move around the environment by attaching themselves to adult bees. They readily spread among colonies and apiaries through natural drift of workers and drones, robbing of weak colonies by stronger ones, swarming, and absconding, or through human-aided exchange of bees and brood frames between colonies. Mites do not live longer than a few days without their host; so unoccupied bee equipment does not harbor live mites.

Varroa mite populations double about once a month — and even quicker when the colony has large amounts of drone brood or when Varroa are transmitted from neighboring colonies.

Although Varroa feeding on adult bees and brood is serious, their role in transmission of viruses (referred to as viral vectoring) is by far their most negative effect. Some of the more significant viruses transmitted by Varroa can reach epidemic proportion and kill large numbers of adults and even the entire colony. These include: Kashmir Bee Virus (KBV), Israeli Acute Paralysis Virus (IAPV), Chronic Paralysis Virus (CPV), Acute Bee Paralysis Virus (ABPV), Deformed Wing Virus (DWV), Varroa destructor Virus (VDV), and Black Queen Cell Virus (BQCV).

Signs of viral infections:

- Weak colony
- Increased numbers of dead and dying bees and/or brood
- Bees that appear to be trembling and uncoordinated
- Hairless, shiny, greasy-looking adult bees
- Newly emerged bees with opaque undersized appearance
- Small-bodied adults with shriveled, malformed wings

Several signs can indicate Varroa Mite Syndrome (VMS), including too few adult bees to cover brood, spotty brood pattern, dying larvae off color and "snot-like" in appearance, sickly appearing adults, high Varroa mite infestation, mite poop in the cells of emerged bees, and/or immature mites visible in cells.

MONITORING FOR VARROA

Good treatment decisions require an accurate assessment of the Varroa mite population within a colony. Because the population can double in as little as a month, frequent monitoring is important. The Honey Bee Health Coalition recommends that beekeepers use either the alcohol or soap Wash method or the powdered sugar shake method. (See the *Tools for Varroa Guide* and the how-to videos for step-by-step instructions on these methods.) Other monitoring methods — such as drone brood assessment, sticky bottom board, and ether roll — are less precise and don't provide the information needed for treatment decisions.

Monitoring for mites using the sugar shake method. A 300-adult-bee sample is coated with powdered sugar then excess sugar and mites are shaken into the counting container. Photo Credit: D.M. Caron

Inexpensive alcohol wash device: two plastic cups with fabric at the bottom of the top cup. Photo Credit: Scientific Beekeeping

Perform Varroa monitoring assessments at least four times during the year, beginning with the Population Increase phase. During the Population Decrease phase, re-check mite levels to confirm that mite numbers are low going into the Dormant phase. Continue sampling during the Dormant phase, if possible. However, if it is too cold (below 50°F) to safely remove and sample bees from the cluster, wait until milder conditions permit sampling.

Always repeat sampling after treatment to confirm the effectiveness of the treatment that was performed.

With smaller apiaries, every colony can be monitored. For larger apiaries, random sampling of 7 to 10 percent of the colonies would be reasonable. An effective control strategy dictates that treatment will commence if any single colony exceeds threshold.

There are several visual signs of a problematic infestation, but visual inspections don't provide a reliable estimate of potential risk to the colony.

SEE NO EVIL?

Visual inspection for varroa mites on adult bees and brood is NOT effective monitoring.

These signs indicate more frequent monitoring may be needed:

- Decreased colony productivity
- Abnormal or spotty brood pattern
- Abnormal adult behavior (e.g., trembling, twitching, reduced flight activity, robbing)
- Excessive number of dead or discolored, sick, greasy-looking adult bees inside or outside the hive
- Visual sightings of other pests or disease symptoms
- Deformed adult wings and/or brood bodies
- Failure to use supplemental food and/or lack of "normal" honey/bee bread reserves

VARROA THRESHOLDS

Varroa mite thresholds that indicate a need for controls vary according to the colony's population phase. The percentages in the table below (based on using either the alcohol/soap wash or powdered sugar shake methods) represent the best management recommendations from the Honey Bee Health Coalition. Treatment is strongly recommended when mite levels reach the danger levels.

Treatment Thresholds by Phase
(%=Number of mites/100 adult bees)

Colony Phase	Acceptable Further control not needed	Danger Control promptly
Dormant with brood	<1%	>2%
Dormant without brood	<1%	>3%
Population Increase	<1%	>2-3%
Peak Population	<2%	>3%
Population Decrease	<2%	>2-3%

Acceptable: Current mite populations are not an immediate threat.
Danger: Colony loss is likely unless the beekeeper controls Varroa immediately.

Decisions on acceptable level of risk and appropriate interventions can be individualized for each beekeeper with variation based on the beekeeper's management objectives, goals, and systems.

VARROA MITE CONTROL

Several treatment options are available for Varroa mite control. The best practice is to use combinations of treatments and management practices and to alternate treatment methods to help slow the development of chemical resistance in mites. Don't rely on a single chemical or management practice to control Varroa.

When treating an apiary for Varroa mites, treat all colonies in the apiary at the same time once one colony reaches the treatment threshold.

Treatment options include:

1. Synthetic miticides
2. Organic miticides
3. Cultural and mechanical practices
4. Genetic practices

Note: Biological controls for Varroa and the viruses they spread are not yet available. Research on promising avenues for the future includes predacious mites, nematodes, pseudo-scorpions, and fungi.

The *Tools for Varroa Management Guide* provides detailed information on the conditions, timing, and efficacy of various treatments, controls, and practices. The accompanying how-to videos demonstrate application and control techniques.

Here is a summary of the treatment options covered in these two resources.

Synthetic Miticides

- Apivar® (amitraz)
- Apistan® (fluvalinate) Not recommended. Varroa mites are resistant to fluvalinate in most of North America.*
- CheckMite+® (coumaphos) Not recommended. Varroa mites are resistant to coumpahos in most of North America.*

* Before using either Apistan® (fluvalinate) or CheckMite+® (coumaphos), test for resistance via the Pettis test (see the Resources section for a link to instructions), and monitor colonies and mite levels closely. Mite resistance to synthetic chemicals can be avoided by using the product according to its label instructions, diversifying Varroa mite treatments, and following an IPM strategy.

Apivar for mite control.
Photo Credit: D.M. Caron

Organic Miticides

- Essential Oils
  - Apiguard® or Thymovar® (Canada) (thymol)
  - Api Life Var® (thymol + eucalyptol, menthol, and camphor)
- Acids
  - Mite-Away Quick Strips® [MAQS®] of Formic Pro® (formic acid)
  - Formic Acid 65%
  - Oxalic Acid
  - HopGuard® II (hops beta acids)

Cultural and Mechanical Practices

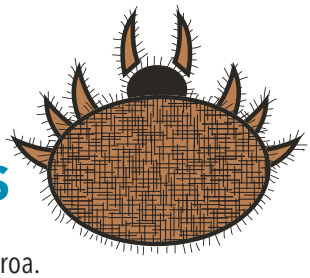
- Drone brood removal
- Brood interruption (includes splits, nucs, indoor overwintering)
- Sanitation (comb culling/biosecurity)
- Screen bottom board
- Heat (106°F (41°C) for four hours) or MiteZapper®

Genetic Practices

- Requeening with resistant stock

Don't use unregistered formulations and products. The efficacy of an unregistered product or the off-label use of a registered product in controlling mites does not indicate that a product has been proven safe for use. This concern applies to bees, the beekeeper, and the public who may consume honey produced from treated colonies.

Cultural, mechanical, and genetic control methods do not require registration. Some are more effective than others. Independent research confirmation of their effectiveness may not exist. These practices alone seldom are sufficient to control Varroa infestations though they can slow the growth of mite populations. The list above provides more reliable mite controls.



SEASONAL SUMMARY: VARROA MITES

The table below organizes IPM cultural control, monitoring, and chemical control strategies by season for Varroa.

<table>
<tr><th></th><th>Late Winter/ Early Spring</th><th>Spring Buildup</th><th>Major Nectar Flow</th><th>Harvest</th><th>Fall</th><th>Late Fall</th></tr>
<tr><td rowspan="3">Cultural Control</td><td rowspan="2"></td><td>Drone brood</td><td colspan="2">Break brood cycle</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Removal</td><td colspan="2">Heat</td></tr>
<tr><td colspan="4">Season long hygienic and disease-resistant stock</td></tr>
<tr><td colspan="5">Screened bottom board</td><td></td></tr>
<tr><td>Monitoring</td><td>Begin sampling of suspect colonies.</td><td colspan="2">Sample 10% of colonies/apiary with alcohol wash or sugar dusting.</td><td>Sample post-harvest.</td><td>Sample every 2-4 weeks.
Perform Pettis test for resistance.</td><td>Continue to sample until season closes.</td></tr>
<tr><td>Chemical Control</td><td colspan="2">If sampling exceeds 2-3% diversify treatments; Apivar, formic acid (MAQS, Formic Pro), thymol (Apiguard, Api Life Var).</td><td>Resample after treatment</td><td colspan="2">Alternate with spring organic (acid or thymol) and synthetic Apivar chemical treatment. If sampling shows any colony >2-3%.</td><td>Oxalic acid on broodless colonies if 2-3% exceeded.</td></tr>
</table>

KEY POINTS TO REMEMBER

- The focus of IPM is to manage pests and diseases, not to eradicate them.
- The four main components of an IPM approach are knowledge of pests and diseases, monitoring, using thresholds, and implementing solutions.
- Stay up-to-date on what pests to look for and the risks they pose to honey bee colonies.
- Monitor for pests and diseases regularly, both before and after treatments. Use this information to drive management and treatment decisions.
- Thresholds are dynamic and may change as new research suggests.
- A combination of control options, including organic and synthetic chemicals, cultural and mechanical practices, and genetic practices should be used to manage Varroa mites.
- Alternate between different chemical controls; don't rely on any single product to treat for a pest or disease.
- Alcohol/soap wash and powdered sugar shake are the most accurate monitoring methods to determine Varroa mite levels.
- Use the Honey Bee Health Coalition's *Tools for Varroa Management Guide* for recommendations when considering Varroa control options.
- Never use unregistered or off-label Varroa control products.

RESOURCES

IPM

What Is IPM? (A one-page infographic from the Entomological Society of America)
http://www.entsoc.org/sites/default/files/files/Science-Policy/ESA-Factsheet-IPM.pdf

Integrated Pest Management for Beekeeping in Ontario Manual from the Ontario Beekeepers' Association Technology Transfer Program (2013)
https://www.ontariobee.com/outreach/manuals-books-dvds

UNDERSTANDING VARROA

Varroa Mite Reproductive Biology by Zachary Huang at Michigan State University (2013)
http://www.extension.org/pages/65450/varroa-mite-reproductive-biology#.Vbgvu7BFBjp

Honey Bee Viruses, the Deadly Varroa Mite Associates by Philip A. Moore, Michael E. Wilson, and John A. Skinner at the University of Tennessee (2014)
http://www.extension.org/pages/71172/honey-bee-viruses-the-deadly-varroa-mite-associates#.VbgmtLBFBjo

SAMPLING AND TREATMENT

Tools for Varroa Management guide and how-to videos from the Honey Bee Health Coalition
http://www.honeybeehealthcoalition.org/varroa

Standardized Sampling Plan to Detect Varroa Density in Colonies and Apiaries, by Katie Lee, et al., from the University of Minnesota, (2010). American Bee Journal. 150: 1151-1155
https://articles.extension.org/mediawiki/files/6/6d/Standardized_Varroa_Sampling_Bees.pdf

Powder sugar sampling one-page tutorial with photos from the University of Minnesota
https://articles.extension.org/mediawiki/files/e/e1/VarroaMites_155.pdf

Alcohol mite-washing device tutorial from Richard Oliver at Scientific Beekeeping
http://scientificbeekeeping.com/an-improved-but-not-yet-perfect-varroa-mite-washer

Easy-to-Use Bioassay Spots Varroa Resistance (Pettis Test) by Jan Suszkiw, USDA Agricultural Research Service
https://agresearchmag.ars.usda.gov/ar/archive/2005/apr/varroa0405.pdf

University of Minnesota Bee Lab
https://www.beelab.umn.edu/bee-squad/resources-beekeepers/varroa

Mid-Atlantic Apiculture Research and Extension Consortium
https://agdev.anr.udel.edu/maarec/educational-resources/powerpoints

Some books and guides on Varroa are outdated with threshold and control recommendations, but most supply accurate information on Varroa life cycle and biology. Particularly helpful:

Splits and Varroa: An Introduction to Splitting Hives as Part of Varroa Control by William Hesbach (2016)

Varroa: Still a Problem in the 21st Century? by various authors, edited by Norman Carreck, published by the International Bee Research Association (2011)

Diagnosing Bee Mites by Diana Sammataro, published by Northern Bee Books (2014)

A Field Guide to Honey Bees and their Maladies by Maryanne Frazier, Dewey Caron, and Dennis vanEngelsdorp, Mid-Atlantic Apiculture Research and Extension Consortium (2011). Pub. AGRS-116. 98 pp. (A field guide essential for all beekeepers with excellent photos for identification of diseases and pests.)

Beekeeping journals and websites have extensive information on Varroa monitoring and control. Be cautious of so-called solutions that seem too simple or claim great success.

CHAPTER 6: OTHER PESTS AND DISEASES

American foulbrood (AFB).
Photo Credit: Rob Snyder, Bee Informed Partnership

The principles of integrated pest management (IPM) and how IPM applies to Varroa mite control were introduced in Chapter 5. This chapter covers control of other diseases and bee pests.

The diseases and bee pests covered in this chapter include:

- American foulbrood (AFB)
- European foulbrood (EFB)
- Chalkbrood
- Sacbrood
- Nosema
- Honey bee tracheal mites (HBTM)
- Wax moths
- Small hive beetles (SHB)
- Other insects/spiders
- Rodents and small mammals
- Large mammals
- Birds

Beekeepers need to know what pests to look for, how to find them, and the risks they pose to honey bee colonies. Most general books and online resources on beekeeping have a section on bee diseases and pests, but make sure the information you consult is up-to-date.

Accurate, prompt diagnosis of pests and diseases helps ensure colony health and productivity. Perform regular visual inspections of the apiary, the colony exterior, and brood frames to identify brood diseases, potential pest problems, population changes, queen problems, and other irregularities.

IRREGULARITIES?
Not all abnormalities are disease or pest related.

Pesticide damage (Chapter 4), queen replacement events (Chapter 7), and declines in forage and nutrition (Chapter 8) may closely mimic diseases and pests, especially situations where the pest is not continuously present or readily identified. Distinguishing such situations, which often require no intervention, will take practice and experience.

SIGNS OF DISEASES AND PESTS

Different pests and diseases have their own monitoring procedures, and beekeepers should understand what normal looks like and know when and how to look for pests and diseases. If diagnosis includes collecting samples for laboratory confirmation, make sure they are timely and properly handled.

DISEASES

American Foulbrood (AFB)

American foulbrood (AFB) is a disease caused by the bacterium *Paenibacillus larvae*. AFB usually leads to the eventual death of infected colonies. It's important to catch AFB as early as possible (i.e., when there might be only a few infected cells) to avoid it spreading to other colonies.

Inspect capped brood on frames in the brood nest to identify initial signs of AFB.

- At a minimum, inspect for AFB in spring and fall. Also check for signs of AFB any time capped cells of brood nest frames can be examined visually.
  - In the population expansion phase (spring), the strongest colonies are the most likely to become infected.
  - As the disease progresses, colonies infected with AFB will be more readily detected at population peak or at population decline (fall).
- A colony light on adult bee coverage or brood density is not normal, and AFB should be considered a possible factor.

Field signs of AFB

- Colony weakness (a general characteristic that can apply to many stressors)
- Brood cappings that are greasy and sunken with puncture holes (perforations)
- Foul odor (distinctive smell – not the usual sour smell of dead brood)
- Dead, decaying larvae or prepupae/pupae light to dark brown, elongated in cells with decomposing remains gluing to lower cell wall.
- A "false" tongue – mouthparts stretching from lower cell wall to top cell wall (not always present).
- Presence of scales on lower cell wall that are hard to remove when the dead larvae fully dehydrate.

Perforations in capped brood. Photo Credit: Rob Snyder, Bee Informed Partnership

Dead larvae infected with AFB. Photo Credit: Rob Snyder, Bee Informed Partnership

AFB scale, or fully dehydrated dead larvae. Photo Credit: Rob Snyder, Bee Informed Partnership

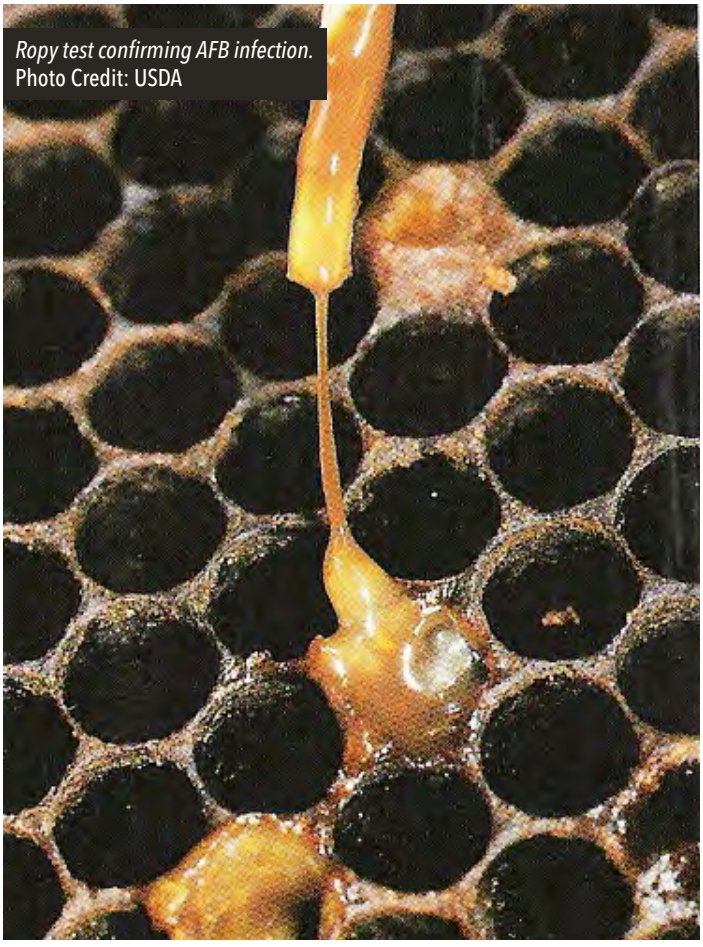
Confirmation of AFB

DO NOT DELAY

ALWAYS get confirmation of AFB as soon as possible; don't delay.

Since AFB is not common and requires immediate attention, confirm any initial diagnosis made using field signs. Three confirmation possibilities are:

1. Conduct the "ropiness" test.
    - Use a small stick or toothpick to swirl the contents of a cell of dead brood, and withdraw it slowly. If a ropy mass strings out up to an inch in length (2.5 centimeters) then snaps back (as in "pulling taffy"), the cell is a positive for AFB.
    - The "ropiness" test is unique to AFB; other dying brood will not rope out.



Ropy test confirming AFB infection.
Photo Credit: USDA

2. Use an AFB diagnosis kit (like a home pregnancy test) available from many bee suppliers.

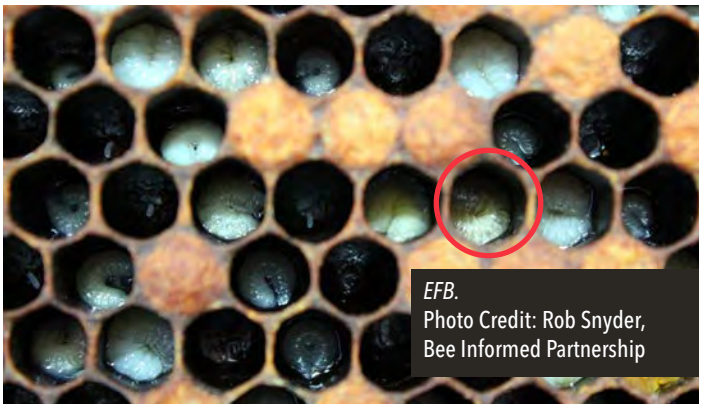
AFB test kit .
Photo Credit: Vita Bee Health

3. Have a lab confirm presence of the AFB bacterium pathogen.
    - Take a sample of suspect brood by cutting out a piece of comb or thoroughly coating a stick or toothpick with the decaying body contents of one or more suspect cells.
    - Put in paper (not plastic or aluminum foil), and send to a lab. Be sure to include return contact information.

Some states have a diagnostic lab that will do AFB analysis of comb or stick/toothpick smears. In some beekeeping clubs and associations, there are individuals who have experience and microscopes that might confirm the bacteria pathogen presence. Private labs will do the analysis for a fee. Anyone can send a sample to the USDA Bee Lab in Beltsville, Maryland. See the Resources section at the end of this chapter for the address.

European Foulbrood (EFB)

European foulbrood (EFB) is a disease caused by the bacterium *Melissococcus plutonius*. It is less serious than AFB. Field signs are different, but on casual examination or for those unfamiliar with brood diseases, EFB disease might be confused with AFB.



EFB.
Photo Credit: Rob Snyder, Bee Informed Partnership

EFB generally appears under conditions of nutritional stress. There seems to be a correlation with certain crops such as blueberry and cranberry and the condition termed bee PMS (Parasitic Mite Syndrome – often re-termed VMS for Varroa Mite Syndrome).

Monitor for EFB during population buildup (spring). In the fall, it is more commonly seen with snot-like (cruddy), spotty brood condition of VMS. Look for EFB in the uncapped brood of weaker colonies or poorly performing colonies alongside stronger units and any time you look at the brood frames of a brood nest.

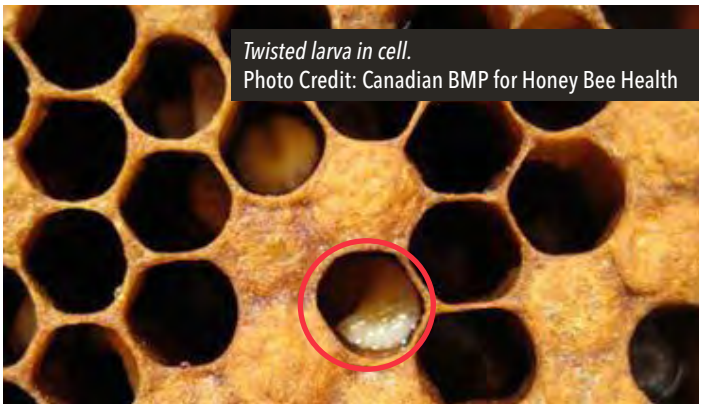
Scattered "shotgun" brood pattern EFB.
Photo Credit: Bee Informed Partnership

Field Signs of EFB

- Discolored larvae (yellow streaking to light yellow-brownish)
- Dying larvae twisted in the cell (in corkscrew fashion)
- Larvae with prominent yellowing/silvery tracheal tube appearance
- No 'roping" of decomposing remains
- Sour odor (but very subtle)
- Dying/dead larvae easily removed – no scale formation as dead larvae dehydrate

Confirmation of EFB

Samples for laboratory analysis are taken the same as for AFB. Use a test kit specific for EFB.



Twisted larva in cell.
Photo Credit: Canadian BMP for Honey Bee Health

Chalkbrood

Chalkbrood is a disease caused by the fungus *Ascosphaera apis*. Incidences of chalkbrood may be more prevalent during colony stress and wet spring months. High incidences usually indicate poor hygienic behavior, stress due to weather, poor management, or co-infection with other diseases. There is a genetic predisposition to chalkbrood infection; such colonies have heavier infestations while others may have lighter effects or no apparent disease.

Chalkbrood is most commonly seen during colony expansion (spring) and during colony decrease (fall), especially associated with snot-like (cruddy) brood condition.

- Before opening a colony, look for infected dead brood mummies at the entrance, on landing boards, and/or in front of colonies. Confirm sightings outside by examining brood frames inside colony.
- Examine open brood cells in colonies showing nutritional stress, in poorly performing or weaker colonies, or any time you look at frames of brood nest.

Chalkbrood.
Photo Credit: Canadian BMP for Honey Bee Health

Field Signs of Chalkbrood

- Mummified larvae not yet removed from cells with a hardened off-white grayish color (sometimes black) and elevated "nipple" appearance
- Chalkbrood mummies in front of the hive or at colony entrance on the landing/bottom board
- Dead brood that may "rattle" in frame and, when removed, dehydrated larvae that look like tiny chalk nubbins

Chalkbrood mummies on entrance landing board and ground.
Photo Credit: Rob Snyder, Bee Informed Partnership

Sacbrood

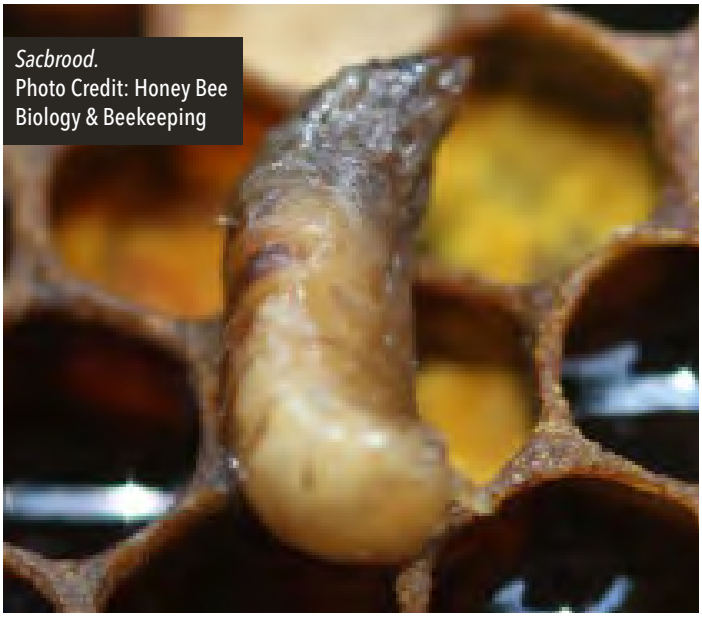
Sacbrood is a disease caused by the sacbrood virus. It affects both brood and adults, but adults with the disease are asymptomatic. Examine colonies during colony expansion or decrease (spring or fall), especially in weaker or poorly performing colonies or any time you examine brood frames.

Field Signs of Sacbrood

- Affected larvae disintegrate into a brown watery sack that is held together by the leathery larval outer skin.
- Head (outer) end of decaying larvae are darker in color.
- Decaying larvae are easily removed with distinctly sac-like appearance.

Confirmation of Sacbrood

Sample for lab analysis to confirm suspected disease cells are not AFB or EFB. Take samples the same way as for AFB. There is no sacbrood test kit.



Sacbrood.
Photo Credit: Honey Bee Biology & Beekeeping

Nosema

Nosema (*nosemosis*) is a fungal disease that infests the midgut of adult bees. It is caused by two different species of microsporidian, *Nosema apis* and *Nosema ceranae*. The latter has apparently displaced *N. apis* in North America. Much of the literature on nosema refers to *N. apis* and may not be relevant to *N. ceranae*. Field symptoms of nosema disease are rather generalized.

Heavy fecal spotting at colony front. Photo Credit: Canadian BMP for Honey Bee Health

Field Signs of Nosema

- Fecal discharge (diarrhea) inside the hive on the tops of frames as well as outside on covers and the front of the hive (more common with *N. apis* than *N. ceranae*)
- Slow spring buildup of colonies when infection is elevated (more than 1 million spores/bee average)
- Crawling, trembling bees at entrance, in front of colony, and on top bars when colony is opened
- Low honey production
- Queen replacement (supersedure) behavior

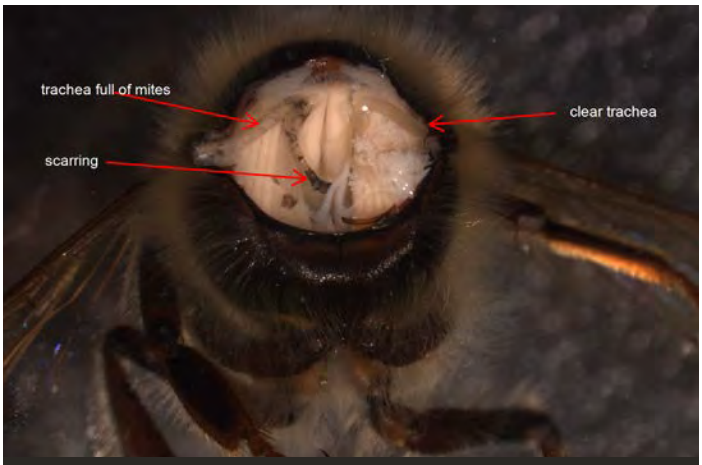
Confirmation of Nosema

Laboratory diagnosis is needed to confirm nosema disease and determine a level of infection.

- Collect a sample of 50 to 100 adult bees from the entrance or honey frames in a jar with 70 percent alcohol.
- Send the sample to a laboratory equipped for nosema analysis.

Honey Bee Tracheal Mite (HBTM) or Acarosis

Tracheal mites (*Acarapis woodi*) live and reproduce within the respiratory (tracheal) system of adult bees; close relatives live on the exterior of the bee. There are few distinctive signs for field determination of a tracheal mite infestation. Unlike Varroa mites (Chapter 5), tracheal mites are not visible with the naked eye.



Adult thorax opened to reveal thoracic trachea HBTM shown in left tube. Photo Credit: Oregon State University

Infested (top) and normal (bottom) thoracic trachea. Photo Credit: USDA

Field Signs of HBTM

- Slow population buildup
- Adult bees crawling in front of the hive, uncoordinated, and incapable of flight
- Adult bees not folding wings one over the other (wings held partially folded, approximating a K-Wing appearance)
- Lethargic bee movement
- Thoracic tracheal darkened and not "healthy" looking upon dissection

K-Wing adult. Photo Credit: Rob Snyder, Bee Informed Partnership

Confirmation of HBTM

- Collect a sample of 50 to 100 adult bees from the entrance or honey frames in a jar with 70 percent alcohol.
- Send the sample to a laboratory equipped for HBTM analysis.

Other Brood Diseases

Other brood diseases may appear from time to time. In many cases, they don't cause significant losses. If you see a small number of damaged brood cells, continue to monitor to see if signs of a more significant infection appear.

PESTS

INSECTS

Wax Moth

Larvae of several moth species can damage unoccupied brood comb or weak colonies. Two species, greater wax moth (*Galleria mellonella*) and lesser wax moth (*Achroia grisella*), are the most serious. Pest moths are usually present in all colonies, but honey bees typically keep the destructive caterpillar stage under control. It is not possible to keep adult moths out of colonies as adults fly at night.

Examine stored brood combs periodically, especially if the storage area is heated, looking for silken tunnels and wax moth activity. Look in weaker colonies for evidence of silken tunnels, especially on outside frames not actively occupied by bees. Wax moth caterpillars or webbing occurs in frame where brood occurs or was reared and not in the honey super combs. To confirm the wax moth caterpillar, look for "prolegs" in addition to the three pairs of functional legs on white elongate caterpillars.

Adult wax moth. Photo Credit: Bee Informed Partnership

Wax moth tunnels. Photo Credit: Honey Bee Biology & Beekeeping

Field Signs of Wax Moths

- Webbing tunnels with black fecal caterpillar droppings
- White caterpillars within web tunnels
- Thinned areas of brood cappings or removal of several worker/drone brood cappings (usually in a straight line)
- Tunneled holes in wax with webbing and debris (usually in a straight line)

Wax moth caterpillars on their silk. Photo Credit: Rob Snyder, Bee Informed Partnership

Small Hive Beetle (SHB)

Small hive beetles (*Aethina tumida*) need to be detected with a colony inspection. Immediately upon opening the colony, look for adult SHB on the underside of the inner cover and the tops of frames before the beetles quickly disperse and hide. In heavy infestations, SHB grubs will accumulate on the bottom board, and slime may ooze out of hive boxes and stain them. Look for damage of slimy comb and fermenting honey stores, usually at the edges of occupied combs in which larvae of various sizes will be evident. Inspect weaker colonies, looking for evidence of slimming. Look on "wet" comb for beetle larvae. Use inexpensive, commercial, oil-reservoir beetle traps inside hives to monitor for adult SHB presence.

Adult small hive beetles (SHB).
Photo Credit: Honey Bee Biology & Beekeeping

Field Signs of SHB

- Visual sightings of adult beetles in the hive
- Beetle larvae seen clustering to feed on the comb or on bottom board or seen exiting the hive en masse to pupate in the soil
- Slime of fermented honey running down frames within or on the edge of brood sphere
- Slimy combs with larvae of many ages very evident within cells in slimed areas

Small hive beetle larvae with slime. Photo Credit: Clemson University

Confirmation of SHB

Confirm any findings of adults or larvae. There are many related scavenger beetles that commonly occur in bee hives. Larvae will have legs (unlike fly maggots) but only three pairs of segmented legs behind the head (no prolegs unlike wax moths). The legs may be tiny, and larvae will vary widely in size from smallest to largest.

Other insects

Scavenger flies, beetles, earwigs, etc. (including over 40 mite species) may be found in front of colonies, on bottom boards, and within dying or recently dead colonies, such as when there is a pile up of dead adults due to a pesticide kill or starvation event in a colony. Scavengers may be encountered in the spring before a colony expands to use its full hive.

Predatory flies, bugs, dragonflies, praying mantises, and other insects (and predatory arthropods such as spiders) capture guard and undertaker bees around colony entrances and foragers flying near colonies and foraging sites. Unless uncommonly numerous, they do not significantly harm a hive population. One exception is predation on virgin queens exiting hives for mating flights. Control of the insect is seldom feasible, and moving the hive might be needed.

RODENTS AND SMALL MAMMALS

Rodents include mice, rats, and squirrels, and small mammals include shrews, moles, skunks, raccoons, and opossums. The most serious rodent pest is the mouse, which enters hives to construct a nest; the remainder enter the colony for shelter (shrews, moles) or to get into stored bee equipment (squirrels) or feed on adult bees from outside the entrance.

Look for gnawing (rodents) at entrances, debris within the bottom box, or signs of mammal activity outside the entrance, such as cleared vegetation and muddy scratches (skunks). Snakes like to stay cool underneath hives, so keeping vegetation down will help control reptiles such as snakes, too.

LARGE MAMMALS

Larger mammals (livestock, humans) are incidental hive pests that may disturb the hive or knock boxes off bottom boards. Bears enter colonies to feed on honey and brood. Diagnosis may take some investigation to affix responsibility.

PEST AND DISEASE THRESHOLDS

Few specific thresholds have been established for bee pests and diseases other than Varroa mites. However, it is far easier to control a pest or disease pathogen at a lower level than at higher, epidemic levels. Thresholds requiring control vary depending on the time of the year, colony strength, apiary location, and beekeeper goals/expectations.

Colonies can tolerate pests, diseases (except AFB), and the damage caused by them at lower levels. However, the number of pests or level of disease can reach a point where economic injury exceeds the cost and time to control such outbreaks, indicating control is warranted. Control might make sense both for economic and bee health reasons.

AFB: Any active AFB infection requires action. Implement control measures immediately following confirmation, as the disease is highly contagious.

Nosema: In general, infection levels of one million or more spores per bee in a sample might trigger treatment. However, this threshold is based on infections with *N. apis* and may not reflect the current knowledge and understanding of nosema infections since *N. ceranae* has largely replaced *N. apis*.

HBTM: When honey bee tracheal mite infestations equal 10 percent or more of sampled adults, treatment is recommended.

Varroa mites: See Chapter 5.

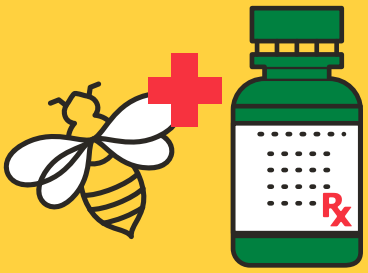
The treatment thresholds listed above assume that only one parasite or disease is present. When colonies are infected with more than one parasite or disease, colonies may be more at risk, and treatment thresholds lower.

PEST AND DISEASE CONTROLS

Treat honey bee diseases and pests with only pesticide and antibiotic products that are legally registered for use in honey bee colonies. When using registered products, always follow the directions on the product label. Proper treatment application will help minimize potential collateral colony damage and maximize treatment efficacy. Following directions will also delay the time before the target disease or pest develops chemical resistance.

Improper and prolonged use of pesticide and antibiotic treatments can leave residues in hive products (e.g., wax, honey). Rotate chemical applications, and use them according to the label directions to reduce the likelihood of residues accumulating.

Genetic, cultural, and physical control methods do not require registration. They may help diminish the risk of chemical contamination, but independent research confirmation of their effectiveness may not exist.



FIND A BEE VET

All medically important antibiotics to be used in feed or water for honey bees require a Veterinary Feed Directive (VFD) or a prescription. Antibiotics are no longer available from commercial sources. Most state veterinary guidelines specify that veterinarians must diagnose a disease condition before providing a prescription for purchase of an approved antibiotic. The Honey Bee Veterinarian Consortium offers a 'Find a Vet' feature for beekeepers.

AFB

Treatment of active AFB infestations is subject to specific laws in most states. Most apiary regulations require immediate destruction of bees, brood, and honey frames of a colony confirmed to have AFB. Where burning is prohibited, kill the adults, and double-bag all bees, and frames and promptly bury them in an approved landfill. Boxes, covers, and tops can be cleaned thoroughly and then lightly torched before reuse. In some states and provinces, colony destruction may be done by officials or be the responsibility of the beekeeper. See the Honey Bee Health Coalition website for links to individual state regulations.

If you confirm AFB in your apiary, notify your state apiary inspector. This information helps them address AFB outbreaks.

Antibiotics registered for the control of AFB include oxytetracycline (Terramycin®), tylosin tartrate (Tylan®), and lincomycin hydrochloride (Lincomix®), but the latter is seldom used. Beekeepers have routinely treated colonies with oxytetracycline (Terramycin®) in both spring and fall. However, there is widespread resistance of the AFB bacterium to this antibiotic. Tylan® is permitted when AFB is actively present in a hive. It should be used only once annually as it has a considerably long half-life (period of effectiveness).

A brand of the antibiotic tylosin
Photo Credit: Elanco

Any treatment with antibiotics can only be done with a prescription or veterinary feed directive (VFD) from a veterinarian. The prescription or VFD is also required to purchase the antibiotic.

Recommendations for AFB prevention include:

- Re-queen colonies with hygienic genetic stock.
- Replace two to four older dark brood frames (or 20 percent) annually with foundation or drawn comb.
- Disinfect deadout colonies with gamma irradiation, and decontaminate boxes and equipment through scorching.
- Clean wax and propolis off hive tools, smokers, and gloves, and disinfect (with bleach solution or alcohol) when moving from one colony or one apiary to the next.
- Avoid purchasing used beekeeping equipment unless it has been inspected by someone who has experience with AFB scale. AFB scales with bacterial spores in the comb can lead to active AFB disease even after years in storage.
- Reduce colony entrances, and/or use robbing screens to reduce robbing of live colonies.

Robbing screen.
Photo Credit: Eric Mussen

EFB

EFB can be controlled by removing, and in serious infestations burning, infected comb and replacing it with clean comb or new foundation frames. This can be done in conjunction with antibiotic treatment using oxytetracycline.

Terramycin antibiotic requires a veterinarian prescription.
Photo Credit: University of Georgia

Practices that help prevent EFB include: re-queening every one to two years, replacing brood frames after five years, preventing robbing, keeping yards clean of old equipment, and feeding hives directly rather than via open or barrel feeding. Establish hospital or quarantine yards for EFB-infected colonies until they can be treated or destroyed.

If feeding honey and pollen, both should be clean and disease-free. Clean and disinfect hive tools, smokers, and gloves after each inspection, and clean bee suits regularly.

Chalkbrood

No registered treatment exists for chalkbrood. To reduce the likelihood of this fungal disease:

- Maintain strong, healthy colonies.
- Replace infected combs with new comb.
- Provide good colony ventilation.
- Requeen colonies showing higher levels of diseased larvae with hygienic genetic stock.

Chalkbrood usually goes away on its own. If it doesn't, requeening may be necessary to interrupt the brood cycle. Keeping hives dry and well ventilated may also help.

Sacbrood

No registered treatment exists for sacbrood. To reduce the likelihood of this viral disease:

- Effectively control Varroa mites.
- Maintain strong, healthy colonies.
- Replace infected combs with new combs.
- Re-queen colonies with hygienic genetic stock.

Sacbrood infestations do not generally cause significant losses.

Viruses

No registered treatments exist for honey bee viruses. Maintain strong, healthy colonies, control Varroa mites and nosema, and requeen with hygienic genetic stock. Burn deadout combs.

Disinfect equipment used for queen rearing, or use brand new equipment. This includes queen cups, grafting tools, and grafting bars.

Nosema

The only chemical registered for the control of the fungal disease nosema (nosemosis) is the antibiotic fumagillin. This product is **not currently** available for purchase, so there is no registered anti-fungal treatment material **at this time**. Nosema treatment options need to be updated in light of current knowledge of nosema ceranae infections.

Fumagilin B (not currently available) .
Photo Credit: Medivet

Non-chemical control recommendations for nosema include:

- Reduce moisture in the hive.
- Improve air circulation, ensuring proper nutrition.
- Requeen colonies.
- Cull old frames to reduce nosema spores in the hive.
- Control Varroa.
- Reduce overall colony stress.
- Disinfect frames and comb with irradiation, acetic acid, or ozone to kill nosema spores.
- Disinfect mating nucleus (nuc) colonies to prevent the spread of nosema to queens.
- Select young nurse bees from healthy colonies free of nosema infections as queen attendants.

Tracheal Mites

Tracheal mites can be controlled using formic acid, either in 65 percent liquid form or with commercially available Mite Away Quick Strips® (MAQS®). Other recommendations include requeening with tracheal-mite-resistant genetic stock.

Wax Moths

Para-dichlorobenzene or PDB (Para-Moth® insecticide) is a pesticide registered for controlling wax moths in stored colony equipment. The product should not be used in living colonies and, when used on stored equipment, should only be used in well ventilated areas.

Cultural control measures include:

- Use resistant strains of honey bees; while such bees are not specifically resistant to wax moths, their resistance to other diseases and pests makes colonies more vigorous and less vulnerable to wax moth infestations.
- Put brood combs into a freezer for 24 to 48 hours, and then bag in heavy trash bags to minimize wax moth damage.
- Before storage, separate dark brood comb from lighter comb and comb that has only been used for honey storage to reduce the attractiveness of stored comb to caterpillars.
- Comb only used for honey storage does not need to be protected, but good air circulation within and around stored frames of supers is helpful.
- Reduce the length of time that comb is stored to reduce the likelihood that it will attract moths.

Reducing exposure to pesticides used in agricultural and residential settings can render colonies less vulnerable to wax moths.

Small Hive Beetle

The only chemical product registered for in-hive control of small hive beetles is coumaphos. As discussed in Chapter 5, coumaphos (CheckMite+®) has become largely ineffective for controlling Varroa mites due to mite resistance. Many traps are available that are designed to capture SHB adults and larvae within the colony. While these traps may reduce adult beetle populations, they will not eliminate infestations, so such traps are more effective as monitoring tools rather than as treatments.

Maintaining strong, healthy, populous colonies and practicing good biosecurity are the best defenses against small hive beetles.

To reduce SHB:

- Maintain strong, healthy, populous colonies.
- Keep Varroa populations below thresholds.
- Address queen replacement issues early.
- Reduce comb surface area that is not covered by a hive's population.
- Promptly remove deadout equipment from the apiary as well as wax scrapings and debris.
- Keep honey houses clean, and promptly handle supers awaiting extraction within three days of removing them from the hives.

- Clean honey spills immediately.
- Separate any harvested frames with brood quickly, and return them to strong colonies.
- Maintain honey house relative humidity below 50 percent, and store wax cappings in beetle-tight containers.
- Following extraction, freeze super frames at 10°F (-12°C) for 24 hours or keep them in a cold room (under 48°F (9°C)) for eight days to kill SHB adults and larvae.
- Place a lamp on the ground to attract larvae, and then kill them.

Yellow Jackets, Hornets, and Wasps

Yellow jackets are serious scavengers that may hasten the demise of weak or failing colonies, especially in the fall in the Pacific Northwest. European hornets may predate on colonies in the East or Midwest.

Control steps include:

- Trap newly emerged wasp queens in the spring via pheromone baited commercial traps.
- Search for and destroy larger nests near the apiary to reduce eventual scavenging pressure mid-summer into fall. Specific hornet and wasp aerosol pesticides will eliminate nests, but protective gear and precaution is needed to avoid stinging.
- Summer and fall trapping with fermenting sweet juices will result in impressive capture numbers but may not significantly reduce predation. Increasing the number of traps is helpful.
- Reduce entrances to enable guard bees to better protect a colony.
- Reduce colony inspections and cover any boxes removed to deny wasps entry.
- Use syrup feeder that can be enclosed inside top coverings or Boardman feeders within the hive itself – avoid entrance feeders and open feeding.

Baited pesticide traps are illegal and not recommended.

Yellow jacket.
Photo Credit: D.M. Caron

Carpenter ant.
Photo Credit: D.M. Caron

Trapping yellow jackets.
Photo Credit: D.M. Caron

Ants

Ants can be persistent hive pests. Some smaller-bodied (sugar) ants nest within the hive (bottom boards or within covers). Other species nest beneath hive stands, and carpenter ants will even nest in wooden parts. Several harvester ant species will attack a hive to kill adult bees and remove their stores. Smaller hives may not be able to fully defend against ants feeding on the bees and/or their honey.

To control ants:

- Establish hives on hive stands that include a motor oil/grease barrier between the ground and the hive to discourage ant nesting within hives and predatory ants.
- Clear vegetation from around colonies.
- In extreme cases, move hives. Sometimes moving only a short distance may reduce ant problems.
- Use ground insecticides to eliminate ants or their nests. Be careful to avoid contaminating hive parts with pesticide.

Birds

Several insectivorous birds may predate on bees as they forage or take orientation flights outside the colony. Bird control is not usually legal. In most cases, predatory bird species feed on only a small number of bees and are not a significant threat. If birds are eating significant numbers of bees, moving the hives might be the best control.

Mammals

To prevent small mammals such as mice from entering colonies:

- Reduce nest entrances.
  - Plastic or cement hive bottoms or bodies or metal entrance reducers might be a better option than wooden equipment, as rodents will often gnaw on wooden parts to reenter.
  - Clear vegetation, elevate colonies, or position tack strips before the entry area to deny skunks and raccoons access to the hive entrance.
- These animals can be drawn to baited traps (live or leg traps) placed within the apiary.
- Moving hives or fencing to keep these mammals out will also be useful.

Exclude large mammals, such as livestock, from the immediate hive entrance by fencing. Electric fencing is necessary to exclude bears and should be installed before any bear incidents. A few states compensate beekeepers for fencing costs while others help with the elimination or removal of individuals that attack hives.

Mouse nest in hive.
Photo Credit: D.M. Caron

Humans

Humans knock over hives as vandalism or to steal honey frames and supers, entire apiaries, and/or genetic stock (i.e. queens). Secure apiary sites are recommended. Proper permission for establishing apiary sites, gated entries, and labeling of hive material may help reduce losses or help recovery of stolen hive material. There are several methods for marking hive equipment from branding to surveillance systems to electronic implants.

Human vandalism.
Photo Credit: D.M. Caron

SEASONAL SUMMARIES

The tables below organize IPM cultural control, monitoring, and chemical control strategies by season for four major diseases and pests.

American Foulbrood	Late Winter/ Early Spring	Spring Buildup	Major Nectar Flow	Harvest	Fall	Late Fall
Cultural Control	Cull 2-4 dark/older frames from brood chamber.	Keep apiaries tidy, remove deadout, and consider equipment sterilization.	Use hygienic and disease-resistant stock and avoid robbing.		Avoid robbing. Practice good biosecurity and sterilize tools/equipment regularly.	
Monitoring	Regularly inspect brood frames, observe colony for weakness and greasy, sunken and perforated cappings, smell for foul odor, and watch for brown unremovable scales in cell bottom. Conduct ropiness test or use AFB test kit on suspicious larvae.				Perform final brood inspection for suspicious cappings.	
Chemical Control	Treat colonies with tylosin or oxytetracycline with veterinarian prescription. If AFB isconfirmed, burn and shake frames and scorch boxes, bottoms, and covers according to state guidelines.					

Nosema	Late Winter/ Early Spring	Spring Buildup	Major Nectar Flow	Harvest	Fall	Late Fall
Cultural Control	Cull 2-4 frames from brood chamber.	Reduce moisture and improve air circulation. Feed colonies to stimulate brood.	Use hygienic and disease-resistant stock and reduce colony stress.	Ensure proper nutrition and winterize colonies.		
Monitoring	If possible, sterilize deadout brood frames.	Observe for proper spring buildup and feed to stimulate brood.	Sample 50-100 older bees from supers, outer frames, or entrance and send to lab for nosema diagnosis.			
Chemical Control	Fumigillan antibiotic (not currently available)	Feed colonies individually rather than through open feeding (barrel)				

Honeybee Tracheal Mites	Late Winter/ Early Spring	Spring Buildup	Major Nectar Flow	Harvest	Fall	Late Fall
Cultural Control		Requeen with hygienic and tracheal mite resistant stock every 2 years.				
Monitoring	Indications may include high winter loss or slow spring buildup.	Sample 50-100 older bees from supers or outer frames and send to lab for diagnosis.		Bees may appear lethargic, crawling in front of hive, or unable to fly. K-wing adults.		
Chemical Control			Treat with formic acid if infestation is above 10%.			

Small Hive Beetles	Late Winter/ Early Spring	Spring Buildup	Major Nectar Flow	Harvest	Fall	Late Fall
Cultural Control	Keep apiaries tidy and remove deadout equipment.	Reduce empty comb space.	Maintain strong colonies and address queen issues early.	Keep honey house tidy and relative humidity <50%.	Clean extracting line before and after use, and flash freeze supers.	
Monitoring	Observe underside of inner cover, frame tops and bottom board immediately after opening hive and observe protein patties for larvae. Use beetle trap to monitor.	Larvae may be observed feeding on comb. Watch for oozing, fermented honey, and slimy comb. Use beetle trap to monitor.	SHB traps are effective tools for monitoring. Keep colonies healthy and strong, reduce equipment to size they can control, and be cautious when feeding protein patties.			
Chemical Control	Coumaphos is registered for control but is not recommended for use.					

KEY POINTS TO REMEMBER

MONITORING

- Monitoring and early diagnosis can prevent the spread or damage of diseases and pests to additional colonies in the apiary and neighboring apiaries and determine the best treatment option and when to use it.
- Beekeepers and hive examination personnel should be trained in the field diagnosis of honey bee pests and diseases.
- Use the same method of monitoring throughout the season.

THRESHOLDS

- No treatment threshold exists for AFB infections. Prompt control steps are required if any infection signs are seen at any time. Confirmation of the AFB bacteria is recommended before any control treatments.
- Nosema treatment thresholds need to be updated in light of current knowledge and understanding of Nosema ceranae infections.
- Honey bee tracheal mite infestations greater than or equal to 10 percent are recommended for treatment.
- Treatment thresholds are lower when colonies are infected with more than one parasite or disease or when confronted with other stress factors (e.g., poor nutrition).

TREATMENTS & CONTROL

- Follow label instructions when using registered pesticide or antibiotic products.
- Tylosin (Tylan®) is the major product currently registered for the control of AFB.
- Requeen with hygienic stock, replace 20 percent of brood chamber frames with foundation or honey super comb each year, and disinfect deadout colony equipment with irradiation or scorching.
- Although coumaphos is registered, it is not recommended for the control of SHB.
- Traps are more effective as a monitoring tool than a treatment for SHB.
- Freeze or store supers in a cool area to kill wax moth and SHB larvae following extraction.

RESOURCES

GENERAL DISEASES

Ecological and evolutionary approaches to managing honeybee disease. Brosi, et al. 2017. Nature Ecology & Evolution, Vol 1 September, p. 1250–1262

A Field Guide to Honey Bees and their Maladies. Maryanne Frazier, Dewey Caron, and Dennis vanEngelsdorp, Mid-Atlantic Apiculture Research and Extension Consortium (2011). Pub. AGRS-116. 98 pp. A field guide essential for all beekeepers with excellent photos for identification of diseases and pests.

Honey Bee Disease and Pests. Canadian Association of Professional Apiculturists. 2013. Third Edition.

DISEASE DIAGNOSIS AND TREATMENT

USDA Bee Lab in Beltsville, Maryland
https://www.ars.usda.gov/northeast-area/beltsville-md-barc/beltsville-agricultural-research-center/bee-research-laboratory/

Send suspect disease samples to (after following the correct relevant procedure):

Bee Disease Diagnosis
Bee Research Laboratory
10300 Baltimore Ave. BARC-East
Bldg. 306 Room 316
Beltsville Agricultural Research Center - East
Beltsville, MD 20705

Veterinary Feed Directives (VFD) Basics. American Veterinary Medical Association (AVMA)
https://www.avma.org/KB/Resources/Pages/VFD123.aspx

Honey Bee Veterinarian Consortium. To locate a vet in your area, check the Find a Vet feature for beekeepers.
https://www.hbvc.org

Shaking is an Effective and Profitable Method for Managing AFB. Adony Melathopoulos et al. 2007. Agriculture and Agri-Food Canada
www.capabees.org/content/uploads/2013/02/shaking.pdf

Nosema Disease – Diagnosis and Control. Canadian Association of Professional Apiculturists. Agriculture and Agri-Food Canada.
http://www.capabees.com/nosema-disease-diagnosis-and-control

CHAPTER 7: QUEEN HEALTH, NEW COLONIES, & HONEY BEE BREEDING

A marked queen. Photo Credit: Bee Informed Partnership

Untangling the queen bee from the romantic associations that society has created of a royal personage is an important step toward better management of an apiary. This is not to say that there isn't something majestic about seeing a well-mated queen when she emerges from underneath her daughters and waddles across a frame, searching for a clean cell to lower her abdomen and lay an egg. However, by understanding how the queen provides the pheromones that serve as the "social glue" that holds a colony together, the beekeeper can better provide the conditions that ensure the colony continues to do well when the queen succumbs to old age or has had a poor mating experience or when other stresses impact her and her colony.

Effects of exposure to extreme temperatures can be substantial for mated queens. Coddled by worker bees, the queen usually finds herself in temperatures between 75° and 95°F (23° and 35°C). Queens will survive exposures to 100°F (37°C) heat or more (in vehicles in direct sunlight, on airport runways, inside hot buildings, etc.), but she will become permanently slower in all her activities, including egg laying. Queens can tolerate relatively short exposures to temperatures near freezing (inside airplane cargo holds, in cold buildings, in shirt pockets when installing packages in cold weather, etc.). When she warms up, she may seem to be moving around normally, but she will likely lay few, if any, eggs.

A colony can benefit from requeening. As a beekeeper gains confidence, he or she can consider selection of desired qualities for bee stock. Too often, beekeepers settle for the queen bees they can get rather than the queen bees they want.

Queen health and honey bee breeding are important best management practices toward maintaining healthy, genetically diverse honey bee colonies. Healthy queens are prolific and efficient egg layers and secrete a number of interacting pheromone chemicals.

Healthy queens are important to ensure the quality and productivity of the colonies. Photo Credit: Maine Beekeepers Association

Workers distribute the queen's pheromones throughout the colony. The normal colony condition revolves around a single queen, and distribution of her pheromones inside the hive is critical to a healthy colony being able to function and respond well to environmental conditions.

When a colony needs a new queen, the queen replacement process involves complex but subtle variations in chemical signals whereby normal behaviors are altered. However, queen replacement may not succeed for a variety of reasons.

QUEEN HEALTH

Queen health is important to ensure quality and productivity of the colony. A good queen is one that is kept healthy during both larval development and after emergence. Early exposure of larvae to abundant royal jelly is known to improve development, leading to queens with higher body weight and larger egg production capacity.

QUEEN REPLACEMENT

The recommended best practice is to replace the queen every one to two years to maintain functional and productive colonies. Replacing queens proactively will result in healthier colony populations. With multiple pressures on hives now – including Varroa mites, decreasing forage, and increased chemical use – many beekeepers requeen annually to ensure colonies maintain queen quality and longevity and work at full capacity.

Requeen when necessary (i.e. when queen cells are found in the brood area). Best quality, highly productive queens are reared in the spring when mixed pollen sources are abundant and young nurse bees are numerous. Queens can be reared from one-day-old to three-day-old larvae. The best queens are reared from one-day-old larvae, progressively fed royal jelly by the youngest nurse bees. As nurse bees age, their gelatinous secretions lose the queen component and turn into worker jelly, which converts potential queens into workers.

Queens reared by the colony for swarming and supersedures usually are reared from one-day-old larvae and should be good queens. In emergency situations, young nurse bees will be stimulated to feed one-, two-, and three-day-old larvae in attempts to rear new queens. Unfortunately, the oldest larvae will develop into replacement queens most quickly. They often will have some worker bee characteristics and fail to be productive queens. It is a good idea to requeen a colony if it is headed by an emergency queen.

Requeening usually is easiest in the spring. Worker populations are still reduced, finding the old queen is easier among fewer bees, spring-reared queens usually are the highest quality of the year, and rapidly building populations of young bees tend to accept replacement queens much better than later in the year.

Alternately, many beekeepers attempt to requeen after the honey flow at population peak phase to stimulate production of extra brood for the winter population. Poor brood patterns in the fall signal the need for requeening.

Marking queens (see table on page 67) helps confirm their age to assist queen replacement.

Many beekeepers prefer to use locally produced hygienic queens, when available, as they are believed to be adapted to local environmental conditions. Hygienic stock helps reduce mite buildup in colonies. In addition, buying from local breeders reduces the risk of introducing pests and diseases through imported queens. Purchase queens from reputable queen breeders that have proper state government disease-free inspection certificates.

Three swarm cells. Photo Credit: D.M. Caron

Supersedure cell. Photo Credit: Honey Bee Biology & Beekeeping

Queen replacement, whether by bees or beekeeper, interrupts Varroa mite buildup since brood rearing is reduced. Swarming and supersedure may also allow colonies to reduce the pathogen (disease) levels.

Emergency queen cells.
Photo Credit: Penn State University

STRATEGIES TO REQUEEN A COLONY

Supersedure Cell

This method is preferred over the use of swarm cells because supersedure cells have less negative impact on the colony. Supersedure queens are not likely to be undersized, and, in an estimated 20 percent of instances when a supersedure occurs naturally, there is no discernible break in the brood production cycle. Such superseding colonies will have two queens, mother and daughter, laying eggs in the same colony.

Swarm Cell

Many hobbyists prefer to requeen a hive by using queen cells from colonies preparing to swarm. This method is generally not recommended over a long time period. Use of swarm cells can perpetuate the swarming characteristic.

Emergency Queen Rearing

Occurs when a colony (or an isolated portion of a colony with brood comb) becomes queenless and the workers convert several developing workers into queens. They change the jelly feeding quantity and quality as well as the orientation of the horizontal worker cell to a vertical queen cell.

To duplicate emergency conditions and create a queenless colony:

- Elevate nurse-age workers to cover frame of open brood to initiate queen cells.
- Newly started cells may (or may not) be transferred to queenless portion of strong colonies (finishing colonies) after 24 hours; however, ensure that the finishing colony maintains a high nurse-age worker population.
- After 14 days, promptly remove capped queen cells prior to the emergence of any single virgin queen.
- Introduce capped queen cells into mating nucs equipped with a worker population and sufficient resources to allow for normal emergence and initial care of virgin queens.
- In tandem, develop drone mother colonies at additional apiary sites a mile (1.6 kilometers) or more outside the apiary hosting the queen mating nuclei.

Although biologically critical, colonies that naturally replace queens are often less productive for the beekeeper depending on when the replacement occurs. There is a saying in the bee world: Colonies are either producing honey or producing queens. Commercial or small-scale queen producers purposely manipulate the chemical pheromones in the hive to optimize the conditions for successful queen production. These producers intentionally create queenless colonies, a situation that worker bees consider an emergency, and prompt the workers to rear queens.

Starting colonies, finishing colonies, and mating nucs come in a variety of shapes and sizes. The use of standard equipment makes management easier in smaller-scale queen-rearing efforts as sources of frames of bees, brood, or food needed for quality replacement queens.

Larger-scale queen rearing usually includes specialized boxes and equipment. Mating nucs are often smaller (mini or baby) to facilitate queen catching once the virgin queen is mated.

LEAVE A MARK

Mark queen rearing equipment so it looks different from regular equipment. Use drone brood frames in drone mother colonies.

PURCHASING BEES AND MAKING NEW COLONIES

To start beekeeping, to increase hive numbers early in the season, or to replace winter losses, beekeepers can purchase bees or make new colonies.

Bees can be purchased in the form of:

- Full-sized colony
- Nucleus (nuc) colony
- Package bees

New colonies can be made by:

- Making a colony divide (split)
- Capturing swarms
- Transferring bees and comb as cut-outs/ transfers from non-hive sites

PURCHASING BEES

When purchasing bees or colonies, seek reputable, local producers (if available) and be sure new hives, nucs, and packages are certified disease free.

Full-Sized Colony

Standard-sized hive box(es) with frames of brood, honey and pollen, the queen, and worker bee population appropriate for the season

For beginners, purchasing a full-sized colony might be challenging without a mentor available. Be certain you are not buying a problem (AFB disease, non-standard equipment, defensive bees, etc.) and that you can move the colony (safest after dark) to its new apiary (if you will not keep it at its current location).

Nuc

Smaller two- to five-frame-sized colonies that usually include a mated queen and a mixture of frames of brood, honey, and pollen

Nucs may be purchased in cardboard, wooden, or plastic boxes. One or more of the frames may be new foundation or an empty drawn frame. Nucs, due in part to overlapping generations, will grow rapidly and need be transferred to standard-size hive bodies within three weeks of purchase, especially in the spring.

Nucs ready for distribution.
Photo Credit: D.M. Caron

Package

Adult bees, a support feeder, and a separately caged queen. Packages usually weigh 2 to 5 lbs. (1 to 2.3 kilograms) and contain from 8,000 to 20,000 bees.

Producers ship packages in a wooden or cardboard screened box with a sugar syrup feed source in a metal can. A less common package option is a tubular plastic container with a gelled feed source (usually produced outside the U.S). The queen, either purchased from a queen breeder or raised by the package bee developer, is held in a cage suspended in the package so the bees cluster around her.

Package installation.
Photo Credit: D.M. Caron

Package bees are produced in warmer, southern climates and shipped or picked up by beekeepers for resale to customers in other locations. Packages are usually ordered right after January. They should be picked up and the bees installed in the hive without delay.

Introducing a Package

The best introduction method is to shake the adult workers from the package into a hive. It is also possible to place the package inside a hive and let the bees exit the package on their own, but sometimes they fail to exit and build their comb inside the shipping package.

Release the queen from her cage at installation by direct release or indirect release, which is less risky. In an indirect release, the workers release their queen by chewing an exit through the candy plug. If queens are shipped with attendants, some recommend removing the attendants in queen cages. If attendants are to be removed, care must be taken to avoid injury to or loss (flight) of the queen.

Removing the queen cage from a 3-pound (1.36-kilogram) package.
Photo Credit: L.J. Connor

If immediate introduction isn't feasible, keep the package in the dark at around 64°F (18°C) in a well ventilated space. Storage is not recommended for longer than a day or two.

Supplement food stores for the newly installed nuc or package hive until forage and weather are adequate for unrestricted flight. Make sugar syrup with an uncontaminated sugar. The newly established package hive can also be supplemented with protein patties. Because packages come with no frames of brood, honey, or pollen, it takes longer for them to build up.

MAKING NEW COLONIES

Dividing/Splitting Colonies

Beekeepers can divide or split colonies to make up losses or expand colony numbers from the strongest colonies rearing their own queens or via purchase of a new queen. Such splits are a smaller version of the original colony.

A split can be made at any time of the active bee season. Splits are easiest to produce when food resources are plentiful and there is a rapid increase in colony growth (spring). Two major advantages of spring splits include the possibilities of halting colony swarm preparations (when splitting the mother colony is done skillfully) and using swarm queen cells started by the bees as a means of more rapidly obtaining a queenright split.

To make a split:

- Remove at least two brood frames (one with mostly capped brood) with clinging adult bee population and a bee-covered frame of honey and bee bread (pollen) from one or more strong, disease-free colonies, and place in a new hive box.
- Shake more younger worker bees into the new box. The frames can also be placed into a smaller split box or in a standard box with a divider panel (follower board).
- Add additional empty drawn or foundation frames to fill the box, and provide the newly constituted split a caged queen or queen cell.
- If possible, move the new split to a new apiary site to reduce drifting of the worker force back to their original hive.
- Provide the new units with sugar syrup feeder. Some beekeepers also provide a protein patty.
- Reduce the split entrance to allow a guard system to develop. The split should build up rapidly.

Swarm Capture and/or Transfer

New colonies can be started via swarm capture. The queen in a swarm should be replaced with a newly raised or purchased queen within a month or when feasible.

Beekeeper with captured swarm.
Photo Credit: D.M. Caron

QUEEN CARE

INTRODUCTION OF QUEENS

Newly developed queens require extra care and handling precautions. Queens can be introduced as mature capped queen cells, as adult virgin queens, or as adult mated queens.

Capped Queen Cells

Place capped queen cells in a queenless colony within a day of projected emergence. For best results, the receiving colony should be queenless for several hours to a day before capped cell placement. The cell can be placed in a protector cage or suspended, still in the vertical orientation, within the brood area. Use of capped cells to requeen is more frequent when the rearing is done by the individual beekeeper. A mating nuc is bypassed if capped cells are used to requeen.

Adult Queen – Virgin or Mated

Adult queens, whether purchased from a commercial queen breeder or reared by the beekeeper, can be introduced into a colony in one of two methods: directly released into a queenless colony or indirectly released within a cage. The colony to be requeened should be queenless for at least an hour, and preferably for a day or two, before requeening. The best practice is to cage the new queen before introduction.

For indirect release, cages of adult queens are plugged with queen candy (a mixture of icing sugar, syrup, and glycerin).

Four or six attendant bees may be added to cages such as Benton mailing cages or push-in cages. JZ-BZ plastic cages and California cages are too small to also include attendants.

To introduce a caged queen:

- The colony should be queenless for a period of time (recommendations vary from several hours to days) before introducing the new queen.
- Cages should be filled with enough candy so that there is a delay in release of the queen.
- Some recommend removing attendants from the cage before introducing. Many beekeepers do this in the safety of a room, vehicle or other enclosure (using an extra veil, for example). Exercise care to avoid injuring the queen or letting her escape while removing attendants.
- Provide empty, drawn comb so the mated queen can start laying eggs upon release.
- Place the cage with the queen in a queenless (or queenless portion of a queenright colony) with the screen side exposed to workers.
- Place the queen cage between frames of brood.

Queens in Benton mailing cages with attendants.
Photo Credit: Jen Holden

Introducing JZ-BZ caged queen between brood frames.
Photo Credit: Canadian BMPs for Honey Bee Health

If immediate introduction of a caged queen is not possible:

- Keep queen and attendants (if none, consider adding two or three) in the cage for less than a week.
- Hold the caged queen in a queenless (or queenless portion of queenright) colony well populated with nurse-aged bees, or keep the caged queen at room temperature and spread a drop of water on the mesh of the cage each day.
- Keep the cage entrances corked (add masking tape over cork for security) so the queen cannot be accidentally released.
- Avoid mesh-to-mesh contact with other queen cages to avoid conflict.
- Maintain proper ventilation.

QUEEN REARING AND BREEDING

Beekeepers may want to rear their own queens. Rearing refers to raising and producing queens, while breeding refers to testing, evaluating, and selecting bee stock with desirable genetic traits. Queens can be bred for several traits, including:

- Increased production (more honey)
- Less swarming
- Pest and disease resistance
- Gentleness

Quality queen stock is an essential part of an effective integrated pest management (IPM) strategy.

There are several methods for rearing queens:

- Grafting (Doolittle Method)
- Frame manipulation methods that do not involve the grafting technique, such as the Miller/Alley/Hopkins Methods
- Cell punching
- Queen cage/confinement boxes, such as Jenter and Nicot kits

GRAFTING (DOOLITTLE METHOD)

For large-scale queen rearing, the Doolittle Method is recommended. It involves grafting (transfer of young worker larvae) into cups, using cell builders (starting and finishing colonies), and transferring capped queen cells into mating nucs.

Before grafting, prepare one of two types of cell builders:

- ***Cell starters:*** Usually a queenless colony (but on a smaller scale, a queenless upper portion of a queenright colony) with enough resources of syrup/honey, pollen, and young nurse bees to start rearing undamaged grafted worker larvae into viable queen cells quickly. Starters might have free flight or be enclosed in swarm boxes.
- ***Cell finishers:*** A strong colony intended to mimic a swarming situation, which causes the bees to take their time to draw out and feed the queen cells and raise larger, better developed queens. A finisher might be queenless (in smaller-scale rearing, the same unit as the cell starter) or queenright. The resident queen in a queenright finisher colony must be contained in the bottom box by a queen excluder to prevent her from moving up to the top box and destroying the developing queen cells.

Larger scale queen rearing involves transferring larvae to special cups and rearing queens to capped stage in strong queenless colonies with lots of nurse-aged workers. Photo Credit: James Wilkes

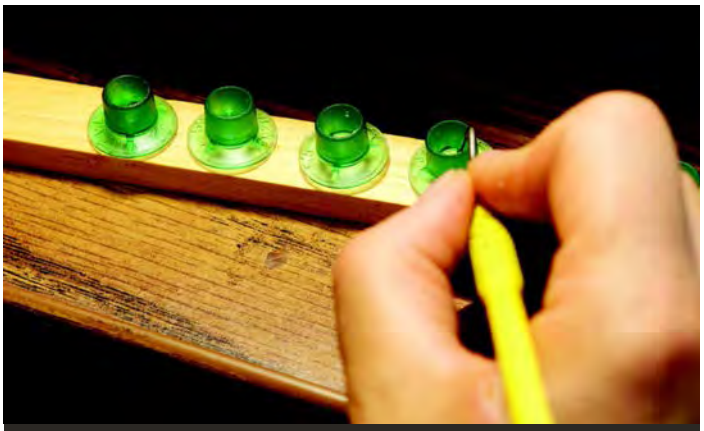
CLOAKE BOARD SYSTEM

This method is a variant of the cell builder method. In this system, a double colony is used, with the queenless starter being the top box where the grafting frames are located and the queenright finisher as the bottom box. A queen excluder between the boxes prevents the queen from moving up to the top box. Queen excluders are also located above the Cloake board to prevent a virgin queen from entering and below the bottom box to prevent the resident queen from swarming. The Cloake board is either retained or pulled out to block or allow the queen pheromone to move between boxes, mimicking a queenless or queenright state, respectively.

GRAFTING

- Remove larvae from colonies with desirable characteristics (selected stock colony) using a variety of grafting tools, and place in artificial queen cups (wax or plastic).
- Attach the queen cups to a grafting bar held by a modified frame (they must hang vertically downward).
- Transfer only one-day-old (or younger) larvae. Keep the frames warm and handle gently to avoid damaging the larvae. Cover grafted cups with a wet towel to ensure larvae do not dry out before placing in the cell starter.

It takes practice and a steady hand to ensure proper grafting. Success rates will vary with the season and hive conditions, but 50 to 95 percent of grafts should be successful.



Plastic graph cups ready for transfer of day-old larva.
Photo Credit: Canadian BMPs for Honey Bee Health

HARVESTING QUEEN CELLS

- Harvest ALL capped queen cells 10 days after grafting.
- Keep cells around 85°F (30°C), and avoid colder or warmer temperatures, as these might damage the developing queen. Avoid rough handling.
- Queen cells can be sold, used in queenless splits to requeen full-sized colonies, or introduced into mating nucs.
    - If mating nucs are used, check for acceptance of and successful mating by examining for eggs two weeks after introduction.
- Mark queens at this time so you will know their age when it is time to requeen.

Here is a paint marking scheme to keep track of queen age:

Color	Year Ending	Remember
White	1 or 6	Will
Yellow	2 or 7	You
Red	3 or 8	Raise
Green	4 or 9	Great
Blue	5 or 0	Bees

Drone production is also important to ensure queens are properly mated; you should seek a higher mating probability with drones of desired genetic stock. Drone frames can be used in colonies with desired characteristics to ensure the area is flooded with high-quality drones.

KEY POINTS TO REMEMBER

- Acquire local queens, as they are more likely to be adapted to local environmental conditions and pest and disease strains.
- Purchase from local producers to avoid the risk of introducing new pests or diseases. Ideally local producers should be certified by the state.
- If nucs or packages cannot be installed immediately, keep them in a dark, well-ventilated area at room temperature.
- Queen rearing refers to raising and producing queens, while queen breeding refers to testing, evaluating, and selecting bee stock with desirable genetic traits.
- Harvest queen cells 10 days after grafting, keep them at 85°F (30°C), and introduce them immediately to a colony or mating nuc.

RESOURCES

NUCS

Increase Essentials by Lawrence John Connor (2014)

QUEEN REARING

Queen Rearing and Breeding by Harry H. Laidlaw Jr. and Robert E. Page Jr. (1997). (The "Bible" of queen rearing and breeding)

Also useful:

Queen Rearing Essentials by Lawrence John Connor (2017)

Rearing Queen Honey Bees by Roger A. Morse (1979)

Better Queens by Jay Smith (2011)

Successful Queen Rearing Manual and accompanying video by Marla Spivak, et al., Minnesota Extension Service

NICOT (QUEEN CAGE) METHOD)

Nicot Queen Rearing: The Non-Grafting Method for Raising Local Queens by Grant Gillard (2013)

DOOLITTLE ORIGINAL

Scientific Queen-Rearing by G. M. Doolittle (first published 1889). Available in recent reprint editions.

CLOAKE BOARD

Originally developed by New Zealand beekeeper Harry Cloake, the Cloake Board now has many variations. Search online for Cloake Board to find descriptions, illustrative videos, and instructions.

CHAPTER 8: HONEY BEE NUTRITION

A bee foraging.
Photo Credit: Bee Informed Partnership

Nutrition management is the new normal in apiculture. Every colony typically needs nutrients from over 250 million flowers to thrive in a full calendar year, along with a clean, uncontaminated water source. Colonies need 35 to 75 pounds (16-34 kilograms) of pollen and about 120 pounds (54 kilograms) of honey per year, and about 22 gallons (83 liters) of water are needed just for colony winter needs.

Honey bees require nectar and pollen to grow both as individuals during larval development and immediately following adult emergence for normal glandular development. Proper nutrition is vital for effective immunological defense against pests and diseases. The floral sources of pollen and nectar should be diverse and abundant to provide all the essential nutrients for sustainable health. Due to land management changes, beekeepers must do more to provide and supplement nutrition for their apiaries than they have ever before.

NUTRITIONAL MANAGEMENT

Honey bees require carbohydrates, proteins (amino acids), lipids (fats), vitamins, sterols, and minerals for normal growth and development. All these nutrients are supplied by the nectar and pollen bees collect. Uncontaminated water also is an important dietary input. Bees use water to maintain a constant temperature and humidity within the hive, to process nectar and pollen, and to liquefy crystallized honey. Water may also be a minor source of dietary minerals.

Plants produce nectar to attract pollinators. Nectar is mainly composed of water and different sugars (though trace amounts of vitamins and minerals are also present) and is the main source of carbohydrates for honey bees. Bees normally convert nectar into honey to be stored in the hive, though they also can consume it directly. Honey is the "fuel" of the colony: if the hive runs out of honey, it will die, just as a car that runs out of gas will not run.

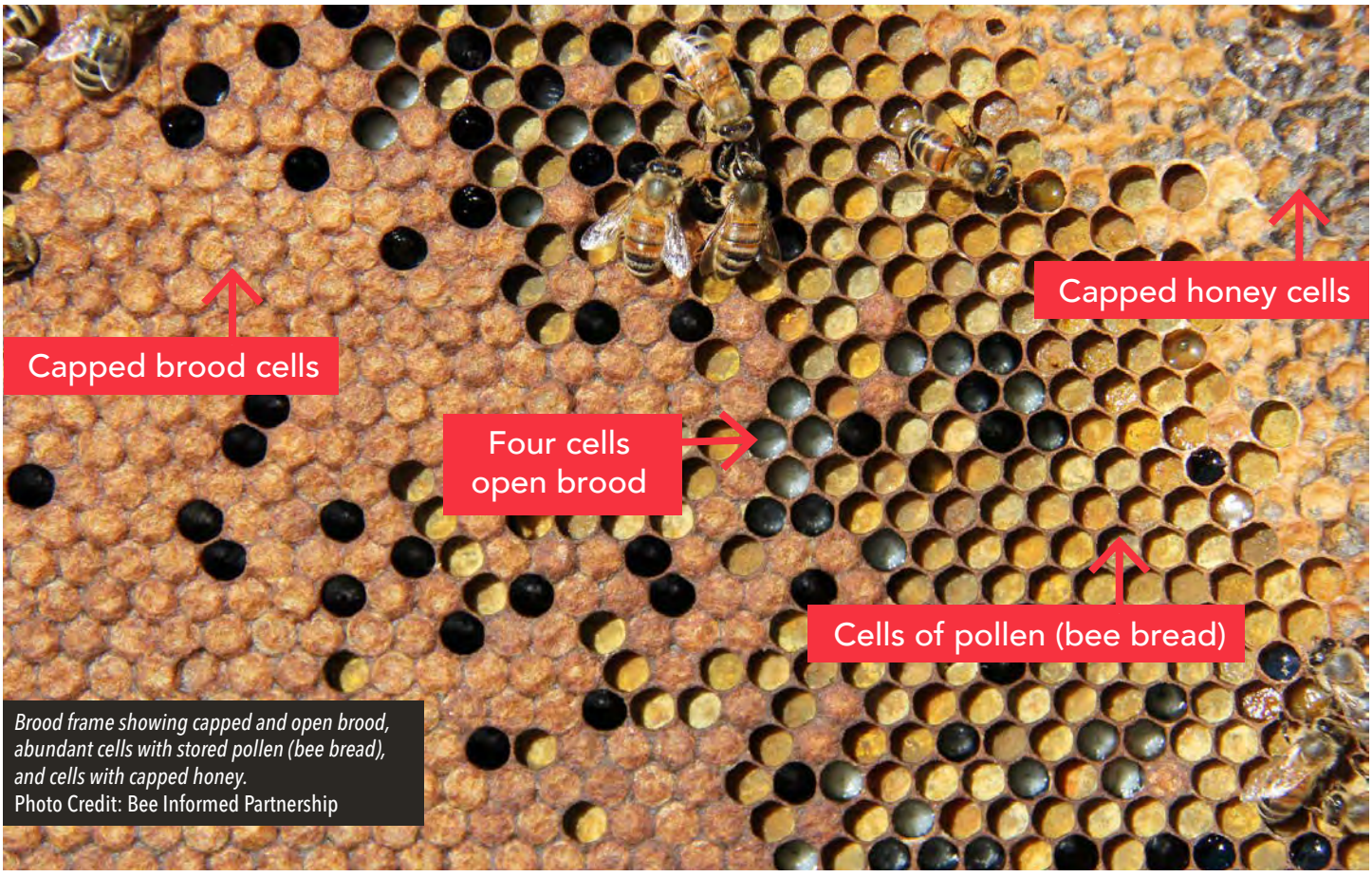
A nectar/pollen forager.
Photo Credit: Canadian BMPs for Honey Bee Health

In addition to the nectar in flowers, bees also can obtain carbohydrates from extra-floral nectaries (on some plants such as cotton) and from sugar sources such as cut sugar cane stalks, rotting natural sugar sources (fruit orchards), discarded sugary fluids (around dumpsters, garbage containers, etc.), and manufacturing and storage sites of foods with sweeteners (candy, soft drink factories, etc.).

Pollen grains are honey bees' main source of protein (including all 10 essential amino acids), lipids, vitamins, minerals, and sterols. Pollen sources differ in the amount and composition of protein, amino acids, lipids, fatty acids, vitamins, minerals, and sterols. Honey bees are not able to assess protein source content (which they can do with carbohydrate sources), so a diversity of pollens is required to obtain adequate protein. A colony without enough pollen cannot rear brood and grow and is vulnerable to disease.

Honey bee foraging at extra-floral nectary.
Photo Credit: T.C. Davis

Close-up of extra-floral nectary of pigeon pea.
Photo Credit: T.C. Davis

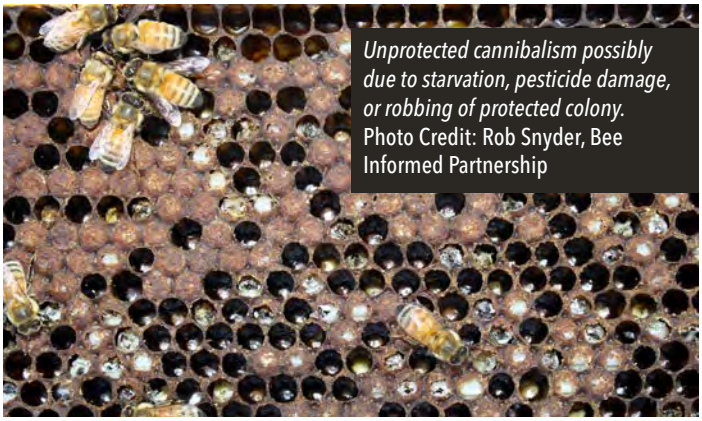


Brood frame showing capped and open brood, abundant cells with stored pollen (bee bread), and cells with capped honey.
Photo Credit: Bee Informed Partnership

SUPPLEMENTING FOR NECTAR/POLLEN

Beekeepers often must feed colonies to provide sufficient nutrient quantity and quality.

- Early in population buildup phase (spring): When floral resources may be scarce, supplemental feeding can help avoid starvation and tide colonies until natural sources of nectar and pollen are readily available and environmental conditions permit collection. Supplemental spring feeding also can stimulate brood production and colony growth if adequate food is not available.
- Population decrease phase (fall): Sugar feeding may be necessary to provide bees with enough honey stores to last through the winter. Feeding supplemental protein can ensure that overwintering bees have the necessary nutrient stores in their fat bodies to rear brood before the colony can forage and to extend the lives of bees that overwinter.
- Feed bees when floral resources are not available to provide nectar or pollen. Colonies that run out of pollen will slow or cease brood production (via reduced queen egg laying or brood cannibalism by workers), and the population will decline. Colonies that run out of honey stores and do not have access to nectar will starve. Starvation is a common cause of colony death overwinter and, in some instances, during spring buildup.



Unprotected cannibalism possibly due to starvation, pesticide damage, or robbing of protected colony.
Photo Credit: Rob Snyder, Bee Informed Partnership

INDICATORS OF COLONY STARVATION

The photo below shows "tails in the cells," the tell-tale indicator that bees have run out of food. It indicates either:

- The beekeeper has not fed a colony when natural floral resources were unavailable,

  OR
- The colony population is too small to utilize existing food stores because there aren't enough workers to convert food stores into heat energy.

Starvation and a pesticide kill can look remarkably similar on the outside of a colony with mounds of dead bees. But the "tails in the cell" is undeniably a sign of starvation.

Colonies that run out of pollen will slow or cease brood production, and the population will decline. Colonies that run out of honey stores and do not have access to nectar (or supplemental sugar feeding) may starve.
Photo Credit: Rob Snyder, Bee Informed Partnership

FEEDING

There are several options for feeding bees.

Recommended

- Sugar syrup made with white, refined cane or beet sugar.
- Honey. Only use frames from disease-free colonies to prevent spreading honey bee pests and diseases. If in liquid form, honey should be first diluted. If honey capped in comb is fed, the honey cappings should be scraped with a hive tool or uncapping scratcher to encourage usage. Robbing, when bees from neighboring colonies enter to steal honey, may be a consequence of feeding honey, especially if done in the fall, due to its attractiveness to nearby bees.
- Dry sugar and fondant (confectioner's sugar). These are recommended when feeding sugar syrup is not an option (such as for the dormant overwinter phase or when too little water is available to dissolve the sugar). Bees need water to dissolve dry sugars before they can be consumed. As a result, dry sugar and fondant may not be accessible to the bees, even when placed directly in the hive. Dry sugar is often ignored by bees and may even be discarded out the hive entrance. Bees do not normally store dry sugars – they only eat them directly. So these feeds, at best, are temporary solutions under specific environmental conditions for colonies with low stores in danger of starvation.

Not Recommended

- Brown sugar, raw sugar, and molasses to feed colonies during the winter. These sweeteners contain indigestible components that can cause dysentery when fed to bees. They should be fed only when bees have open foraging and can readily discard feces.
- Liquid invert sugar sources such as high-fructose corn syrup (HFCS). Though HFCS is readily available and inexpensive, research has shown that it can weaken bee immune systems and increase vulnerability to microbial enemies and pesticide exposure. If HFCS must be used, the higher fructose content option is recommended. Store HFCS in cool dark areas to avoid development of higher levels of hydroxymethylfurfural (HMF), a toxic sugar and crystallization. Do not feed HFCS that is dark tan or brown in color.

MAKING SUGAR SYRUP

Make sugar syrup at a concentration of 1:1 (equal parts sugar and water, by weight) or 2:1 (2 parts sugar to 1 part water, by weight).

- Thinner 1:1 sugar syrup is generally used in the early population increase phase (spring) to feed colonies low on reserves and in danger of starving. Spring feeding can also stimulate brood production, promote a great percentage of foragers to collect pollen, and promote colony growth.
- Thicker 2:1 sugar syrup is used in the population decrease phase (fall) to ensure colonies have enough stores to survive the dormant phase (winter). Since bees need to ripen (i.e. concentrate) syrup before it can be stored, a 2:1 syrup can be concentrated and stored more readily. Each colony should be fed 4 gallons (15 L) of 2:1 sugar syrup in the fall to prepare them for winter. Such feeding can begin as soon as supers are removed (at or following population peak) and should be completed before the temperature gets below 50°F (10°C). Bees will stop taking down sugar syrup once it gets too cold. Some evidence exists that overwintering on sugar syrup honey is more favorable for the bees.

FEED IN WARM WEATHER

Feeding should begin as soon as supers are removed and should be completed before the temperature gets below 50°F. Bees will stop taking down sugar syrup once it gets too cold.

FEEDERS

Sugar syrup can be fed to bees in different ways.

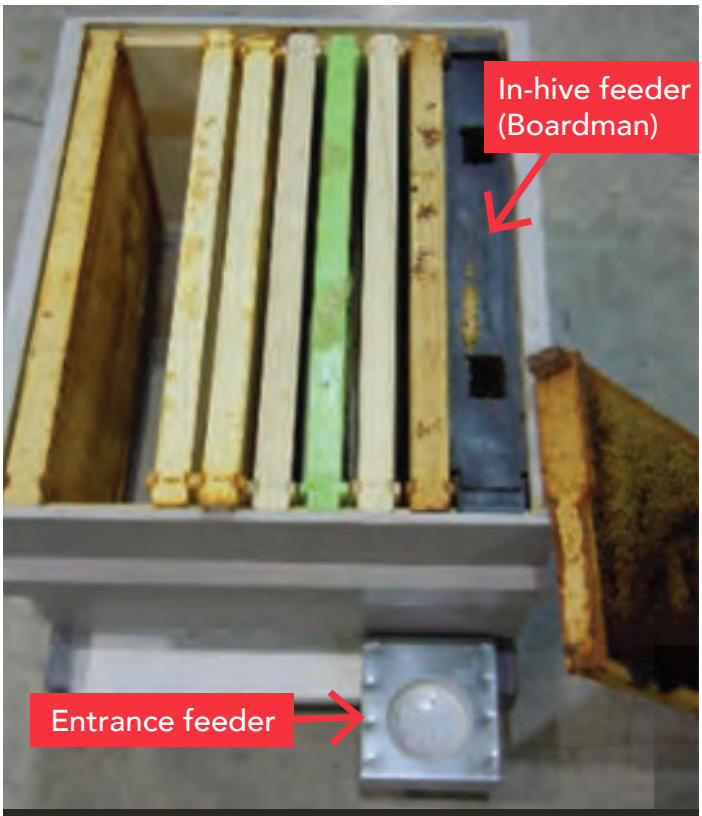
Recommended

- Hive-top feeders and inverted pails. Ideal for spring or fall feeding, as they hold large amounts of syrup, do not require the bees to leave the hive (helpful when the weather outside is cold or rainy), can be changed and refilled without exposing the colony, and do not encourage robbing.
- Division board or in-hive frame feeders. Do not require the bees to leave the hive and are useful for spring feeding and for queen rearing. Opening the hive is necessary to refill. Do not work as well in the winter because the bees do not want to leave the cluster to feed from the in-hive frame feeder.
- Resealable plastic bags. More economical, though requires frequent changing/refilling. Syrup pockets unavailable to bees may develop as the plastic collapses. Adding an odor to the syrup helps bees find such offerings.

Feeding sugar syrup on top of colonies (recommended).
Photo Credit: D.M. Caron

Not Recommended

- Boardman (entrance) feeders. These do not hold very much syrup, bees will not break cluster to take syrup from them if it is cold, they encourage robbing, and they are exposed to the sun, which can make the syrup runny or cold from low night-time temperatures, making them less attractive.
- Open feeding. While it is easy for beekeepers with many colonies to feed bees from barrels of sugar syrup, this encourages robbing behavior, can spread disease, and generally favors strong colonies taking most of the syrup. It will also feed any colonies in the general area, not just those of the beekeeper, and is highly attractive to scavenging yellow jackets.



Feeding sugar syrup with in-hive Boardman (entrance) feeder (not recommended).
Photo Credit: D.M. Caron

WATER

Water is important for honey bee health, for maintenance of hive temperature and humidity, and for liquefying crystallized honey. Provide clean, accessible water sources if there are no natural streams, ponds, and wetlands nearby. Bees will sometimes select "dirty" water sources over "clean" feeders, as they provide minerals bees need seasonally and give an identifiable odor for bees to key in on. Adding decaying vegetation or allowing vegetative growth in-feeder may provide for better acceptance.

Water can be provided in almost any container, such as a trough, bird bath, kiddie pool, bucket, rain barrel, poultry water dispenser, etc. Place twigs, straw, or other floating material or solid perches (rocks) in open water sources to give the bees something to land on to prevent drowning.

Open water sources should be covered. Do not place them in the bees' flight path to reduce bees defecating in it and potentially spreading disease. Put the water source out in the apiary early in the season to train bees to it before bee visitation to neighbors' pools or ponds becomes problematic.

Empty and refill water sources often all season to avoid creating breeding grounds for mosquitoes.

Bees taking "dirty" water.
Photo Credit: Canadian BMPs for Honey Bee Health

POLLEN SUPPLEMENTS & SUBSTITUTES

Hives should have frames of pollen. Bees store excess pollen as bee bread. Pollen is the only source of protein for bees, and bees need pollen for proper growth and development, including the development of glands necessary to feed and raise brood.

If pollen is not available, colonies should be fed protein supplements or substitutes.

TYPES OF POLLEN SUPPLEMENTS AND SUBSTITUTES

Supplements contain some amount of pollen while substitutes do not. Pollen is the most attractive protein source to bees, and its addition to a protein supplement can greatly increase the supplement's attractiveness, nutritional value, and consumption.

Protein substitutes include:

- **Brewer's yeast:** The closest to pollen in terms of protein content and higher in vitamins and minerals.
- **Egg powder:** A good option in terms of protein content and for retention of moisture.
- **Soybean flour:** A good option in terms of protein content though less attractive to bees. Must be expeller-processed to remove excess fat.
- **Skim milk powder:** Should be low in lactose, which is toxic to bees.
- **Torula yeast:** A good option though harder to obtain.

PREPARATION & APPLICATION

Recommended

- Protein mixed into a sugar syrup with 5-10 percent added bee-collected pollen, if available. The mix should create a paste or patty that can be rolled flat between two pieces of wax paper. The wax paper prevents the supplement from drying out.
  - Place this protein patty directly on the frames above and to the sides of the brood area to ensure it is used by the bees. Slice a few slits in the wax paper to help the bees discover and access the protein patty.
  - Pre-mixed protein patties, with or without pollen, can also be purchased instead of made.
- Adding pollen increases attractiveness of the feeding patty to bees.
  - Trap and collect pollen or purchase it from a beekeeping supply store or supplier. It is important to purchase pollen from a trusted supplier. A pollen supplement should contain at least 5 percent pollen though 7-10 percent pollen content makes the bees more attracted.
  - The pollen addition is meant to make the patty recognizable to the bees as food. Pollen supplies nutrients that are accessible to bees and not available in the protein sources listed above.

Feeding protein supplement.
Photo Credit: D.M. Caron

Not all trapped pollen is equal in attractiveness. Protein content varies based on the source of pollen as do the amino acids present. Pollen trapped and collected for later use should ideally have around 20 percent protein content and come from a source that contains all 10 essential amino acids. Combine pollen from as many different plants as possible. Avoid using pollen from any single plant source. Beekeeper-collected pollen should be dried and kept frozen to maintain its nutritional value.

Using pollen in protein supplements may pose risks. Pollen can contain spores from American foulbrood, chalkbrood, and nosema and may be contaminated by pesticides. Collect pollen only from colonies that are strong and disease-free. If purchasing pollen, ensure that it comes from a reputable source. Irradiated pollen can also be purchased from some sources.

Not Recommended

Dry powder protein supplements for in-hive feeding. Bees can ignore the powder or throw it out the hive entrance, similar to feeding dry sugar.

If you use dry powder supplements, place them in a feeder outside of the hive. Be careful to avoid the spread of pathogens resulting from bees of different hives intermingling at the open source. Stronger colonies may also out-compete weaker hives at open feeding sources of dry pollen.

Open feeding of protein substitute.
Photo Credit: D.M. Caron

Timing of Application and Awareness of Weather Patterns

Pollen and nectar availability are highly dependent on weather and microclimate. Be aware of the resources your bees have access to and provide supplemental sugar syrup and protein to increase brood production and population size. Understanding these interactions will take time and experience.

Feed protein supplements to the colony at least six weeks before the increased population is desired. That is, early enough in the spring for brood to emerge as adults and for the adult population to increase. Feeding protein is more useful when the bees have some access to natural pollens. Continue providing bees with sugar syrup and/or protein supplements until natural nectar and pollen sources are readily available and the weather permits bees to collect them outside the hive. If feeding is stopped or intermittent, the queen may halt egg laying, and/or the bees may begin to consume the colony's eggs and larvae.

HABITAT

Diverse habitat can help bees better cope with environmental and in-hive stressors. Honey bees require plants, shrubs, and trees in the area surrounding their hives that bloom throughout the year to provide nectar and pollen. Abundant resources are important, as are the diversity and quality of the nectar and pollen provided.

Ideally within a 3-mile (4.8-kilometer) radius of an apiary, a wide variety of plants should be available that bloom at different times of the year without significant gaps. At least some should be substantial nectar-producing plants, and the pollen produced by these plants should contain high levels of protein and all 10 essential amino acids.

Diversity is important because any one plant may not contain all of the essential amino acids. Knowledge of the available forage in the area is important when selecting a spot to place hives. Beekeepers should develop a feeling of the carrying capacity of the surrounding area when making decisions on where and how many hives to keep in a location. This is particularly true in urban areas where there may be many other beekeepers nearby and too little available forage to sustain numbers of colonies.

If suitable land is available for planting and managing honey bee forage, seed mixtures appropriate for various regions can be purchased. As with any crop, the land will need to be prepared for planting, suitable inputs (fertilizer, water, etc.) supplied, and weeds managed.

Establishing a perennial forage planting may take three to five years. Check with local extension agents for selection of plant materials and guidance on establishing and maintaining the planting.

The best options are:

- Common cover crops
- Plants that act as green fertilizer
- Seed mixtures that are competitive with weeds
- Plant species that require fewer inputs

Hive adjacent to canola field.
Photo Credit: Chris Hiatt

Apiary surrounded by Conservation Resource Program habitat in Kentucky .
Photo Credit: Tammy Horn Potter

Bees in a meadowfoam crop.
Photo Credit: Beetanical Apiaries

Federal conservation programs provide cost-sharing for private landholders to plant pollinator forage. Beekeepers can work with local farmers to encourage participation in these programs.

Another option is to leave pieces of unused land wild for wildflowers and other forage plants to grow. Encourage neighbors, farmers, and others in the community to do the same. Unused land can include fencerows, property borders, ditches, roadsides, land surrounding streams, and other waterways. Runoff borders between crops and water sources are ideal for additional pollen sources for bee colonies. Also, strips can be specifically planted in agricultural land, road shoulders, or utility rights-of-way to create pollinator corridors or alternative forage opportunities. Studies show that competition between plants and alternative pollinator species improves pollination success of target crops.

Pollinator plantings can include wildflowers and other annuals as well as perennials, shrubs, and trees. Though initial set-up and planting may be more expensive and labor-intensive when perennials, shrubs, and trees are included, these plants will be beneficial because they ensure that forage is available in future seasons to support honey bees and native pollinators.

Maintain these plantings to ensure they are not overrun by undesirable weeds. This is particularly important in gardens and urban areas where aesthetics is a factor or homeowner covenants specify grass not diversity. Think of layering a habitat: ground cover with a suitable mixture of flowering plants that can be mowed, bordered by flowering species 1-3 feet (30-90 centimeters) above the ground cover, mid-level plant layer, shrub tree layer, and finally flowering trees at the margins (or as "specimen" plantings spaced within the ground cover).

NATIVE AND ADAPTIVE

When possible, choose species that are native to the habitat and well adapted to the climate. Non-native and ornamental species can also be chosen though beekeepers should make sure they are not known to be invasive.

HONEY & HONEY-BOUND HIVES

When everything goes well, honey harvesting is the payoff for good beekeeping. Bees utilize 120 pounds (27 kilograms) of honey per year (60 pounds in the spring and summer and 60 pounds in the fall and winter). Beekeepers should leave 60 pounds of honey, depending on the season, but also take enough to create space in the hive for the queen to lay and additional resources to be stored. Southern beekeepers may leave less stores because the foraging season is longer; beekeepers in more northerly locations may wish to leave more stores unless they winter bees indoors.

Honey harvesting is a major component of beekeeping operations. Balance a productive honey harvest with the space within a hive. If honey is not removed, the bees can become hive-bound, the queen will not have a place to lay her eggs, and the bees will swarm. Remove honey in a manner that prevents contamination and the spread of pests and diseases.

Harvesting honey.
Photo Credit: Chris Hiatt

SEASONAL SUMMARIES

	Late Winter/ Early Spring	Spring Buildup	Major Nectar Flow	Harvest	Fall	Late Fall
Sugar Syrup Feeding	Light colonies Stimulate brood rearing (1:1 mixture or less)	Feed splits Stimulate slowly in developing colonies Stimulate brood in pollination colonies (1:1)	Feed only in: • Poor seasons or locations • Intensive colony expansion (feed summer splits) • Feed to finish if honey to be harvested in comb	Heavily late splits Feed in seasonal dearth 2:1, but avoid robbing	Feed 4 gallons (15 Liters) of heavy syrup (2:1 per full-sized colony) Transfer honey filled frames to colonies light on stores (if both donor and receiving colonies are healthy)	Emergency feeding of dry sugars (sugar candy). Also feed honey filled frames from freezer
Pollen Supplement Feeding	Brood rearing stimulation Insurance when poor weather prevents pollen access Stimulate colonies for pollination services	Continue patty feeding of pollination colonies to be used in blueberries, cranberries, or vegetable seed production	Not usually recommended. Consider only in: • Poor seasons or locations • Intensive colony expansion	Use patties on splits or in seasonal dearth Avoid "growing" small hive beetles	Little evidence of colony or economic benefit; however, some beekeepers prefer to feed patties when colonies are to be used for almond pollination	Stored fall pollen sufficient until early spring as brood rearing ceases or is greatly curtailed
Water Supply	Provide a clean water source, especially if lack of natural source or contamination is suspected					

KEY POINTS TO REMEMBER

NUTRITIONAL MANAGEMENT

- Honey bees acquire all the essential nutrients for growth and development from nectar and pollen.
- Nectar is the main source of carbohydrates; pollen is the main source of protein, lipids, vitamins, and minerals.
- Feeding sugar syrup is used to stimulate brood rearing in the spring, prepare colonies for winter in the fall, and prevent starvation during periods of nectar dearth.
- Sugar syrup made with pure sucrose (white, refined sugar) is the best option for feeding bees.
- Water is essential – a clean, accessible water source should be provided when no natural sources are available.

POLLEN SUPPLEMENTS & SUBSTITUTES

- Protein supplements are fed to stimulate brood rearing in the spring and prevent population decline during periods of pollen dearth.
- Pollen is the most attractive protein source to bees – adding it to protein supplements greatly increases the supplement's chance of being consumed.
- Not all pollen is equal in nutritional value. Protein content and the number of essential amino acids vary from one pollen source to another.
- Pollen trapped and collected for later use should ideally have around 20 percent protein content and should contain all 10 essential amino acids.
- Pollen can contain pesticide residues and disease spores. Only use irradiated or disease-free pollen.
- When feeding a protein supplement, feeding must be continued until natural pollen sources are available.

HABITAT

- Honey bees require abundant and diverse forage in the area that blooms throughout the season without any significant gaps.
- The carrying capacity of the surrounding area must be considered when deciding where and how many hives to place in a yard.
- Encourage neighbors, farmers, and other community members to participate in conservation programs that cost-share forage planting and/or to leave pieces of unused land for wildflowers and other forage plants to grow.
- Providing a clean, uncontaminated water source is especially important in areas where intensive pesticide use is common.

RESOURCES

BEE NUTRITION

Vanessa Corby-Harris, et al. (2018) Emerging Themes from the ESA Symposium Entitled "Pollinator Nutrition: Lessons from Bees at Individual to Landscape Levels," Bee World, DOI: 10.1080/0005772X.2018.1535951
https://www.tandfonline.com/doi/full/10.1080/0005772X.2018.1535951

DIRTY WATER

Lau, Pierre & Nieh, James. (2014). Drinking dirty water: Why do honey bees (Apis mellifera) collect agricultural water and urban runoff?
https://www.researchgate.net/publication/267521048_Drinking_dirty_water_Why_do_honey_bees_Apis_mellifera_collect_agricultural_water_and_urban_runoff

HONEY BEE HEALTH COALITION RESOURCES

STATE AND FEDERAL BEEKEEPING RESOURCES

The contacts and resources at the following link have been compiled for you by the Honey Bee Health Coalition. The websites or people you visit and contact may provide contradictory information. Please use your own judgment, and seek multiple sources of information prior to decision making. In addition to the federal and state resources contained below, please also seek out local resources and bee clubs and associations.

https://honeybeehealthcoalition.org/federalstateresources

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PRECAUTION AND LEGAL RESPONSIBILITY.

Any product mentioned in this document must be used in accordance with the directions on the label. The user assumes the risk to persons or property that arises from any use of the product in a way that is inconsistent with the label.

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