# TOOLS FOR VARROA MANAGEMENT

## A GUIDE TO EFFECTIVE VARROA SAMPLING & CONTROL

HEALTHY BEES · HEALTHY PEOPLE · HEALTHY PLANET™

HONEY BEE HEALTH COALITION™

Fourth Edition - October 31, 2016

Copyright © 2015 The Keystone Policy Center on behalf of The Honey Bee Health Coalition

This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License. The Honey Bee Health Coalition offers this Guide free of charge, and permits others to duplicate and distribute it. You may not use the material for commercial purposes. If you distribute the Guide, please give appropriate credit to the Coalition as its author. We encourage readers to distribute it to beekeepers and anyone else who can benefit from it.

## ABOUT THE HONEY BEE HEALTH COALITION

The Honey Bee Health Coalition was formed in 2014 as a cross-sector effort to promote collaborative solutions to honey bee health challenges. The diverse Coalition brings together beekeepers, growers, researchers, government agencies, agribusinesses, conservation groups, manufacturers and brands, and other key partners dedicated to improve the health of honey bees and other pollinators. The Coalition's mission is to collaboratively implement solutions that will help to achieve a healthy population of honey bees while also supporting healthy populations of native and managed pollinators in the context of productive agricultural systems and thriving ecosystems.

A major tenet and founding principle of the Coalition is the recognition that the current decline in overall honey bee health is a multi-factorial problem, and all stakeholders have a role to play in managing bee health issues. The Coalition is focusing on accelerating improvement of honey bee health in four key areas: forage and nutrition, hive management, crop pest management, and outreach, education and communications. As part of the hive management focus area, the Coalition has developed this "Tools for Varroa Management" Guide that beekeepers can use to help focus on more effectively controlling the Varroa mite in managed hives.

For more information please visit at *http://honeybeehealthcoalition.org/*

# TABLE OF CONTENTS


ABOUT THE HONEY BEE HEALTH COALITION 2

INTRODUCTION 4
- Integrated Pest Management and Varroa Mite Control 5

ABOUT VARROA MITES 6
- Honey Bee and Varroa Mite Seasonal Development 6

MONITORING VARROA MITE POPULATIONS 7
- Recommended Sampling Methods 7
- Interpreting Sample Findings 9
- Alternate Sampling Methods for Varroa Assessment 10

SELECTING CONTROL METHODS 10
- Summary of Controls Discussed in this Guide 11
- Control Options by Seasonal Phase 11

DESCRIPTIONS OF VARROA CONTROLS 13
- Chemical Controls 14
- Non-Chemical Controls 19
- Disclaimer 22
- Precaution and legal responsibility 22
- Acknowledgements 22

ADDITIONAL RESOURCES 23
- General information 23
- Sampling 24
- USE of MAQS from NOD 24
- Integrated Pest Management 24
- Other resources 25

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, and, ultimately, agricultural food production may be impacted. In addition, colonies with Varroa are a source of mites that can spread to other colonies, even in other apiaries, through drifting, robbing, and absconding activity of bees.

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

This Guide will explain practical, effective methods that beekeepers can use to measure Varroa mite infestations in their hives and select appropriate control methods. The Honey Bee Health Coalition offers this Guide free of charge and asks that you please reference the Coalition if distributing.

This Guide represents the current state of the science regarding Varroa mites. It will be updated as new products or information become available. Check cover page to be sure you have the latest edition.

PHOTO COURTESY OF THE BEE INFORMED PARTNERSHIP

## DESCRIBING VARROA MITE LEVELS

The most accurate way to describe Varroa mite infestation is the **number of mites per 100 adult bees.** For brevity, this Guide expresses mite levels as a percentage.

For example: "3 mites per 100 adult bees" is written as "3 percent" in this Guide.

## Integrated Pest Management and Varroa Mite Control

The information presented in this Guide will best help beekeepers who recognize that optimum management of Varroa is based on understanding:

» The life cycles of both the honey bee colony and the mite.

» The number of mites present in the colony at any point in time.

» How tactics to control mites vary according to the seasonal phase of the bee colony and type of beekeeping operation.

» An IPM approach discourages reliance on a single, repeating treatment; it involves timely use of appropriate tools, including chemical control when necessary.

Successful Varroa control solutions are proactive. They control Varroa before the mites reach levels that threaten colony productivity and survival, rather than respond after the damage has occurred.

***Integrated Pest Management (IPM)*** is a set of proactive, non-chemical and chemical methods that offers beekeepers the best whole systems approach to controlling Varroa.

This Guide presents information about IPM techniques that integrate:

» Rigorous monitoring of mite populations to detect increases in the number of mites early and to assess the effectiveness of controls.

» Use of cultural practices (*i.e.*, breeding, screen bottom board, removal of drone brood, etc.) to deter mite population build-up.

» Rotation of chemical products that considers mite/bee population dynamics and minimizes potential development of mite resistance caused by repeated use of any one chemical control.

IPM techniques can help beekeepers maintain a colony's Varroa mite levels below 2 to 5 mites per 100 adult bees (*i.e.*, a 2 to 5 percent infestation level). Current data suggest that using these treatment thresholds may be a successful strategy for decreasing overall colony losses.

There is no "one-size-fits-all" solution for Varroa management. This Guide also reviews the efficacy, application, advantages, and disadvantages of a wide variety of control methods. This allows beekeepers to choose an approach suited to their individual circumstances and risk tolerance.

Doing nothing about Varroa mites is not a practical option for most beekeepers. Honey bees are not capable of surviving or thriving unless the beekeeper prevents Varroa from reaching damaging levels. If the beekeeper does not control Varroa, a colony will most likely die and, in the process, spread mites and infections to other colonies in the same apiary and surrounding area.

## ABOUT VARROA MITES

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.

Adult Varroa mites are phoretic – they 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.

Even after a colony has been treated, Varroa mites remain and mite populations can increase quickly and unexpectedly. As a rule, in colonies with brood, ***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. Therefore, beekeepers should have an IPM plan in place to frequently and regularly monitor and manage Varroa mites in their colonies.

### Honey Bee and Varroa Mite Seasonal Development

Honey bees and the parasitic Varroa mite cycle through four temporal phases. In some locations, there is one cycle per year and, in other locations, more than one cycle. The phases are:

» Dormant

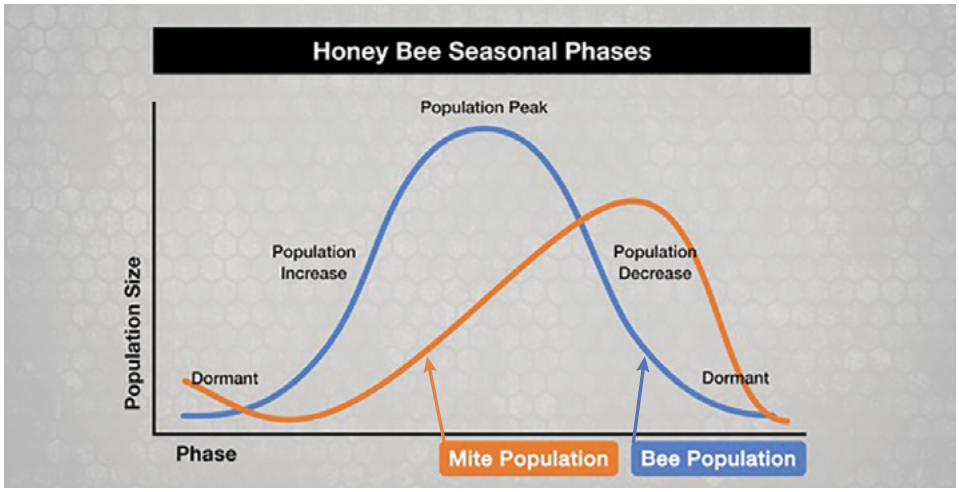
» Population Increase

» Population Peak

» Population Decrease

Varroa mite populations increase and decrease in synchrony with the seasonal pattern of honey bee development. Mite populations reach their highest levels soon after the brood and adult honey bee populations reach their peak, when there are more brood bees on which Varroa reproduce. When the bee population and the amount of bee brood decline, the phoretic mite numbers drastically increase on the adult bees. Eventually, Varroa numbers decrease, along with the adult bee population. The size of the mite population at the start of bee Population Decrease phase is critical because the colony needs to be healthy enough to rear sufficient numbers of bees to survive the dormant phase. During broodless periods, all mites are carried on adult bees, except in locations where reduced brood rearing may be continuous during this phase (see Figure 1).

Figure 1: Varroa Mite Life Cycle




For details on the Varroa Life Cycle consult:
www.extension.org/pages/65450/varroa-mite-reproductive-biology

## MONITORING VARROA MITE POPULATIONS

Bee colonies can tolerate a low number of mites, but will decline or die as mite numbers rise. Monitoring (sampling) for Varroa mites enables a beekeeper to detect a colony's mite population. Accurately assessing and understanding mite population is the basis of an IPM control strategy.

Waiting too long to confirm elevated mite population numbers is risky. A delay in treatment can reduce a colony's likelihood of survival over the winter and contribute to spreading mites to other colonies.

Beekeepers can assess mite populations during any of the phases of bee/mite population cycles. ***Generally, a beekeeper should perform Varroa monitoring assessments at least four times during the year, beginning with the Population Increase phase.***

During the Population Decrease phase, mite levels should be re-checked to confirm that mite numbers are low going into the Dormant phase. During the Dormant phase, sampling should continue, if possible. However, if it is too cold 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.***

Aggressively treat colonies whenever sampling results warrant.

### Recommended Sampling Methods

Two sampling methods provide the best estimates of mite populations. Both involve removing mites from the bodies of adult bees, then counting the mites to establish a standard percentage measure of mite numbers (*i.e.*, number of mites per 100 adult bees). The recommended sampling methods are the ***powdered sugar shake and the alcohol or soap wash.***

This section also evaluates alternative sampling methods that are less reliable than those recommended, but are capable of providing, and should only be used as a secondary confirmation of the Varroa levels indicated by more accurate methods.

*See the References and Additional Resources* section for journal articles on sampling methods.

PHOTO COURTESY OF THE BEE INFORMED PARTNERSHIP

### Equipment Needed:

- Wide mouth jar, such as quart Mason canning jar
- Solid lid replaced with modified # 8 screen mesh
- Powdered sugar, or
- Alcohol (any of the following): ethanol, ethyl alcohol, or isopropyl (rubbing) alcohol, or
- Soap: automotive windshield washer fluid
- White plate, tray, or similar device. (Paper boards or sheets can be used for the powdered sugar shake method.)
- Water mister (to dissolve powdered sugar)

### Collecting the Sample (Both Methods)

Collect a sample of approximately 300 adult bees from one to three brood-nest combs (avoiding the queen). Three hundred bees are equivalent to about ½ cup of lightly packed bees.

- Mark a wide-mouthed, open neck glass or plastic collection jar with a line at ½ cup.
- Select a brood frame. Look for the queen. If she is present, move her to another frame.
- Collect 300 adult bees directly into the collection jar from a brood frame by moving collection jar downward over adult bees so they fall backwards. Or shake bees directly from two or three brood frames into a larger collecting container (honey bucket, cardboard container, or lipped tray) and scoop up ½ cup of bees and quickly pour them into the quart jar.

Experiment with your collection technique to consistently obtain a 300-bee sample.

The powdered sugar shake method is non-lethal, so the bees may be returned to the hive after testing. With the alcohol or soap wash method, the bees will be sacrificed.

### Powdered Sugar Shake Method

1. Add approximately two tablespoons of powdered sugar to the jar.
2. Vigorously shake the jar for at least one minute to cover the bees in sugar and dislodge the mites from the bees. To improve the consistency of mite counts, shake the jar for a consistent length of time for every sample.
3. Set the jar down and wait three to five minutes. (Rushing the process increases the risk of undercounting the mites.)
4. Invert the jar and shake it like a salt shaker, capturing the falling mites onto a clean plate or pan below. Shake the inverted jar until mites stop falling out.
5. Spray the powdered sugar deposit in the plate or pan with a water mist to dissolve the sugar.
6. Count the mites that remain.
7. Add an additional tablespoon of sugar to the jar, shake and roll the bees again for 30+ seconds, and repeat steps 4, 5, and 6 to improve the accuracy of the count.
8. Count the number of mites in the plate or pan.
9. Calculate the mite number per 100 adult bees. (See *Counting the Mites*)
10. Sampled bees can be released back into the top of their colony or at colony entrance.

For best results, sift the powdered sugar through a flour sifter to ensure a fine texture. ***Do not perform this test in high humidity or during strong nectar flow, because dampness will cause the sugar and mites to adhere to the bees.***

### Alcohol or Soap Wash Method

Perform the alcohol or soap wash away from the smoker.

1. Add enough alcohol (inexpensive rubbing alcohol works well) or soap (use a low-sudsing soap, such as winter automotive windshield washer fluid) to completely cover the bee sample in the jar.
2. Vigorously shake the jar for at least one minute to dislodge the mites from the bees. To improve the consistency of mite counts, shake the jar for a consistent length of time for every sample.
3. After shaking, empty the liquid contents into a clear plate or white shallow pan through a mesh screen that traps the adult worker bodies.
4. Add more alcohol or soap to the jar and repeat steps 2 and 3. (This increases the accuracy of the count.)
5. Count the number of mites in the plate or pan.
6. Calculate the mite number per 100 bees. (See Counting the Mites.)

### Counting the Mites (Both Methods)

The goal of mite assessment is to determine the number of Varroa mites per 100 adult bees, expressed as the percentage of infestation.

Counting steps:

» Count the number of mites collected in the plate or pan.

» Divide that number by the number of bees in the sample.

» Multiply by 100 to yield a percentage.

*Example*:

A beekeeper samples 300 adult bees and counts 12 mites in the pan.

12 mites ÷ 300 bees = .04 X 100 = 4% (4 mites per 100 adult bees)

To increase the accuracy of the assessment, count the actual number of bees in each sample. As you gain experience with sampling, your sample sizes will become more consistent.

#### *How many colonies to sample for Varroa mites?*

If an apiary has fewer than ten colonies, sample each colony. For larger apiaries, sample 300 adult bees collected from one brood frame in a minimum of eight randomly selected colonies in each apiary (or 3 percent to 5 percent of total colonies within multiple apiaries).

## Interpreting Sample Findings

When using the recommended powdered sugar shake or alcohol or soap wash sampling methods we suggest ***using the following guidelines (Table 1) to determine when a colony needs treatment and to evaluate treatment.***

Table 1: Treatment Thresholds by Phase;(%=Number of mites/100 adult bees)

| Colony Phase | Acceptable<br>Further control not needed | Caution<br>Control may be warranted | Danger<br>Control promptly |
|---|---|---|---|
| Dormant with brood | <1% | 1-2% | >2% |
| Dormant without brood | <1% | <2-3% | >3% |
| Population Increase | <1% | <2-3% | >3% |
| Peak Population | <2% | <3-5% | >5% |
| Population Decrease | <2% | <2-3% | >3% |

***Acceptable:*** *Current mite populations are not an immediate threat.*

***Caution:*** *Mite population is reaching levels that may soon cause damage; non-chemical control might be employed while chemical control may be needed within a month; continue to sample and be prepared to intervene.*

***Danger:*** *Colony loss is likely unless the beekeeper controls Varroa immediately.*

***When mite levels are below 2 percent,*** the mite numbers are considered to be reasonably low, so immediate control is not needed. If sampling was done after treatment, this low level means that the treatment was successful in reducing the mite population below damaging levels.

***When mite levels are between 3 percent and 5 percent,*** further control efforts may or may not be needed or the beekeeper may decide to wait a week or so before taking another sample. The variable rate of 3 to 5 percent is based on beekeeper risk tolerance – a 3 percent level represents a lower risk of mite damage or colony loss compared to 5 percent or higher levels.

***When mite levels are above 5 percent,*** apply mite control immediately, using a proven, effective, seasonally appropriate treatment method (See Table 3: Control Options by Seasonal Phase). If post-treatment tests show that mite numbers remain above 5 percent after treatment, apply another control chemical or method without delay.

Recommendations on when to treat, and at what percent infestation rate to treat, have recently changed. Beekeepers should stay current with future changes based on new research findings. Older recommendations often suggested waiting until higher infestation levels are reached (10 percent to even 20 percent) before treating, whereas current recommendations emphasize treatment thresholds of 2 percent, 3 percent, or 5 percent.

### *Colony Losses Associated with Varroa Mite Levels*

Various studies have found that winter colony losses increase with higher levels of Varroa mite infestation. Losses can be expected even at a 3 percent infestation, and can increase rapidly with higher infestation levels. Some colony losses are inevitable, but treatment of Varroa can keep losses at sustainable levels for most beekeepers.

### *Use Caution When Interpreting Assessment Results*

Be very careful interpreting results from any single sampling technique. Inexperience with sampling procedures will affect results. Mite infestations vary from one colony to the next. The same level of mite infestation poses different risks during different phases of the bee/mite annual cycle.

### *Sample Often*

Sampling several times throughout the year helps reduce sampling error and increase confidence in sampling results. Frequent sampling can detect mite increases at critical times of the season.

For example, mite populations can rapidly surge after honey harvest, or when colonies stop rearing brood and adult bee population decreases. This is a time when the colony must be healthy enough to successfully rear more bees to survive the Dormant phase. A single sample may not detect a rapid transition of mites from brood to adult bees during this period. A good rule is, "If in doubt, resample."

It is also important to sample after treatment to assess control effectiveness.

## Alternate Sampling Methods for Varroa Assessment

While the two most accurate ways to determine numbers of Varroa mites present during any seasonal phase of a honey bee colony are the powdered sugar shake method and the alcohol or soap wash method, some beekeepers continue to use methods that are less efficient and less accurate or are difficult to obtain consistent results. The Honey Bee Health Coalition does not recommend relying on the methods identified in the following (Table 2) table.

Table 2: Less Reliable Sampling Methods

| Less Reliable Sampling Methods | |
|---|---|
| Method | Concern |
| Ether Roll | ▪ Only detects 50 to 60 percent of mites.<br>▪ Material is highly flammable. |
| Drone Brood Assessment | ▪ Difficult to interpret results of percent of brood infested. Drone brood is not always present when sampling is needed. |
| Visual Inspection of Mites on Adults | ▪ Unless mites are on thorax or top of abdomen, they are not easily seen.<br>▪ Finding mites on adults indicates that a high total mite population already exists. |
| Sticky (debris) Board | ▪ May be useful to check mite population trends or as 'quick check' to confirm treatment effectiveness.<br>▪ Ants or other scavengers might remove mite bodies and interfere with estimates.<br>▪ Difficult to interpret number of mites per hour or per day to estimate total mite population. |

# SELECTING CONTROL METHODS

As stated in the Introduction to this Guide, there is no "one-size-fits-all" solution to Varroa mite management. Each beekeeper should select the control methods that are right for them. Success may require experimentation with several methods. It is important to seek to integrate methods and not simply rely on one chemical or non-chemical control. Relying on a single chemical or family of chemicals for treatment will hasten development of resistance in mite populations.

Newly established colonies, whether from splits or captured swarms, generally have low mite levels the first year and may not need treatment. Older colonies typically have higher mite populations and need highly proactive treatment.

Depending on a colony's level of Varroa infestation, beekeepers should begin to integrate Varroa control methods on colonies exhibiting high mite levels during the Population Increase phase (see Figure 1).

The most critical time to administer Varroa treatment(s) is after honey supers are removed (*i.e.*, at or just after the Population Peak phase).

While mite densities may vary across colonies, all colonies in an apiary should be treated at the same time with the same chemical or non-chemical technique. If sampling results indicate high mite populations in one colony within an apiary, do not delay treatment. Delay increases the risk of harm to the colony and the spread of Varroa mites to other colonies.

***Note:***

» Beekeepers should ensure that all control products are legal for use. Legal restrictions are changing and vary from state to state. ***Read the product label and follow all label instructions and precautions. It is a violation of Federal law to use any registered product in a manner inconsistent with its labelling. Chemical controls should be rotated to delay the development of mite resistance.***

» The efficacy of the various products and treatments identified in the tables and product descriptions below are based on published studies, Bee Informed Partnership Management Surveys (http://beeinformed.org/national-management/), and the collective professional judgment of the principal drafter and HBHC subgroup members. Information presented in the tables below should not be construed as an endorsement or recommendation of any product or treatment.

## Summary of Controls Discussed in this Guide

### Chemical Control Products

» Synthetic Chemicals

- Apivar® (amitraz) *see page 14*
- Apistan® (fluvalinate) *see page 15*
- CheckMite+® (coumaphos) *see page 15*

» Essential Oils

- Apiguard® or Thymovar® (Canada) (thymol) *see page 16*
- ApiLife Var® (thymol + eucalyptol, menthol, and camphor) *see page 16*

» Acids

- Mite-Away Quick Strips® [MAQS®] (formic acid) *see page 17*
- Formic Acid 65% *see page 18*
- Oxalic Acid *see page 18*
- HopGuard® II (hops beta acids) *see page 19*

### Non-Chemical Controls

» Screen Bottom Board *see page 19*

» Sanitation (comb culling/biosecurity)*see page 20*

» Drone Brood Removal *see page 20*

» Brood Interruption *see page 21*

» Requeening with Resistant Stock *see page 21*

PHOTO COURTESY OF THE BEE INFORMED PARTNERSHIP

***See details on each of these controls in the "Descriptions of Controls" section below.***

## Control Options by Seasonal Phase

Different control options are appropriate for each of the four population phases of the honey bee/ Varroa mite seasonal cycle. Below is a summary of options for each seasonal phase.

Table 3: Control Options by Seasonal Phase

| Dormant Phase | |
|---|---|
| Bees are clustered; no brood in northern locations with reduced brood rearing in southern locations; all or most Varroa mites are phoretic (*i.e.*, on adult worker bodies, as there is little to no developing brood) and both populations are in decline because there is little or no reproduction occurring within the colony. | |
| Highly Effective Options:<br>▪ Oxalic acid (fumigation method)<br>▪ Winter or broodless period<br>▪ HopGuard® II | Notes:<br>▪ Best utilized when no brood.<br>▪ Varroa mortality over extended broodless period is high.<br>▪ HopGuard II works best when little/no brood |
| Moderately Effective Options:<br>▪ In beekeeping regions with brood during this phase, Apiguard, Thymovar®, ApiLife Var®, formic acid, or Formic Acid Quick Strips (MAQS®) provided temperatures are within optimal ranges. | Notes:<br>▪ The effectiveness of Apiguard®, Thymovar®, ApiLife Var® and formic acid (MAQS®) during the dormant phase when there is no brood is largely unknown. |
| Least Effective Options:<br>▪ Anything that risks colony success through this phase<br>▪ Screen bottom board | Notes:<br>▪ Screen bottom board removes a small percentage of mites that fall from adult bodies. It is best used in combination with other techniques. |

| Population Increase | |
|---|---|
| Seasonal colony buildup; colony brood population growing rapidly and adult worker population increasing; Varroa mite population usually low but increasing; pre-honey flow supering of colonies. | |
| Highly Effective Options:<br>▪ Apivar®<br>▪ Apiguard®, Thymovar®, or ApiLife Var®<br>▪ MAQS® (formic acid)<br>▪ Drone brood removal | Notes:<br>▪ Apivar® must be terminated after a 42- to 56-day treatment period, two weeks prior to adding supers<br>▪ Apiguard® treatment must be terminated prior to adding supers.<br>▪ ApiLife Var® must be terminated after 2 or 3 treatments (7-10 days each). Remove ApiLife Var® tablets from the hive at least one month before harvesting honey. (If colonies are not used in honey production, use would be OK.)<br>▪ MAQS™ use is legally permitted when colonies are supered.<br>▪ Drone brood removal may be used 2-3 times on strong, populous colonies. |
| Moderately Effective Options:<br>▪ HopGuard® II<br>▪ Colony division<br>▪ Requeening using hygienic stock<br>▪ Basic sanitation | Notes:<br>▪ Hopguard® II effective on smaller colonies during buildup or following almond pollination service. It may help keep mites reduced during buildup but effectiveness needs to be confirmed.<br>▪ Dividing the colony during the Population Increase phase will most likely negatively affect surplus honey production.<br>▪ Hygienic queens are not always available.<br>▪ Basic sanitation may help reduce other stressors. |
| Least Effective Options:<br>▪ Screen bottom board<br>▪ Powdered sugar<br>▪ Mineral oil<br>▪ Failure to perform managements | Notes:<br>▪ A screen bottom board is marginally effective.<br>▪ There is little evidence that powdered sugar or mineral oil has any effect on mite populations. |

| Population Peak | |
|---|---|
| Period of nectar flow and rental of colonies for pollination services; bee population (both adult & brood) at peak; mite populations increasing, nearing peak; often honey supers on colonies. | |
| Highly Effective Options:<br>▪ MAQS®<br>▪ Apivar®, or Apiguard® or ApiLife Var® (if no supers are present or colonies are not producing honey.) | Notes:<br>▪ MAQS®, Apiguard® and ApiLife Var® are not suitable for use in all temperatures. See the detailed descriptions of products below for temperature ranges for use of these products.<br>▪ Apivar® (amitraz) is highly effective. Be cautious about using it too often to avoid risk of developing resistance. |
| Moderately Effective Options:<br>▪ Requeening with hygienic stock<br>▪ Division of colonies<br>▪ HopGuard® II<br>▪ Oxalic acid drip | Notes:<br>▪ Requeening or dividing colonies may negatively affect honey production (if colonies are strong enough to produce surplus). Hygienic or locally selected stock is not widely available.<br>▪ HopGuard® II can be utilized while honey supers in place; it is important to check control effectiveness following use as there is limited field test data.<br>▪ Oxalic acid is best used when there is little or no capped brood in the colony during the Dormant Phase or because of queen replacement that interrupts brood rearing. |

| Population Peak | |
|---|---|
| Least Effective Options:<br>▪ Screen bottom board<br>▪ Drone brood removal | Notes:<br>▪ A screen bottom board removes a small percentage of mites that fall from adult bodies. Use it in combination with other techniques.<br>▪ Drone brood removal is restricted in this phase by the absence of sufficient drone brood and the difficulty of accessing the brood nest beneath honey supers. |

| Population Decrease | |
|---|---|
| Post-honey harvest; bee population decreasing; colonies rearing overwintering bees. Varroa mite populations growing, peaking, and then declining until eventually only phoretic mites on adult bees after colonies become broodless. | |
| Highly Effective Options:<br>▪ Apivar®<br>▪ MAQS®<br>▪ Apiguard®, Thymovar®, or ApiLife Var®<br>▪ HopGuard® II | Notes:<br>▪ Apivar® should not be used until surplus honey is removed.<br>▪ MAQS®, Apiguard®, Thymovar®, and ApiLife Var® are not suitable for use in all temperatures. See the detailed descriptions of products below for temperature ranges for use of these products.<br>▪ HopGuard® II limited test data support its effectiveness. Confirm control effectiveness following use. |
| Moderately Effective Options:<br>▪ Requeening with hygienic bees<br>▪ Dividing colonies<br>▪ Oxalic acid drip | Notes:<br>▪ Hygienic stock is not widely available.<br>▪ Requeening and dividing colonies may be difficult.<br>▪ Oxalic acid is most effective if there is little to no capped brood present. |
| Least Effective Options:<br>▪ Apistan® or CheckMite+®<br>▪ Drone brood removal<br>▪ Screen bottom board<br>▪ Sanitation | Notes:<br>▪ Mite resistance to Apistan® and CheckMite+® is well documented.<br>▪ Colonies are unlikely to raise drones during this phase.<br>▪ Basic sanitation may help relieve stress. |

### Non-Reliable, Non-Tested Methods and Illegal Chemicals

Several treatments are ***ineffective*** for Varroa mite control, including:

» Low-dosage mineral oils

» Additional acids (such as lactic acid)

» Food stimulants and supplements

» Powdered sugar

» Small cell, "natural" comb for the rearing of smaller bees

Beekeepers should never use a non-registered chemical to control mites. Such use may violate both federal and state laws and may result in unintended consequences to the colony and beekeeper.

Other methods that beekeepers may read or hear about should be adequately tested before adoption and should only be used with extreme caution. Always check for efficacy during and after use.

## DESCRIPTIONS OF VARROA CONTROLS

More detailed descriptions of Varroa mite controls appear below.

*Bee Informed Partnership*

The descriptions include "BIP results" from the Bee Informed Partnership (BIP). BIP is a national effort to provide beekeepers with the resources needed to reduce honey bee colony loss by providing

relevant, timely colony data for beekeepers to make informed management decisions.

BIP began as a multi-institutional grant funded by USDA-NIFA and became a non-profit in 2014 to continue the valuable work between commercial beekeepers and technical transfer teams (trained field agents who offer regular, on-site hive inspections and sampling for large commercial beekeepers and queen breeders) as well as those diagnostic and outreach services to all beekeepers.

BIP gathers information about current management practices using both participant surveys and data gathering efforts of Technical Transfer Teams. BIP correlates the survey results and other data with colony health.

The website www.beeinformed.org shares the resulting information about honey bee colony management practices with beekeepers in a user-friendly format and database. The information presented in the BIP results is an analysis of four years of beekeeper winter loss and management practices survey. The results compare colony loss rates between those using a given management practice in a given year and those that do not. BIP results show correlations that are not necessarily evidence of causation, so they should be interpreted with caution.

## Chemical Controls

The registered chemical control products listed in this table, must be used according to their label. Misuse or use **not** in accordance with the label may result in colony loss or damage, adverse effects on the user, and is a violation of federal law. Always read and follow the safety instructions from the label during handling and application of these control products and work in a safe environment.

*Synthetic Chemicals*

| Apivar® | |
|---|---|
| **Name** | Apivar® (Vetó-pharma) |
| **Active Ingredient** | Amitraz (formamidine) |
| **Formulation** | Apivar®: Applied as slow-release impregnated rigid polymer strip |
| **Mode of Action** | Contact |
| **Treatment Time/ Use Frequency** | 42 to 56 days, then remove strips; Treat all hives in apiary at same time. |
| **Time of Year** | **Population Increase:** Only if colonies will NOT be supered within 8 weeks;<br>**Population Decrease:** Immediately following peak population once honey harvested. |
| **Effectiveness** | Up to 95% effective. Please note that this depends on mite resistance and previous exposure. See label for mite resistance management. |
| **BIP Results** | 35 to 47% fewer overwintering colony losses with use in three consecutive survey years. |
| **Conditions for Use** | Place strips between brood frames: check to confirm strips are in the bee brood area within the bee cluster, move if needed, to active brood area. 1 strip per 5 frames of bees.<br>NOTE: Chemical is controlled release so immediate mite kill may not occur. |
| **Restrictions** | Do not use more than 2 times per year; rotate with other chemical controls; do not use when colonies are supered for honey; wait two weeks before supering following use. |
| **Advantages** | Safe and highly effective unless there is mite resistance. |
| **Disadvantages** | Low levels of break-down residue detected in beeswax & honey; potential for mites to develop resistance. |
| **Considerations** | The only legally permissible (*i.e.*, registered for use in bee colonies) amitraz formulation is Apivar®; do not reuse strips; store unopened packages at room temperature; perform resistance test and/or monitor mite levels following use to confirm control effectiveness. (See Bibliography & Resources for information on resistance testing.) |

| Apistan® | |
|---|---|
| **Name** | Apistan® (Wellmark International) |
| **Active Ingredient** | *Tau*-fluvalinate (synthetic pyrethroid) |
| **Formulation** | Impregnated strip |
| **Mode of Action** | Contact |
| **Treatment Time/ Use Frequency** | 42 days (7 weeks); Do not leave strips in hive for more than 56 days (8 weeks); Treat all hives in apiary at the same time. |
| **Time of Year** | **Population Increase:** Before flow if 7 weeks or more until supering;<br>**Population Decrease:** Following honey harvest |
| **Effectiveness** | 95 to 99% but ONLY if no mite resistance |
| **BIP Results** | No difference in survivorship between treated & untreated colonies in 3 of 4 years; 31% fewer overwintering colony losses with use in one survey year. |
| **Conditions for Use** | Temperatures > 50°F (10°C); Do not use during nectar flow. |
| **Restrictions** | Best if daytime temperatures > 50°F (10°C); do not use when colonies are supered for honey. |
| **Advantages** | Highly effective with susceptible mite populations (Note: mite resistance has been well documented). |
| **Disadvantages** | Widespread mite resistance; contamination of hive components (*e.g.*, elevated fluvalinate residues in wax and comb pollen); persistent continued use may affect brood development; interaction with other pesticides can occur and jeopardize colony health. |
| **Considerations** | May adversely affect queen and drone reproductive health; wear latex gloves; perform resistance test before use and/or monitor mite levels following use to confirm control effectiveness. (See Bibliography & Resources for information on resistance testing.) |

| CheckMite+® | |
|---|---|
| **Name** | CheckMite+® |
| **Active Ingredient** | Coumaphos (organophosphate) |
| **Formulation** | Impregnated plastic strip |
| **Mode of Action** | Contact |
| **Treatment Time/ Use Frequency** | Treatment time 6 weeks; Do leave the strips in hive for more than 45 days; Use 2x/ year |
| **Time of Year** | **Population Increase:** Only if colonies will NOT be supered within 6 weeks<br>**Population Decrease:** After honey harvest |
| **Effectiveness** | 85 to 99% (if no mite resistance). Effective against the small hive beetle (but application method is different compared to when used for mite control.) |
| **BIP Results** | No difference in colony survivorship between treated & untreated colonies in 3 of 4 years; 24% fewer overwintering colony losses in 1 survey year. |
| **Conditions for Use** | Wait two weeks after use before supering. |
| **Restrictions** | Do Not use in queen rearing colonies; Do Not use when colonies are supered for honey. |
| **Advantages** | Effective and easy to use when mite populations are susceptible (note: extensive mite resistant populations in United States and Canada); can be used to control the small hive beetle adults (applied in different manner). |
| **Disadvantages** | Mite resistance; organophosphate; contamination of hive components; (*e.g.*, elevated coumaphos residues in wax and comb pollen) long half-life; negative activity with other products; negatively affects reproductive health of queens queen rearing & drones (sperm production). |
| **Considerations** | Wear latex gloves; perform resistance test and/or monitor mite levels following use to confirm control effectiveness. (See Bibliography & Resources for information on resistance testing.) |

*Essential Oils*

| Apiguard® Thymovar® | |
|---|---|
| **Name** | Apiguard® (USA) and Thymovar® (Canada) |
| **Active Ingredient** | Thymol (essential oil) |
| **Formulation** | Apiguard gel - individual hive dose or bulk tub; Thymovar - individual dose as wafer |
| **Mode of Action** | Fumigant |
| **Treatment Time/ Use Frequency** | **Apiguard:** Twice at 2 week intervals, apply individual dosage tray or 50 gm per for double hive (remove or spread remaining gel over frame top bars at end of 4th week)<br>**Thymovar:** Twice at 3-4 intervals, 1 wafer for single hive and 2 for double hive, remove excess materials at end of 2nd application. |
| **Time of Year** | **Population Increase:** Only if colonies will not be supered within 6 weeks<br>**Population Peak:** Only if bees are not storing honey & not during pollination rental if temps are elevated<br>**Population Decrease:** Post-honey harvest or approaching dormancy |
| **Effectiveness** | 74 to 95% (more effective with warmer temperatures) |
| **BIP Results** | 26 to 31% fewer overwintering colony losses with use in 4 consecutive survey years |
| **Conditions for Use** | Temperatures >59°F and <105°F (15 to 40°C) |
| **Restrictions** | Do Not use when colonies are supered for honey. |
| **Advantages** | Naturally derived; no known Varroa resistance to Thymol, easy to use. |
| **Disadvantages** | May reduce queen egg-laying activity; may increase adult and young larvae mortality; works best under warmer temps; may cause bees to beard in hot weather; human skin irritant. |
| **Considerations** | Use Gloves; Effectiveness reduced for light mite infestations; requires closed screen bottom board; do not feed sugar syrup during treatment; consider using spacer rim above brood nest for individual gel trays. (Thymovar – spacer rim is not needed) |

| ApiLife Var® | |
|---|---|
| **Name** | ApiLife Var® |
| **Active Ingredient** | Thymol + camphor, menthol and eucalyptol oil (essential oils) |
| **Formulation** | Tablet: divide into 1⁄4 pieces and place 4 pieces on top of brood box in each corner of the bee cluster. |
| **Mode of Action** | Fumigant |
| **Treatment Time/ Use Frequency** | 2 or 3 tablets for 7-10 days each (leave 3rd tablet in hive for 12 days); Repeat or combine with another chemistry, if heavy mite numbers. |
| **Time of Year** | **Population Increase:** Less effective but better during early season buildup or low mite numbers;<br>**Population Peak:** If honey supers are not present<br>**Population Decrease:** After nectar flow, with temperature considerations |
| **Effectiveness** | 70 to 90% |
| **BIP Results** | 24.5 to 40% fewer overwintering colony losses with use in 4 consecutive survey years |
| **Conditions for Use** | Use between 65 to 85°F (18-30°C); ineffective below 45°F (8°C). |
| **Restrictions** | Do not use more than 2x/year; do not use when colonies are supered for honey; wait one month before harvesting honey following removal of strips |
| **Advantages** | Naturally derived, no known resistance to essential oils mix. |
| **Disadvantages** | Temperature considerations: may run bees out of hive if temperature is 80°F (26°C) or above; increase in bee adult irritability; honey taste tainting. |
| **Considerations** | Wear gloves; high temperatures may cause bees to exit hives and/or adult/brood deaths; may melt plastic hive parts; not available in all states (CA or HI). |

*Acids*

| Mite-Away Quick Strips® | |
|---|---|
| **Name** | Mite-Away Quick Strips® (MAQS®) |
| **Active Ingredient** | Formic acid (organic acid) |
| **Formulation** | MAQS®: saccharide gel strip in a laminated paper wrap formulation of 46.7% formic acid. |
| **Mode of Action** | Fumigant |
| **Treatment Time/ Use Frequency** | Treatment time is 7-10 days. For a full dose, use 2 strips and 1 sachet. For a half dose, use only 1 strip. Replace with fresh strip after a 14 day interval. A single strip can be used every 2 to 6 weeks throughout the beekeeping season. Do not feed colony when using MAQS |
| **Time of Year** | **Population Increase/Population Peak:** Unique chemical that can be used while honey supers present<br>**Population Decrease:** Following harvest if not too warm |
| **Effectiveness** | 61 to 98% under temperature limitations; if too warm (>92°F - 33°C) less effective |
| **BIP Results** | 16 to 31% fewer overwintering colony losses with use in four consecutive survey years. |
| **Conditions for Use** | Full dose (1 sachet, 2 strips) or ½ dose (single strip) per a single or double brood-chamber of standard Langstroth equipment or equivalent hive with a colony cluster covering a minimum of 6 frames. There should be a strip touching each top bar containing brood. Note, when using a ½ dose, a second, single strip treatment is recommended. Use when outside day temperature 50-92° F (10-33°C). |
| **Restrictions** | Temperatures above 92°F (33°C) can cause brood and queen mortality and perhaps bee absconding. Consider using extra hive ventilation or the ½ dose under higher temperatures. |
| **Advantages** | Natural product; OK to use while bees storing honey; able to kill mites under cappings. Not necessary to remove strips following treatment as bees will chew and discard. |
| **Disadvantages** | Potential for bee brood mortality and queen losses. |
| **Considerations** | Applicators and other handlers must wear coveralls over a long-sleeved shirt, long pants, socks and shoes, acid resistant gloves (neoprene or nitrile) and protective eyewear. Although not required a respirator is recommended when handling this material. Clean or replace Personal Protective Equipment (PPE) at end of day's work. Rinse off pesticides at rest breaks. Follow the manufacturer's instructions for cleaning and maintaining PPE. Wash separately in detergent and hot water separately from other laundry; leave screen bottom board (if used) open and add empty hive body or spacer frame above brood chamber for additional ventilation. May see bee bearding first couple of days; use permitted when honey supers on colonies but do use strips in supers. |

| Formic Acid 65 % | |
|---|---|
| **Name** | 65% formic acid |
| **Active Ingredient** | Formic acid |
| **Formulation** | In Canada 65% Formic acid liquid is permitted to be applied in soaked absorbing pads, slow release pads or Mitegone pads |
| **Mode of Action** | Fumigant |
| **Treatment Time/ Use Frequency** | 21- 30 days; Absorbing pad (30-40 ml per 2 story hive) up to 6 applications: one every 1-10 days; Slow release pad (250ml) once, Mitegone (120-125 g formic acid 65% per pad), one pad per 5 frames of bees; 2x per year |
| **Time of Year** | **Population Increase:** Only if colonies will not be supered within 6 weeks<br>**Population Decrease:** Post-honey harvest |
| **Effectiveness** | 60 to 93% under temperature limitations |
| **BIP Results** | None for Canada. |
| **Conditions for Use** | Use when outside temperatures are between 50 - 86 °F (10°C and 30°C), and leave hive entrances fully open. |
| **Restrictions** | Do not use more than 2x/year; do not use when colonies are supered for honey; Stop treatment or remove pads if temperature above 86 °F (30 °C) |
| **Advantages** | Naturally derived, no known resistance to formic acid. |
| **Disadvantages** | Potential for bee brood mortality and queen losses under higher temperature |
| **Considerations** | Applicators and other handlers must wear protective clothing, acid resistant gloves (neoprene or nitrile) and protective eyewear. Although not required a respirator is recommended when handling this material. Clean or replace. Follow the manufacturer's instructions for cleaning and maintaining Personal Protective Equipment (PPE). |

| Oxalic Acid | |
|---|---|
| **Name** | Oxalic Acid |
| **Active Ingredient** | Oxalic acid dihydrate (organic acid) |
| **Formulation** | Sugar syrup drip with syringe or drenching applicator, also Sublimation ( fumigation). NOTE: mist application approved for caged (package) bee use. |
| **Mode of Action** | Contact |
| **Treatment Time/Use Frequency** | Treatment at application; Use no more than 2x/year. |
| **Time of Year** | Early population increase and late population Decrease when brood is little and brood rearing reduced<br>**Dormant Phase:** Best used when brood not present |
| **Effectiveness** | 82 to 99% when brood not present |
| **BIP Results** | 37 to 41% fewer overwintering colony losses with use in 2 consecutive survey years. |
| **Conditions of Use** | Mix 32 gms (approx. 1.2 tablespoons) of oxalic acid into 1 liter of 1:1 sugar syrup. With syringe trickle 5 ml of this solution directly onto the bees in each occupied bee space in each brood box; maximum 50ml per colony of Oxalic acid in sugar syrup; fumigation of 2 g per hive and follow label and vaporizer directions. |
| **Restrictions** | Recently registered for use in US; Permitted in Canada. Do not use in enclosed overwintering areas and when honey supers are in place |
| **Advantages** | Cleanses bee adults of mites during broodless periods. |
| **Disadvantages** | Corrosive; Liquid application may chill adult cluster. Not effective in colonies with much brood. Fumigation application is extremely dangerous to applicator health - follow label precautionary directions for handling, must use acid resistant gloves, protective eyewear and respirator to apply. |
| **Considerations** | Legalized in US in Spring 2015<br>*http://www3.epa.gov/pesticides/chem_search/ppls/091266-00001-20150310.pdf* |

| HopGuard® II | |
|---|---|
| **Name** | HopGuard® II |
| **Active Ingredient** | Potassium salt (16%) of hops beta acids (organic acid) |
| **Formulation** | Folded cardboard strips |
| **Mode of Action** | Contact |
| **Treatment Time/ Use Frequency** | One folded strip/ 5 frames of bees in each brood box, 4 week treatment; Max use 3 times per year |
| **Time of Year** | **Population Peak:** Ok to use when honey supers on hive; limited data suggest checking effectiveness after use.<br>**Population Decrease:** Especially when brood reduced.<br>**Dormant Phase:** Suggested use when brood not present or brood reduced. |
| **Effectiveness** | Data suggests HopGuard® II optimally effective when little or no sealed brood present. May also be used when honey suppers are in place, and at the onset of winter brood development or following almond pollination. Effectiveness range 75-95 %. More effective with little to no brood. |
| **BIP Results** | 10% fewer overwintering colony losses with use in one survey year. |
| **Conditions for Use** | Corrosive – use appropriate clothing and eye protection. |
| **Restrictions** | Recently registered (Section 3) in all states but individual states need to approve registration in state. Check with State Department of Agriculture for registration status in your state. Only use strips, discard any leftover excess liquid material in the pouch.<br>Registration in Canada is pending. |
| **Advantages** | Natural compound; No known resistance to Hopguard; can be used during honey flow. |
| **Disadvantages** | Strips are "messy" to use; use disposable gloves; check effectiveness of mite control following treatment. |
| **Considerations** | New material only available 2 years and formulation changed in second year; little data or experience reported with product use. |

## Non-Chemical Controls

| Screen Bottom Board | |
|---|---|
| **Name** | Screen Bottom Board |
| **Technique** | Replace solid bottom board with #8-mesh (1/8") screen surface |
| **Formulation** | Passive |
| **Mode of Action** | Falling mites drop out of colony through screen. |
| **Treatment Time/ Use Frequency** | Continuous, year-round |
| **Time of Year** | Year-round, unless in cold climate regions, it should be removed. |
| **Effectiveness** | Perhaps up to 10% effective (in northern areas only) |
| **BIP Results** | Nationally no advantage in 4 consecutive survey years; however, in northern states a 12.4% reduction of loss was recorded in one survey year. |
| **Conditions for Use** | Replace hive bottom; leave space below for trash ('garbage pit'). |
| **Restrictions** | May attract scavengers beneath hive; may reduce brood rearing in lowest box during population increase (early spring) and bees may be hesitant to go downward into lowest brood box to rear brood. |
| **Advantages** | Low-tech and inexpensive; may be used with hive debris sticky board; an be used with stickyboard as monitoring method for Varroa infestation. |
| **Disadvantages** | Minimal to little control; may need to close hive bottom when fumigant Varroa control chemicals are used; may inhibit brood rearing in lower frames in spring with cool temperatures. |
| **Considerations** | Minimally to not effective; must be used with other controls; not reliable as single control technique; works best with good hive location (sunny site, good air drainage and hive ventilation with winter protection in northern locations). |

| Sanitation | |
|---|---|
| **Name** | Sanitation (bee biosecurity) comb management |
| **Technique** | Brood Comb Culling (replacement) + culling brood comb with high number of drone cells; basic hive sanitation; locating hives in sunny sites with good air drainage; Reducing bee adult drifting. |
| **Formulation** | Remove and replace brood frames every 3 to 5 years; remove brood frames with more than ⅓ of cells with drone-sized cells/brood |
| **Mode of Action** | Culling older brood frames and removing drone brood cells to reduce accumulated residues in hives; remove dead-outs; store equipment inside or covered stacks for security; place hives in sunny areas with good air drainage; space out colonies in apiary by adding distinguishing color, markings, or apiary landmarks to reduce drifting of adult bees; clean hive inspection tools between hives. |
| **Treatment Time/ Use Frequency** | Continuous examination and taking actions as needed every time hives inspected. Move undesired frames to edge of box during active season, remove when broodless. |
| **Time of Year** | **Population Increase** and **Population Decrease** |
| **Effectiveness** | Unknown; considered to improve overall colony health and bee environment in the hives. |
| **BIP Results** | Beekeepers who replaced more than 50% of their comb in a given year lost more colonies than those beekeepers who did not replace any comb in all 4 survey years. |
| **Conditions for Use** | Possible negative effect on bee population if 5 or more combs removed at one time. |
| **Restrictions** | May reduce potential honey harvest; brood comb culling best performed under ideal comb drawing conditions (or replace with empty drawn honey combs from honey supers). |
| **Advantages** | May assist with improving overall bee colony health and performance and reduce accumulated residues of used control chemicals for Varroa control. |
| **Disadvantages** | Culling costs in colony resources. |
| **Considerations** | Minimally to not effective if used without other controls; avoid movement of frames or bees between colonies except as specific management activity. |

| Drone Brood Removal | |
|---|---|
| **Name** | Drone Brood Removal (Drone Trapping Varroa) |
| **Technique** | Remove and destroy drone brood once capped. |
| **Formulation** | Use drone frames in brood chamber. |
| **Mode of Action** | Mites preferentially attracted and reproduce in drone brood; removal of capped drone cell selectively removes mites without harming adult bee population. |
| **Treatment Time/ Use Frequency** | Treatment at Population Increase and Peak Population. Remove drone brood at 28-day interval (before adult bees emerge). |
| **Time of Year** | Only when colonies rear drones (**Population Increase** and **Peak Population**) |
| **Effectiveness** | Not as effective as stand-alone treatment; effectiveness compounded by repeating 2 to 3x during colony population increase. |
| **BIP Results** | Nationally 11% fewer overwintering colony losses detected in 1 of 4 years; however, northern states saw 10 - 33% reductions in loss recorded by operations using this technique in 3 of 4 years. |
| **Conditions for Use** | Only applicable during population Increase and peak population when colonies actively rearing drones. |
| **Restrictions** | Need to remove capped brood in timely manner before adult drones emerge. |
| **Advantages** | Inexpensive and effective. |
| **Disadvantages** | Time consuming management; may be minimally effective. |
| **Considerations** | Use colored drone comb or shallow frame in standard box (stimulating bees to build drone comb from bottom bar); cull drone cells built between brood boxes; to improve effectiveness, reduce drone brood on other brood combs to consolidate for easier removal. |

| Brood Interruption | |
|---|---|
| **Name** | Brood Interruption |
| **Technique** | Interruption of colony brood cycle |
| **Formulation** | Divide colony (can combine this method with requeening using with Varroa resistant stock); or cage queen for 1-2 weeks to disrupt egg-laying, thus interrupting brood rearing. |
| **Mode of Action** | Interrupt growth cycle of mite population. |
| **Treatment Time/ Use Frequency** | Treatment during Population Increase or Post-population peak (during nectar flow or post-harvest). Use once annually; may reduce harvest yield. |
| **Time of Year** | **Population Increase**, **Peak Population** or **Post-harvest** |
| **Effectiveness** | Little data; not a stand-alone treatment. |
| **BIP Results** | No information |
| **Conditions for Use** | Need a queen or queen cell for each division created. |
| **Restrictions** | Splitting and requeening splits difficult when there are few forage resources. |
| **Advantages** | Non-chemical and potentially effective It utilized with adult mite cleaning chemical control & subsequent introduction of hygienic/resistant stock. |
| **Disadvantages** | Requeening and/or holding original queen in cage not always successful; highly time consuming; need to purchase or raise queens to place queen in split. In short season climates it may effect honey production.. |
| **Considerations** | Effective but requires good beekeeping skills for season-long management (commercial beekeepers who split their colonies tend to retain the newer colonies better than non-split ones); may use brood interruption to create time with no capped brood cells and use chemical control that is effective when there is no brood (oxalic acid or HopGuard® II); potential lower honey harvest or population growth due to delay in brood production. |

| Requeening | |
|---|---|
| **Name** | Requeening (ideally with Varroa resistant stock) |
| **Technique** | Utilize bee stock with demonstrated hygienic or other mite reducing behaviors, if possible. |
| **Formulation** | Requeen using selected stock. |
| **Mode of Action** | Selected stock demonstrates slower mite population growth. |
| **Treatment Time/ Use Frequency** | Treatment during Population Increase or Peak Population or post-honey harvest. Use annually when queens available. |
| **Time of Year** | **Population Increase:** As necessary<br>**Peak Population:** Post honey harvest<br>**Population Decrease:** Making of nucs |
| **Effectiveness** | Long-term solution to reduce need for chemical controls. Works well when combined with other methods. |
| **BIP Results** | Low survey responses. Use of locally selected bee stock resulted in 18 to 41% fewer overwintering losses in 3 consecutive survey years; Caucasian hybrid stock: 42% fewer losses; Buckfast hybrid stock: 92% fewer losses; Buckfast bees: 84% fewer losses; no statistically significant results for Varroa Sensitive Hygiene (VSH) or Minnesota (MN) Hygienic from 3 consecutive survey years. |
| **Conditions for Use** | Works best with proper queen introduction methods |
| **Restrictions** | Not always easy to introduce new queen into colony, especially when resources are not abundant. |
| **Advantages** | Stocks selected for mite resistance or tolerance may reduce chemical dependency. |
| **Disadvantages** | Cost of buying or rearing queens; requeening not always successful. |
| **Considerations** | Known stocks with some potential mite population reductions: Varroa Sensitive Hygiene (VSH), Russian bees, Carniolan bees (in northern locations), Minnesota Hygienic, improved Carniolan stock, Buckfast bees. |

## Disclaimer

The Honey Bee Health Coalition, its members, Keystone Policy Center, and their respective representatives, directors, officers, agents, independent contractors, and employees (hereinafter collectively referred to as "Authors") disclaim any liability for loss or damage resulting from the use and application of any mite treatment product or Varroa control technique referred to or described in this Guide. The treatment products and control techniques referred to in this Guide are generally recognized as beekeeper standard practice and specific pesticides are labeled for such use. No warranty of accuracy or reliability is given, and the Authors shall not be responsible to any person for any loss or damage, including by reason of negligence. Nothing in this Guide is intended as an endorsement or recommendation of any product or technique. Readers should exercise their own judgment in researching information and making decisions about their respective situations. It is the responsibility of the reader to evaluate the accuracy, completeness or utility of any information or other content of this Guide. Readers desiring further information are encouraged to consult their local university extension service.

## 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.


## Acknowledgements

The Honey Bee Health Coalition would like to give special thanks to members and peer reviewers that helped compile information, draft, review, and edit the Tools for Varroa Management Guide.

**Special thanks to:**

***Principal drafter:***

» Dr. Dewey M. Caron* - Western Apicultural Society, Emeritus Professor University of Delaware and Affiliate Faculty Oregon State University

***Honey Bee Health Coalition Sub-group:***

» Mark Dykes* - Apiary Inspectors of America

» Dr. David Epstein* – *Ex*-officio, U.S. Department of Agriculture, Office of Pest Management Policy

» George Hansen – American Beekeeping Federation

» Dr. Medhat Nasr* – Alberta Argriculture and Forestry – Canadian Association of Professional Apiculturists

» Danielle Downey* - Project Apis m.

» Karen Rennich* – The Bee Informed Partnership

» Dick Rogers – Bayer Bee Care Center

» Robert M. Sears – Eastern Missouri Beekeepers Association

» Dr. Thomas Steeger* – *Ex*-officio, U.S. Environmental Protection Agency

***Denotes members of the Revision Committee**

***Peer reviewers:***

» Peter Loring Borst – Finger Lakes Beekeeping Club

» Dr. Rick Fell – Virginia Tech

» Katie Lee – University of Minnesota

» Dr. Eric Mussen – University of California Davis

» Dr. Juliana Rangel-Posada – Texas A&M University

**The views and opinions expressed in this document are those of the author and do not necessarily reflect those of the U.S. EPA, USDA, or the U.S. Government.**

# ADDITIONAL RESOURCES

## General information


Dieterman, *et al.* 2013. *Varroa destructor*: research avenues towards sustainable control. Journal of Apicultural Research 51(1): 125-132 summary information on taxonomy, collection, species identification (morphological and molecular), and experimental collection, rearing and preservation of mites.

Frazier, M, Caron, Dewey and VanEngelsdorp, D. 2011. A Field Guide to Honey Bees and Their Maladies. Penn. State Univ. Pub. AGRS-116. 98 pp. A field guide essential for all beekeepers. Excellent photographs for identification of diseases and pests.

Huang, Z. (2013). Varroa Mite Reproductive Biology - eXtension. Retrieved August 9, 2015 from, *http://www.extension.org/pages/65450/varroa-mite-reproductive-biology#.Vbgvu7BFBjp.*

Lee, K. et al. (2010a). Standardized sampling plan to detect Varroa density in colonies and apiaries. Amer. Bee Journal. 150: 1151-1155.

Moore, P., Wilson, M., & Skinner, J. (2015). Honey Bee Viruses, the Deadly Varroa Mite Associates - eXtension. Retrieved August 9, 2015, from *http://www.extension.org/pages/71172/honey-bee-viruses-the-deadly-varroa-mite-associates#.VbgmtLBFBjo*

Morse, Roger & Flottum, Kim. 1997. Honey Bee Pests, Predators and Diseases. A.I. Root, Medina, OH. ISBN 0936028106. 718 pp. Hardback. Not updated varroa information.

Nasr, M. 2015. Recommendations for Management of honey bee diseases and pests in Alberta 2014-2015. *http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/prm13239/$FILE/2014-recommendations.pdf*

Rosenkranz, P., Aumeier P., & Ziegelmann, B. 2010. Biology and control of *Varroa destructor*. Jour Invert Pathology 103: S96-S119

Sammataro, D. 2014. Diagnosing Bee Mites, with emphasis on Varroa. Northern Bee Books, UK. Retrieved August 9, 2015, from *http://www.ars.usda.gov/services/docs.htm?docid=2744&page=14* webpage for mite reproduction

Sammataro, D. (2011). Global Status of Honey Bee Mites. Challenges and Sustainable Solutions Honey Bee Colony Health Contemporary Topics in Entomology, 37-54.s

Webster, Thomas, & Delaplane, Keith. 2001. Mites of the Honey Bee. Dadant and Sons, Hamilton, IL. ISBN 978-0915698110. 280 pp. Paperback. Older information but good general biology chapter by S. Martin Biology and Life History of Varroa Mites and chapter by M.T. Sanford. Introduction, Spread and Economic Impact of Varroa Mites in North America.

## Sampling

Dietemann, V., *et. al.* 2013 Standard methods for varroa research. COLOSS BEEBOOK Volume II: Standard methods for *Apis mellifera* pest and pathogen research Ed by Vincent Dietemann,

Ellis, J. D., Neumann, Peter. Jour Apic. Res. (2013) Vol 52(1).

Lee, K. *et al.* 2010a. Standardized sampling plan to detect Varroa density in colonies and apiaries. Amer. Bee Journal. 150: 1151-1155.

Lee, K. *et al.* 2010b. Practical sampling plans for *Varroa destructor* in Apis mellifera colonies and apiaries. J. Econ. Entomology 103(4).

### Sampling for varroa tutorials

*www.extension.umn.edu/honeybees*

*https://agdev.anr.udel.edu/maarec/educational-resources/powerpoints*

*http://capabees.org/content/uploads/2013/02/varroathreshold.pdf*

*www.scientificbeekeeping.com*

*www.beeinformed.org/2011/09/test-for-varroa/*

## USE of MAQS from NOD

*http://nodglobal.com/application-usa/* In English for US Beekeepers (also w/ Spanish subtitles)

*http://nodglobal.com/application-can/* In English w/ French subtitles for Canadian beekeepers

*https://www.youtube.com/watch?v=UAZvkjHaA1g&feature=youtu.be*

*https://www.youtube.com/watch?v=Y6s6mqUvab0&feature=youtu.be*

### Varroa information

Good general information on varroa mites *http://nodglobal.com/the-varroa-mite/*

From Vita infographic on v*arroa www.vita-europe.com/gallery*

## Integrated Pest Management

Delaplane, K.S. & Hood, W.M. 1999. Economic threshold for *Varroa jacobsoni* Oud in the southeastern USA. Apidologie 30:383-395

Delaplane, K,S., Berry, J.A., Skinner, J.A., Parkman, J.P., and Hood, A.M. 2005. Integrated pest management against *Varroa destructor* reduces colony mite levels and delays treatment threshold. J. Apic. Res. 44(4): 157–162.

### Screen Bottom board

Calderone, N.W., 1999. Evaluating Sub sampling Methods for Estimation Numbers of *Varroa jacobsobi* Mites Collected on Sticky Boards, Journal of Economic Entomology, Vol 92 (5): 1057-1061

Ellis, J.D., Delaplane, K.S. & Hood, W.M. 2001 Efficacy of a bottom screen device, Apistan™, and Apilife Var in controlling *Varroa destructor* ABJ Vol 141 (11):813-816.

### Hygienic bees

Harbo, J., and Harris, J. 2001. Resistance to *Varroa destructor* (Mesostigmata: Varroidae) when mite-resistant queen honey bees (Hymenoptera: Apidae) were free-mated with unselected drones. Jour. Econ. Entomol. 94: 1319-1323.

Harris, J. 2007. Bees with Varroa Sensitive Hygiene preferentially remove mite infested pupae aged < five days post capping. J.Apic. Res. 46: 134-139.

McNeil, M.E.A. 2014 Survivor stock. Amer B Jour 154(10):1087-1089

Spivak, M. 1996 Honey bee hygienic behavior and defense against *Varroa jacobsoni* Apidologie 27:245-260

### Chemical control

Berry, J.A., W.M. Hood, S. Pietravalle, and K.S. Delaplane. 2013. Field-level sublethal effects of approved bee hive chemicals on honey bees (*Apis mellifera* L). PLoS ONE DOI: 10.1371/journal.pone.0076536

Delaplane, K.S. and Berry, J.A. 2010. A test for sub-lethal effects of some commonly used hive chemicals, year two. Proceedings of American Bee Research Conference, Orlando, Florida. American Bee Journal 150(5): 498-499.

Oliver, R. 2014. Amitraz: red flags or red herrings. American Bee Jour 154(10): 1119-1112

### Miticide resistance

Beltsville (Pettis) Test to Detect Varroa Mite Resistance to Apistan and Coumaphos: *http://www.agf.gov.bc.ca/apiculture/factsheets/223_pettistest.htm*

### Other

Berry, J.A., Owens, W.B., & Delaplane, K.S. 2010. Small-cell comb foundation does not impede Varroa mite population growth in honey bee colonies. Apidologie 41: 41-44 doi 10.1051/apido/2009049.

Berry, J.A., Afik, O., Nolan IV, M.P., and Delaplane, K.S. 2012. Revisiting powdered sugar for Varroa control on honey bees (*Apis mellifera* L). Journal of Apicultural Research 51(4): 367-368.

Chandler, D., Sunderland, K. D., Ball, B. V. & Davidson, G. 2001 Prospective Biological Control Agents of *Varroa destructor* n. sp., an Important Pest of the European Honeybee, *Apis mellifera*. Biocontrol Science & technology 11(4): 429-448.

Ellis, A, Hayes, Gerry W., and Ellis, James D. 2009 The efficacy of dusting honey bee colonies with powdered sugar to reduce varroa mite populations Jour Apic Res. Vol. 48 (1): 72 - 76.


## Other resources

*www.scientificbeekeeping.com*

*www.beeinformed.org/2011/09/test-for-varroa/*

Bee Health App i Tunes:

*https://itunes.apple.com/ca/app/bee-health/id1005231410?mt=8*

Bee Health App google Play:

*https://play.google.com/store/apps/details?id=ca.ab.gov.beehealth&hl=en*