# GUIDE TO VARROA MITE CONTROLS FOR COMMERCIAL BEEKEEPING OPERATIONS

HONEY BEE HEALTH COALITION

June 1, 2021

Photo Credit: George Hansen

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## INTRODUCTION

Commercial beekeepers are caught in a vicious cycle with regard to control of Varroa mites (Varroa destructor). They can use approved Varroa mite control products that may be unaffordable or they can use cheap, off-label products that appear effective in the short term, but risk increasing mite resistance and ultimately adding to beekeepers' economic losses. While there is no "silver bullet" for eliminating Varroa mites, this guide shows how some commercial beekeepers are succeeding by applying various combinations of cultural and approved/registered chemical controls.

For three decades, commercial beekeepers have been battling Varroa mites by using both chemical varroacides and non-chemical methods, such as brood interruption. Some varroacides, like the organophosphate pesticide coumaphos and the synthetic pyrethroid pesticide tau-fluvalinate, were effective in the past, but are now much less useful because Varroa mites have developed resistance to those chemicals. Today, amitraz is the varroacide most widely used by commercial beekeepers, and it currently represents one of the most effective means of controlling Varroa mites. However, inevitably, Varroa mites will develop widespread resistance to amitraz. There are signs that some beekeepers are already beginning to see resistance.

In the short term, relying on off-label products to treat Varroa may seem to be the lowest-cost strategy. But overuse of amitraz, for example, increases the long-term risk of mite resistance and significant economic damage to the industry, as beekeepers may be left without effective control options. The operational decisions that each beekeeper makes will either promote or reduce the likelihood of developing resistance.

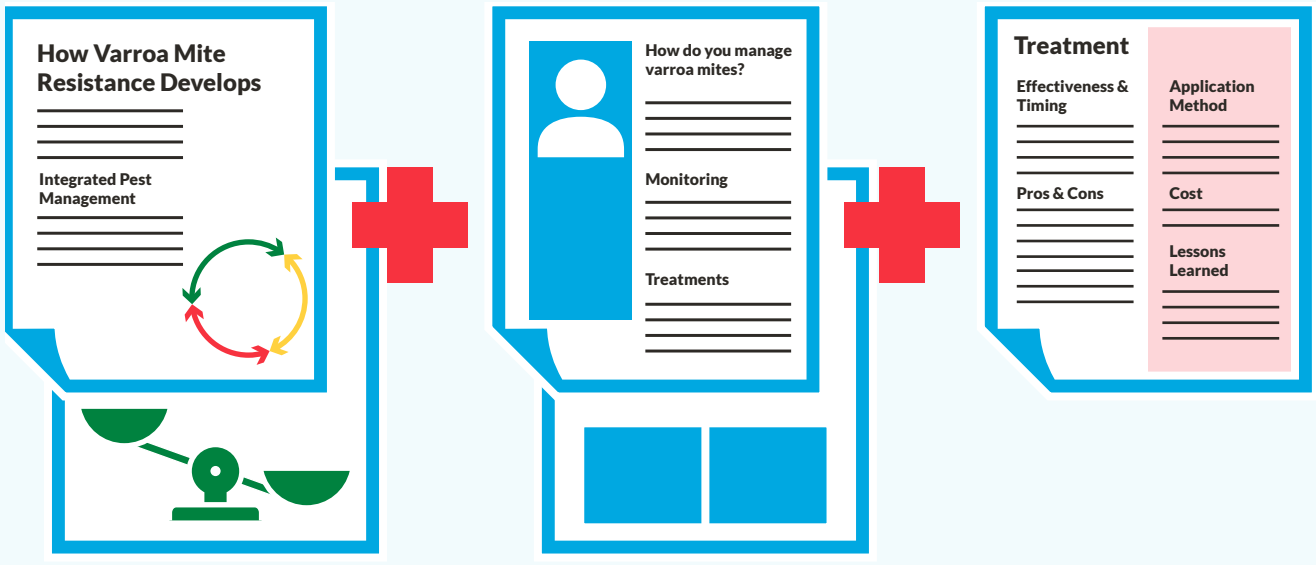
Using unregistered products to control Varroa also creates risks to bees, to honey (contamination), to beekeepers themselves, and to the beekeeping industry. These products, many of which are not formulated for use in or around honey bee colonies, may have long-term detrimental consequences even if bees are able to tolerate them in the short term.

## What's In This Guide

This guide is intended to help commercial beekeepers evaluate a variety of Varroa control methods that can be integrated into a management plan to protect their bees and their business. It highlights the experiences of beekeepers who are having success as they explore alternative strategies to limit their reliance on off-label amitraz and avoid using unregistered products. As new products and formulations are approved in the future, we will update this guide, so that it reflects current science and regulatory decisions. The guide includes:

- A **review of the causes and impacts** of Varroa mite resistance to varroacides
- **Case studies** of Varroa control approaches used by six commercial beekeepers from different regions of the U.S.
- A **discussion of several control methods** that can be used in an integrated pest management (IPM) strategy or a highly specific, knowledge-driven approach, referred to as *precision apiculture*

The Honey Bee Health Coalition does not condone off-label use of amitraz. However, its members recognize that such use is a current reality for many commercial beekeeping operations. Our goal is to lay out a vision for the future that addresses the risks of resistance created by off-label use. Widespread resistance to amitraz is a question of 'when' not 'if', and poses a serious threat to the long-term financial health of every commercial beekeeping business. Continuous use of off-label amitraz, with increasing dosages (as it becomes less effective), is likely to cause amitraz to lose its effectiveness in the near future, just as coumaphos and tau-fluvalinate have become largely ineffective for controlling Varroa mites.



## How Varroa Mite Resistance Develops

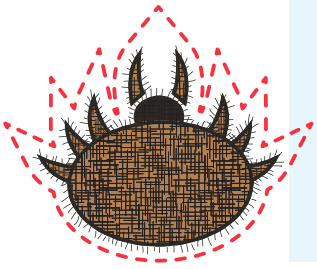
As many commercial beekeepers have learned, pesticides, such as those intended to control the Varroa mite, can lose their effectiveness over time as the target pest develops resistance.

In general, "resistance" is defined as a **significant decrease in the sensitivity of a pest population to a pesticide.** It is a heritable trait, passed from generation to generation. Pests and pathogens evolve and adapt to changes in the physical, chemical, and biological stressors in their environment. Continuous exposure to a single product can accelerate adaptation and promote resistance development. Each exposure that doesn't kill a mite directly enables a proportion of the mite population that is less sensitive to the product to proliferate. As time goes by, resistance traits become amplified among survivors.

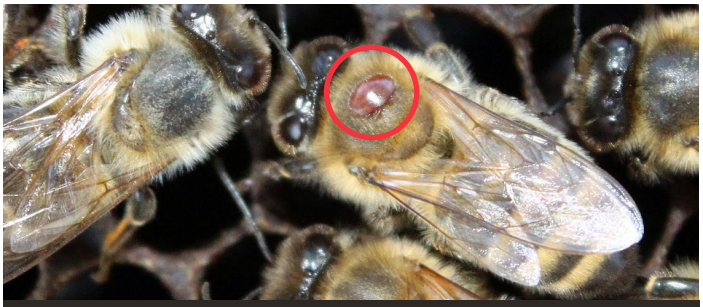
### VARROA MITE RESISTANCE CAN LEAD TO SIGNIFICANT ECONOMIC LOSSES

When faced with declining efficacy of amitraz, many beekeepers are resorting to more frequent treatments at higher doses. Some are using unapproved products, such as Taktic™ (12.5% amitraz) and Bovitraz™ (12.5% amitraz). These approaches may still be the least expensive options in terms of both direct product costs and indirect labor costs. But pursuing these cost savings may increase the risk of catastrophic losses in the future, as resistant mites cause colonies to fail.

The potential for widespread Varroa mite resistance to amitraz and the evidence of amitraz-resistant mites in commercial operations should cause great concern among beekeepers, especially because there is currently no single substitute varroacide available. If other mites, such as Tropilaelaps, enter managed colonies in the U.S., similar concerns about pesticide resistance may emerge.



*Varroa mite specimen.* Photo Credit: Bee Informed Partnership



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

In this document, some beekeepers profiled also use the word "resistance" to describe the process of selecting colonies that exhibit traits or hygienic behaviors to control Varroa mites, and raising and selling queens from those colonies. **Please note: mite-resistant colonies and mite resistance to pesticides are two fundamentally different biological processes.**

Research on migratory colonies conducted by the USDA has detected mite resistance to amitraz in some commercial beekeeping operations; however, the extent of resistance can vary widely within and across apiaries (see Appendix). At this time, the population of these resistant mites has not yet expanded, but the researchers cautioned that small changes in the efficacy of amitraz can translate to large changes in colony survivorship.

If beekeepers continue to rely on amitraz as their only weapon against Varroa, it's only a matter of time until widespread resistance emerges. ***Then what?***

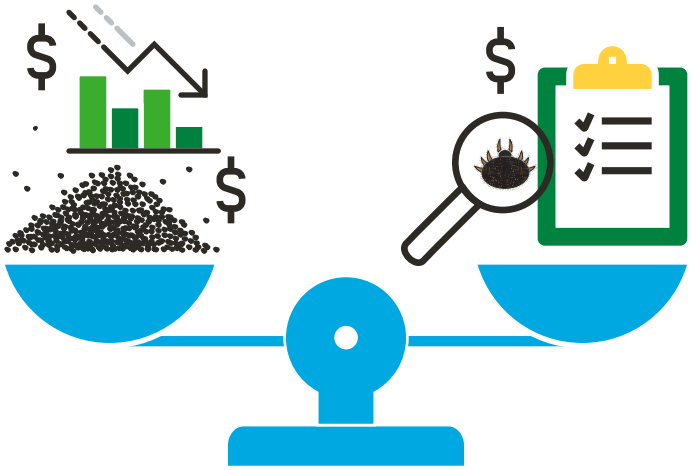
## Chemical Contamination

When a miticide, such as amitraz, becomes less effective, beekeepers tend to compensate by using higher and higher amounts of the product. This approach can cause an accumulation of residues and raise in-hive exposure levels that have undesirable effects on honey bees.

- USDA surveys have detected widespread residues of amitraz and its degradation product, DMPF, in both wax and honey. These residues were found in 69% of wax samples and 76% of honey samples.
- In 2010, 98% of the wax samples collected from migratory colonies contained significant *tau-fluvalinate* residues, which were the highest measured of all pesticide residues.
- Peak residues of coumaphos, which is also frequently detected in wax, are similar to exposure levels in studies in which there were significant increases in the number of rejected queen grafts and decreases in the weight of queen pupae.

Public awareness of residues in honey and beeswax may reduce consumer trust in the integrity, safety and wholesomeness of these products and pose a serious threat to the beekeeping industry. The Food and Drug Administration (FDA) monitors various commodities, including honey, for pesticide residues. If residues exceed legal limits (tolerances) set by the Environmental Protection Agency (EPA), FDA may take enforcement action. Honey wholesalers may also reject shipments of honey that exceed tolerances.

Multiple factors affect colony health and the influence of each factor can vary over time and space. Commercial beekeepers must be vigilant and adapt to balance economic loss thresholds and the costs of monitoring, maintenance, and treatment.



**Trade-offs** involve uncertainties and ramifications that are either considered in advance or become apparent later, when it may not be possible to reverse them. The adage "pay now or pay later" is particularly relevant with respect to pesticides, such as varroacides, which are intended to be toxic. Before going on the market, these products are evaluated for their efficacy and, perhaps more importantly, for their margin of exposure (MOE), which is the margin between the toxicity effect level and the exposure dose for humans. The lower the MOE, the more likely the chemical is to pose an unreasonable risk, both to humans and to bees.

For varroacides, formulation-specific data help to inform regulatory decisions regarding this margin for bees when the product is applied in accordance with the directions for use on the label. However, there is also an MOE for the applicator. When any pesticide is used inconsistently with label specification, the MOE for non-target organisms (e.g., bees and humans) becomes an unknown. Therefore, business decisions which weigh costs versus benefits may not be fully informed. When MOEs are left to chance, those costs are inevitably born by bee colonies, applicators and unwitting consumers.

**MAXIMUM LEVEL**

A tolerance is the EPA-established maximum residue level of a specific pesticide chemical that is permitted in or on a specific human or animal food in the U.S. For amitraz, including its metabolites and degradation products, the tolerance is 0.2 mg/kg in honey and 9 mg/kg in honey comb (https://www.federalregister.gov/documents/2013/03/20/2013-06191/amitraz-pesticide-tolerances).

As discussed above, the use of multiple products at levels well beyond what is specified on product labels has led to a record of exposures in various colony matrices (i.e., beebread, wax, honey) at concentrations that surpass most other compounds being detected. These residues may impact the quality and safety of hive products and, ultimately, the reputation of the beekeeping industry.

## Integrated Pest Management

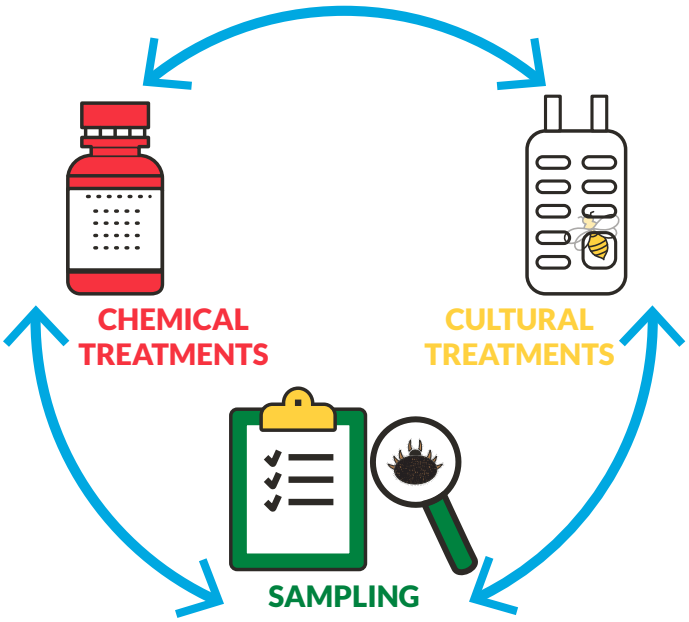
Relying on a single product to treat Varroa in honey bee colonies is a risky strategy, even though many commercial beekeepers still follow it. The case studies in this guide show how large-scale beekeepers in different regions are successfully adapting integrated pest management (IPM) strategies in their businesses and local conditions. First adopted in federal policy in 1972, Integrated Pest Management is the implementation of diverse methods of pest control, paired with monitoring, to reduce unnecessary pesticide applications (*https://nifa.usda.gov/program/integrated-pest-management-program-ipm*). This strategy emphasizes the value of using pesticides in combination with other management approaches to minimize the effects of the target pest while supporting a profitable system and reducing negative effects.

**Integrated pest management can:**

- Cost-effectively address the Varroa mite threat
- Lengthen the time over which products retain their efficacy
- Contribute to long-term colony viability
- Minimize accumulation of varroacide residues in hive products (honey, wax, etc.)

## Precision Apiculture

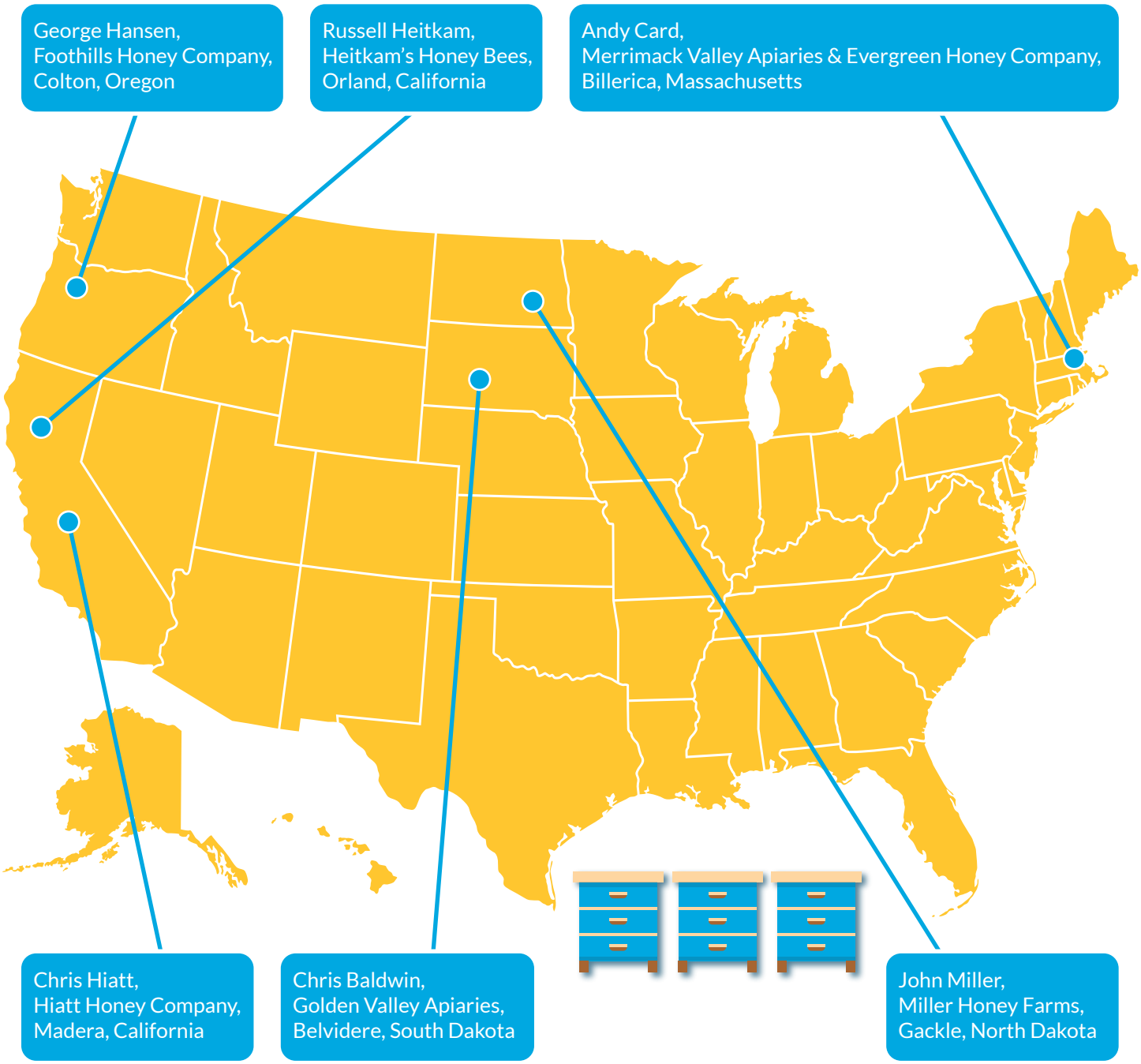
This guide takes IPM one step further to introduce a more focused term, **precision apiculture**, to describe the strategy beekeepers use to not simply guess the impact of their integrated practices, but to know whether precise actions are effective or not. Switching between chemical products and/or cultural methods of pest control can reduce the rate of pest adaptation and is a normal part of IPM, but precision apiculture includes sampling hives on a regular basis, counting mites, keeping records, and selecting hives from which to breed based on these records. Sampling is especially important before and after mite treatments to assess treatment necessity and effectiveness. Varroa mites are less likely to adapt (i.e., develop resistance) to multiple control efforts simultaneously than to a single product or strategy. Within these approaches, even varroacides that have lost much of their effectiveness, such as tau-fluvalinate, may still offer some benefit when used infrequently or in rotation.



# CASE STUDIES

## Introduction

The six commercial beekeepers profiled below were chosen for their commitment to monitoring for Varroa mites, reducing or eliminating off-label use of varroacides, and developing a commonly held vision for a future that includes amitraz as a useful tool for years to come. They are all U.S.-based and represent a diversity of geographies, business focuses, and Varroa control strategies. The views expressed by the beekeepers represent their experiences and perspectives.



## Chris Hiatt, Hiatt Honey Company, Madera, California

Hiatt Honey Company was started 52 years ago in Washington by Chris Hiatt's father, a schoolteacher, who had spent a couple summers working for an Oregon beekeeper. Chris said that, after running hives in Alberta, Canada, his dad decided to summer bees in North Dakota in the 1970s. With five brothers involved, the company is now based in Madera, California, in the Central Valley, as well as in Ephrata, Washington, and Bowman, North Dakota. Business revenue comes primarily from honey production, and the portion derived from pollination services has grown over the years to about 40% of revenue. The company's bees pollinate almonds, blueberries, plums, cherries, and kiwis in the Central Valley as well as apples in Washington. The operation's 20,000 colonies spend all summer in North Dakota, and then most overwinter outdoors in California while a few truckloads winter indoors in Idaho. Chris is vice president of the American Honey Producers Association and has served on the steering committee of the Honey Bee Health Coalition.

### HOW HIATT MANAGES VARROA

In recent years, Chris has used a combination of methods to manage Varroa:

- Monitoring
- Brood breaks
- A variety of chemical treatments

This combination has generally helped the operation meet its goal going into almond pollination of no higher than 35% colony loss, which is better than the national average. Chris noted that a 15% annual loss was the norm 15 years ago, and it was 10% before that.

### MONITORING

The company monitors for mites in the spring and fall, and sampling is done in select yards on 10 to 15 hives per yard. Chris said he expects to have high mite loads after pulling honey, and monitoring is a focus after that. "You have to follow up and monitor, especially in the fall and the spring when you do mite treatments. You have to go back and check and see if it worked to reduce mites below threshold," he said. "If you let the mites get too high, the viruses are already in there, and they're ticking time bombs."

### ROTATING WITH THYMOL

Chris's operation uses the thymol product Apiguard® the most in its chemical treatment rotation. The business applies Apiguard® in the spring, between almonds and oranges, and again in May before the colonies go to North Dakota. In July, the company uses oxalic acid in between the first and second honey pull. Then in late August and early September, Chris said he uses amitraz in the form of Apivar® strips. Once the colonies are back in California, the business applies Apiguard® again in October and November. "After we had done an Apivar® treatment, coming in with an Apiguard® after that, it really cleaned them up," he said. The hives that indoor winter in Idaho also receive an oxalic treatment. In total, it adds up to five or six treatments per year.

***"If you let the mites get too high, the viruses are already in there, and they're ticking time bombs."***

Avoiding mite resistance became a top priority after the family business experienced heavy losses in the late 1990s and early 2000s when mite resistance increased to tau-fluvalinate and then coumaphos, and Chris said the benefits of using his chemical rotation outweigh the costs. "Apiguard® is pretty expensive, but we just see it as a valuable rotation to amitraz," he said. "Apivar® is expensive too, but you have to keep your hives alive, so we just see it as a necessary evil." He said oxalic is cheaper to buy, but the labor required to apply it makes it expensive.

## SPLITS AND REQUEENING

Chris noted that the operation also splits all its colonies after almonds and again after apples, and mite counts become lower because of the brood break created. "That's a form of mite control," he said. The company also requeens 75% to 80% of its colonies every year. The operation also just started using several hundred queens from the breeding project in Hilo, Hawaii, with the Varroa Sensitive Hygiene (VSH) trait. Chris is also using Purdue Mite-Biter queen stock in his summer and fall requeening. "We're just trying everything," Chris said. The company only used one treatment per year until about 2010. "We would do one in the fall and split everything in the spring, and that was good enough ... but it caught up to us just like everyone."

He expects to need to add another chemical treatment to the rotation at some point and is considering indoor wintering more colonies.

For general advice, Chris recommends going to conventions and networking and said he and his family have learned much from conversations with other beekeepers and from staying involved in the industry.

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|---|---|
| **Beekeeper** | Chris Hiatt |
| **Business** | Hiatt Honey Company |
| **Region** | California, North Dakota |
| **Location** | Madera, California |
| **Years in operation** | 52 (Second generation) |
| **Colonies** | 20,000 |
| **Business line** | Primarily honey production |
| **Crops pollinated** | Almonds, blueberries, plums, cherries, kiwis, apples |
| **Chemical treatments used** | Apiguard® (thymol), Apivar®(amitraz), oxalic acid |
| **Other Varroa management strategies** | Splits (brood breaks), requeening, VSH stock |

## Russell Heitkam, Heitkam's Honey Bees, Orland, California

Russell Heitkam's dad, Patrick, started Heitkam's Honey Bees about 40 years ago. The business is based in Orland, a town in a part of northern California that Russell said is the top queen-producing region in the world. After previously running 6,000 colonies, the company now runs 3,000 with the same number of employees. "We think that is the answer to having healthy bees — tending to them better rather than having more losses;" he said. "Running fewer beehives is more profitable for us, and certainly it's a lot easier." The business raises about 90,000 queens a year, and most of its revenue comes from queen and package bee sales. The operation pollinates almonds, and Russell brokers about 7,000 hives for almond pollination. The business also pollinates prunes — not because it pays, but rather because it's good for the bees. The operation doesn't make money from honey production. Russell said after package bee sales finish for the year, the hives don't produce any more revenue, so the business focuses for the next nine months on keeping the colonies alive and on raising queens.

### HOW HEITKAM MANAGES VARROA

Russell combines several methods:

- Frequent monitoring
- A variety of chemical treatments

Russell's operation recently stopped using off-label amitraz (i.e. Taktic™), in favor of a variety of miticide treatments, which have been successful so far. "We're doing samples and our mite levels are low, and if your mite levels are low, you're going to be OK," he said. But with less than two full years of using his new strategy, he cautioned that it's too early to make comparisons.

### MONITORING

The company does monthly monitoring with a Bee Informed Partnership (BIP) Technical Transfer Team. In a day of monitoring, Russell's team and the BIP Field Specialists check about eight of the 100 hives in a yard with alcohol washes. Then they repeat this at three more yards that represent different scenarios in terms of nutrition and mite treatment timing. This seems to provide an accurate cross-section of the operation, he said, and it helps him make mite treatment decisions. He doesn't wait until mite levels reach the threshold of three mites per 100 bees. "I think that's too late," he said. "We are almost constantly treating. ... I'm not treating because I have high levels of mites; I'm treating because I don't want high levels of mites."

### CHEMICAL TREATMENTS

Now in his second year of not using Taktic™, Russell said his new approach seems more effective at controlling mites. He noted the industry's history with chemical treatments and current reliance on Taktic™. "The use of that chemical saved the commercial beekeeping industry from collapse," he said. But after years of having to increase the number of annual applications, and after his concerns grew about the chemical's unregulated nature leading to

***"All treatments work, but you have to know how to use them and when to use them. ... I don't rely on any of them. I rely on all of them."***

potential adverse effects to his and his employees' health, he decided to stop using it. "The employees were clearly concerned about the use of chemicals, and I am, too. I don't like it." The change meant his mite treatment costs significantly increased, he said, but "I'm looking at spending more money to do what I think is the right thing." He acknowledged that his new treatment strategy does incorporate Apivar® strips twice a year, so "I do use amitraz. I just don't use it with Taktic™ anymore."

Russell starts the year with a drench or vapor treatment of oxalic acid coming out of winter. Then he uses Apivar® strips during almond pollination. The Apivar® strips have worked well for keeping mite levels low for a long time, he said. He uses Apivar® strips again in November, when his operation's mite levels are low, to protect from infestations caused by potentially high mite levels of neighboring beekeepers returning from out of state. At $10 per hive, the strips are expensive, but he weighs that against a dead hive, which he considers as a $500 loss. "To spend $10 to save $500, it wasn't an expense at all. It was something that needed to happen," he said. Then he uses oxalic acid again going into winter. Beyond amitraz strips and different methods of applying oxalic acid, Russell's treatment approach has also involved two formic acid products, the thymol product Apiguard®, and the hops-derived product Hopguard®. He emphasized the importance of using a variety of chemical treatments over time. "They all work, but you have to know how to use them and when to use them," he said. "I don't rely on any of them. I rely on all of them."

When considering treatments, Russell said, beekeepers should also consider the value of creating brood breaks. "One or two or maybe more throughout the year is a key factor in controlling mites, and yet you're going to forgo something if you do that." The colony population reduction caused by the brood break will affect package and honey production, but those costs are outweighed by the benefits of managing Varroa effectively to avoid colony losses. "You can't possibly justify killing beehives by making honey," he said.

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| **Beekeeper** | Russell Heitkam |
| **Business** | Heitkam's Honey Bees |
| **Region** | California |
| **Location** | Orland, California |
| **Years in operation** | 40 (Second generation) |
| **Colonies** | 3,000 |
| **Business line** | Queen and package sales |
| **Crops pollinated** | Almonds, prunes |
| **Chemical treatments used** | Apivar® (amitraz), oxalic acid, formic acid, Apiguard® (thymol), Hopguard® |
| **Other Varroa management strategies** | Monitoring, brood breaks, splits |

## George Hansen, Foothills Honey Company, Colton, Oregon

A first-generation beekeeper, George Hansen started keeping bees in Western Oregon about 40 years ago after working for several years as a teacher. He and his wife are in the process of transitioning the beekeeping business to their children. Their business runs roughly 7,000 colonies and derives about 75% of its revenue from pollination services. George's bees pollinate a variety of crops in California and the Pacific Northwest including almonds, cherries, blueberries, pears, and apples in the spring and crops grown for their seed such as clover, cabbage, pumpkin, and radish later in the year. George also sells nucs (nucleus or starter colonies) and honey, which represent about 15% and 10% of revenue, respectively. George has served as president of the American Beekeeping Federation and a producer representative on the National Honey Board. He currently serves on the boards of the Bee Informed Partnership and Project Apis m. and on the steering committee of the Honey Bee Health Coalition.

*The **Bee Informed Partnership Tech Transfer Team** is composed of highly trained Honey Bee Health Field Specialists who offer regular on-site colony inspections and sampling for commercial beekeepers and queen breeders. The data they collect help provide large-scale beekeepers with science-based management options to maintain healthy colonies. More information can be found at: Technical Transfer Team – Bee Informed Partnership*

### HOW HANSEN MANAGES VARROA

George combines several methods:

- Frequent monitoring
- A variety of chemical treatments
- Varroa sensitive hygiene (VSH) stock

Since using this combination over the last few years, the business's mite levels have stayed low. "We can hardly find them," he said, though he cautioned that "next year we might be in a whole different boat, which is why we monitor." The business plans to continue this approach with minor tweaks.

### MONITORING

George works with the Bee Informed Partnership Technical Transfer Team to check Varroa mite levels four times a year in addition to frequent sampling by his staff throughout the active season. He and his employees use the alcohol wash method to sample two or three hives in every yard of about 100 hives. "We're pretty serious about outliers and mite bombs," he said. "It's an indicator of the need to do something." His operation doesn't wait until the average colony is above the Varroa mite threshold to treat because workers see the hives at three-week intervals for much of the season. "We're really constrained because our bees aren't in our possession a lot of the time."

### CHEMICAL ROTATION

George's operation rotates chemical treatments in different seasons to prevent mite resistance to any one material. He starts with Apivar® strips during almond pollination, which has worked well to protect his colonies from others nearby that may spread Varroa. Then in June and early July, when honey supers are on, he treats with formic acid. This treatment is expensive and disruptive to the colonies, but effective. It creates a brood break, which also helps reduce Varroa levels. Formic may interfere with honey production, but that is less important to him than keeping Varroa levels low. "If they [the Varroa mites] ever get high, even if you

***"I'm extremely uncomfortable using unregistered products. Even if costs are higher short-term, I need to find other ways to control mites that will work and will work over time. That will cost me more initially but will make me money down the line."***

knock them back down again before winter, the damage has been done. … The viruses become active. They have a life of their own, and they don't need the Varroa anymore."

If another treatment is needed in August or September, George uses formic acid or Apivar®, depending on mite levels. He tries not to use formic again because it would decrease colony size too late in the year. He also doesn't want to use amitraz more than once a year because of resistance concerns.

Lastly, in October and November, he uses oxalic acid. George said although off-label use of Taktic™ would be much cheaper in the short-term than the chemical combination he uses, those savings are outweighed by the long-term benefits of avoiding amitraz resistance. "If you're dependent on the cheapest thing, and then it doesn't work anymore, you're really stuck," he said. "Even if it costs more short-term, I need to find other ways to control mites that will work and will work over time. That will cost me more initially but will make me money down the line."

### VARROA SENSITIVE HYGIENE (VSH)

Most recently, George has made the ambitious decision to convert his existing stock to that with VSH trait. George has also started using Hilo Bees stock with the VSH trait (www.hilobees.com). These bees recognize when Varroa mites are in capped brood, open those cells, and remove the pupae and the mite. The mite then loses one of its two chances to reproduce. Since 2018, George has been part of a promising VSH breeding research project. The colonies he received in May 2019 had mite levels of 1% or lower in October, despite spending the season next to non-VSH colonies with high mite levels and not receiving any treatments. Researchers are working to balance the VSH trait with other desirable qualities, but tradeoffs of this stock may be lower honey production and smaller colony size at certain times of year. However, he said, more of the VSH colonies overwinter, they don't need treatments, and they are big enough to go into almonds, so the stock's benefits outweigh the costs. "For me, this is a no-brainer. If I can reduce the stress on the outfit from mites, and therefore viruses, it just seems to be the thing to do."

In addition to buying queens bred for VSH, the business is raising more of its own queens with the goal of reaching 50% of colonies with mite-resistant behavior within the next couple years. "We think that's the ultimate system," he said. "That's the change that we're going for. In the meantime, we're trying to buy time by using the strategy of using multiple types of materials so that we don't come up against the wall of a resistance issue."

### WITH NEW TREATMENTS, EXPERIMENT FIRST

For beekeepers wanting to try a new treatment, George shares this advice: "No matter how good it sounds, try it on a small group and let your experiment go to fruition before you buy and apply anything to your whole outfit." He encouraged others to monitor after applying a treatment, have a plan for if the treatment doesn't work, and be ready to change management strategies as time passes.

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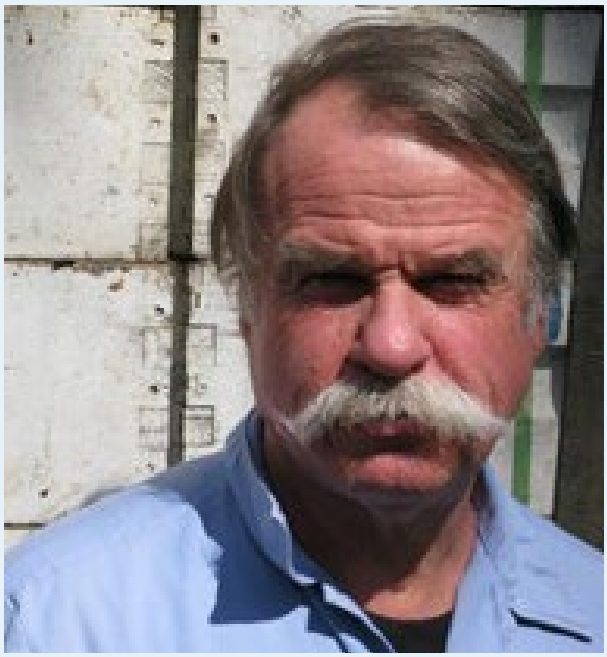
| **Beekeeper** | George Hansen |
| **Business** | Foothills Honey Company |
| **Region** | Pacific Northwest |
| **Location** | Colton, Oregon |
| **Years in operation** | 40 (Second generation) |
| **Colonies** | 7,000 |
| **Business line** | Primarily pollination services |
| **Crops pollinated** | Almonds, cherries, blueberries, pears, apples, various seed crops |
| **Chemical treatments used** | Apivar® (amitraz), formic acid, oxalic acid |
| **Other Varroa management strategies** | Varroa Sensitive Hygiene (VSH) stock, selecting for mite resistance, frequent monitoring |



## Andy Card, Merrimack Valley Apiaries & Evergreen Honey Company, Billerica, Massachusetts

A second-generation beekeeper, Andy Card grew up around his parents' beekeeping business in Massachusetts. Merrimack Valley Apiaries started in the 1950s, providing pollination services to apple, blueberry, and cranberry growers in the region. In 1973, Andy joined the business full-time, and now the third generation has entered the business. The Cards still operate a bee farm in Massachusetts, and over the decades, they have added two bee farms in New York and two more in Louisiana. The business runs between 30,000 and 35,000 colonies, with about 25,000 in Louisiana and 8,000 in the Northeast. Pollination services form nearly half of the operation's revenue. The business still pollinates apples, blueberries, and cranberries in the Northeast and has been pollinating almonds in California since the late 1980s. The Cards have been shifting their business model toward honey production — Andy said the business produces about 1% of the nation's reported honey crop — and sales of starter colonies (about 5,000 in 2019) and queens.

### HOW CARD MANAGES VARROA

The Cards' operation combines:

- Two kinds of chemical treatments
- Breeding for mite resistance

"Our approach is constantly evolving," he said. He emphasized the importance of stock with hygienic behavior, an aspect of the Cards' strategy that he hopes will allow the business to eventually stop using amitraz in the form of Apivar® strips.

### MONITORING

Andy said the business monitors frequently for mites and more so for hives used for pollination services that are at higher risk of direct and indirect pesticide exposure. He views the mite treatment threshold differently from some other commercial beekeepers. Andy considers three or four mites in a standard sample of 100 bees a "pretty low" level, and when he finds what most would call a mite bomb, for example an outlier hive with 20 mites per 100 bees, he said he doesn't consider that an indicator of the need to treat surrounding hives but rather a sign of that hive's genetic deficiency. "That does not mean that you should go out and put more chemicals on," he said. "Some of them are just not genetically predisposed to be mite resistant."

### CHEMICAL TREATMENTS

The Cards' business uses two types of chemical treatments at different times of year. In the spring after the bees are done pollinating almonds, the Cards apply oxalic acid. The family switched from using formic acid after Andy said extensive monitoring found that treatment wasn't creating enough mite suppression. Then once a year, after the honey flow, the operation applies amitraz with Apivar® strips. The business has been reducing its amitraz use over time, but Andy said it is not yet able to skip one amitraz treatment per year. "The more you apply amitraz, the less opportunity you're giving

***"Our outfit is working to achieve enough hygienic behavior in the bees so that an amitraz treatment isn't needed and honey production is still sufficient."***

your own bees to develop and maintain resistance because the chemical's doing all the work." When the operation is deciding when to treat, he said timing is more important than mite load. The business will avoid treatments during the honey flow, even when some colonies reach eight to 10 mites per 100 bees, until the operation can use the Apivar® strips. "If we didn't have the hygienic behavior, perhaps we might have problems with that," he said.

### BREEDING FOR RESISTANCE AND REQUEENING

The key to fewer treatments, Andy said, is breeding colonies that have defenses against the mites (mite resistance). His schedule of chemical treatments works because "the bees are fairly hygienic," he said, and the business is "very aggressive about requeening." The Cards raise 30,000 to 40,000 queens a year and try to requeen every colony twice per year. The operation's breeding strategy involves choosing the two most productive colonies in each yard that also have low mite loads. From there, the business whittles down the best colonies from roughly 600 to 10. "That pays for itself, in a sense, because you're going for productivity and mite resistance at the same time." This kind of selection is expensive to do, he said, but the benefits to the business outweigh the costs. The operation focuses on the Varroa Sensitive Hygiene (VSH) trait in its stock without overemphasizing it in a way that causes honey production to decrease too much because the bees are always uncapping and checking for mites. "Our outfit is working to achieve enough hygienic behavior in the bees so that an amitraz treatment isn't needed and honey production is still sufficient."

| | |
|---|---|
| **Beekeeper** | Andy Card |
| **Business** | Merrimack Valley Apiaries and Evergreen Honey Company |
| **Region** | Northeast and Southeast |
| **Location** | Billerica, Massachusetts |
| **Years in operation** | 70 (Second generation) |
| **Colonies** | 30,000-35,000 |
| **Business line** | Pollination services, honey production |
| **Crops pollinated** | Almonds, apples, blueberries, cranberries, some vegetables |
| **Chemical treatments used** | Apivar® (amitraz), oxalic acid |
| **Other Varroa management strategies** | Varroa Sensitive Hygiene (VSH) stock, breeding for mite resistance and productivity, frequent monitoring |

## Chris Baldwin, Golden Valley Apiaries, Belvidere, South Dakota

A first-generation beekeeper, Chris Baldwin started keeping bees in New Jersey at age 11. Soon he was selling honey out of his school locker, and by the early 1970s, he was working for a commercial beekeeper in Nebraska who wintered some bees in Texas. He eventually became the manager and owner of that business and, as the Nebraska agricultural landscape changed, he moved the operation to South Dakota. Chris semi-retired in 2018 and sold all but 100 of his business's roughly 1,800 colonies. The operation's primary source of revenue was honey production followed by pollination services for almonds in California and starter colony sales.

### HOW BALDWIN MANAGES VARROA

Chris uses one approach:

- Stock selection through selective breeding

Chris has approached Varroa management differently from most commercial beekeepers after he stopped using chemical treatments in 2007. He said "I'm not passing any judgment on you if you treat. Unless you want to be dedicated to not treating and accept the losses you have in the process, then don't do it."

He calculates his annual colony loss rate as the percentage of colonies lost between May 1 and March 1 of the next year. His typical loss rate was about 30%, plus a smaller portion of colonies lost likely due to queen failure in March and April, the time of year when he built colony numbers back up.

Chris said other commercial beekeepers and beekeeping experts seem amazed by his business' strategy and colony survival. The broker he used for almond pollination described his bees as remarkably consistent. Chris quoted him as saying, "When I look at one hive of bees, I've looked at all of them. How do you do that?" Chris attributes his business's success to Russian queens and his focus on breeding. "I have never bought bees other than breeding stock — queen bees — and I'm very, very proud of that. I have never needed to buy bees from somebody else to maintain my numbers."

### MONITORING

Chris used the ether roll method to monitor for Varroa mites before he stopped monitoring for Varroa specifically in the early 2000s.

### AVOIDING CHEMICAL TREATMENTS

Chris's business used chemical treatments in the past. After tau-fluvalinate and then coumaphos stopped working as effective mite controls, he started using oxalic acid in 2003 based on the recommendation of his friend Marion Ellis at the University of Nebraska. Chris said the oxalic acid worked best when he used it in a sugar syrup drizzle

***"I was just determined that we could breed bees that — at least, if not bullet-proof — could sustain themselves."***

rather than as a vapor. In 2006, he decided not to use any chemical treatments, and then in 2007, he tried the new thymol product Apiguard®. "It dropped mites out of the hives," he said, "but I had bees that I didn't treat, and the bees I didn't treat were just as good as the ones I treated."

After that, he stopped using chemical treatments. He said this simplified his beekeeping. "I am basically keeping bees like I did before there were mites. … I'm not worrying about, 'Am I getting a treatment on?'" he said, and "I'm not exposing myself to God knows what." He understands why other beekeepers use chemical treatments, but for him the costs outweigh the benefits. "I've always believed the selling point of honey was it's a pure, natural product."

## STOCK SELECTION

In 2003, Chris first introduced Russian breeder queens. Before that, "I could get bees to survive without treatment when they had Varroa, but they wouldn't thrive," he said. "When I got the Russian stock, that changed everything."

He focused on selective breeding as his primary Varroa management strategy, based on his earlier success with that approach for managing tracheal mites. To select his best colonies for breeding, Chris said he would mark the ones that produced the most honey in the summer. Then he would return to those colonies in the winter and use the ones that survived. After doing this for years, he said, "I'm so far away from the Russian stock now that who knows what kind of bees I actually have." He was able to advance with the breeding despite his Texas location, which has been a hindrance because of drone sources from operations from all over the country, and despite being his business' sole employee. "I was just determined that we could breed bees that—at least, if not bullet-proof—could sustain themselves." Today, he wonders what the industry would look like if more beekeepers pursued selective breeding.

Chris noted some circumstances that helped him have changed. He ran 3,000 colonies at the business's peak and, throughout the 1990s, they each produced at least 130 pounds of honey a year. "I had a number of exceptional years of honey production when the price of honey was good. If I didn't need that money that year, I didn't put it into the hives. I invested it," he said, noting that he used a diversity of investment strategies. Years later, during a drought in 2006 and 2007, he didn't extract any honey. The business wouldn't have survived without taking on debt, which he said was only available because of his earlier financial decisions. Today, beekeepers face more variable weather, higher costs for necessities like trucks, stricter business lending practices, and lower honey prices, he said. Still, he wonders what the industry would look like if more beekeepers pursued selective breeding.

| | |
|---|---|
| **Beekeeper** | Chris Baldwin |
| **Business** | Golden Valley Apiaries |
| **Region** | South Dakota, Texas |
| **Location** | Belvidere, South Dakota |
| **Years in operation** | 46 (First generation) |
| **Colonies** | 1,800 |
| **Business line** | Honey production |
| **Crops pollinated** | Almonds |
| **Chemical treatments used** | None |
| **Other Varroa management strategies** | Selective breeding |

## John Miller, Miller Honey Farms, Gackle, North Dakota

John Miller is a fourth-generation beekeeper. His family's company was founded in Utah in 1894. The business was then based in Blackfoot, Idaho, for 100 years until it moved its headquarters to Gackle, North Dakota, in 2017. The company has also had a branch in Newcastle, California, since 1976, and prior generations were in the San Bernardino area of California starting in 1907. In 2019, John sold the company to his son, Jason, and a partner. The operation provides pollination services to almonds in California, apples in Washington, and pit fruits including plums, apricots, and peaches in both states. The company derives the majority of its revenue from almond pollination. The business also produces about 750,000 pounds of honey per year.

For more information on indoor facilities, see the publication from Project Apis m: "Indoor Storage of Honey Bee Colonies in the United States."

### HOW MILLER MANAGES VARROA

The business's Varroa management strategy has evolved significantly in recent years with the completion of a cold storage building. The company now combines:

- Rotation of chemical treatments including amitraz and oxalic
- Cold storage building for indoor wintering

John said he measures success by the percentage of colonies that can be rented for almond pollination on February 1 each year. In 2018 and 2019, the first two full years of using the cold storage building, the company was able to rent 92 and 93% of its colonies. "These buildings are revolutionizing how bees are overwintered," he said. In 2020, the business saw significant colony loss (40%) that John attributed to an unprecedented wet September. The year seems to be an outlier.

### MONITORING

The company spends about $1,800 per year on Varroa monitoring with Bee Informed Partnership (BIP). The operation takes advantage of a subsidy for North Dakota beekeepers to work with BIP, and John emphasized that all beekeepers should be using monitoring and data to inform their decision making. In addition to BIP's random sampling throughout the year, John does his own sampling with alcohol washes. He returns to the same colonies in the same yards, which he said helps him understand the arc of the season.

### CHEMICAL TREATMENTS

The operation uses chemical treatments eight times per year, mainly oxalic acid and different forms of amitraz. John said the business has used off-label amitraz treatments. "I hate to see resistance coming," he said, but in the California Central Valley, "we're down there with everybody, and you've got all kinds of drift and hives collapsing and absconding and blowing up."

***"An indoor wintering facility pays for itself in five years. To me, it's just a no brainer, and you can look at it through losses, or you can look at it through revenue because, if 35% [of the colonies] come out dead, you've got to rebuild all those colonies next spring."***

## OVERWINTERING WITH A COLD STORAGE BUILDING

John decided to invest in a cold storage building in North Dakota after years of using potato cellars for indoor wintering. "We were frustrated with long-term 35% winter kill," he said, and he thought the cold storage used for produce could be applied to bees. "Bees have been trying to tell us for 10,000 years how they like to winter. We just haven't been paying attention."

After touring cold storage buildings used by Canadian beekeepers, John designed an 18,000 square foot building tall enough to drive trucks through and to give workers enough space to safely work on top of the trucks using harnesses attached to the ceiling. He said the building cost $120 per square foot including the site selection, property acquisition, and materials for construction, insulation, and refrigeration.

The building maintains a temperature of 40 degrees Fahrenheit with set carbon dioxide and humidity levels. "Big buildings are like stadiums. You put 15,000 hives in the building, and they generate heat, and they generate heat all winter long," he said. The refrigeration runs constantly, and the system occasionally lets in more fresh air to keep carbon dioxide from spiking. "The building is almost fighting with itself," he said, to control the three factors. John said the goal is a carbon dioxide level of 8% for 66 days in a row to kill the majority of mites. With weather and other challenges, he estimated that the refrigeration system can maintain the necessary conditions 90% of the time, which is enough to significantly increase colony survival. "The building pays for itself in five years. To me, it's just a no brainer, and you can look at it through losses, or you can look at it through revenue because, if 35% [of the colonies] come out dead, you've got to rebuild all those colonies next spring."

For other beekeepers interested in cold storage, John shared some best practices. "Anybody who does this needs to look at 10 years of prior data for their electric provider," he said. Focus on when the power went out, for how long, how often, and during what kind of weather. This will determine the grid reliability and could point to choosing a different electric provider. The building should have a backup generator capable of providing 25% of the power required.

John also stressed the importance of maintaining a clean building. He removes dead bees from hives before they are stored to reduce the mortality of housekeeper bees. He also checks the colonies for the cluster and feeds them a pollen substitute. Then throughout the winter, he sweeps the building to remove dead bees that could be spreading pathogens. Proper spacing of colonies is another critical factor, he said.

| | |
|---|---|
| **Beekeeper** | John Miller |
| **Business** | Miller Honey Farms |
| **Region** | California, Washington, North Dakota |
| **Location** | Gackle, North Dakota |
| **Years in operation** | 126 (Fourth generation) |
| **Colonies** | 15,000 |
| **Business line** | Primarily pollination services |
| **Crops pollinated** | Almonds, plums, apricots, peaches |
| **Chemical treatments used** | Apivar® (amitraz), oxalic acid |
| **Other Varroa management strategies** | Indoor wintering, monitoring |

# PRECISION APICULTURE, TAKING IPM INTO THE 21ST CENTURY

## Introduction

When Varroa mites first appeared in the United States in the 1980s, Dr. Hachiro Shimanuki, Research Leader at the USDA Honey Bee Lab, said, "the good beekeepers get better, the bad ones get out." Precision apiculture can reduce chemical use, promote healthier hives, and reduce hive losses if commercial beekeepers can commit, as the previous case studies have shown, to the knowledge-based decisions known as integrated pest management. The remainder of this guide is an overview of precision apiculture methods used by the beekeepers profiled (i.e., routine sampling, determining mite thresholds, and then deciding on a course of action using approved products and incorporating mite-tolerant stocks). The chemical control methods covered are used by the beekeepers profiled. The "holy grail" is not reliance on a miticide, but rather multiple strategies that rely on feedback from the hives (i.e., sample mite counts), biology of overwintering (storage units), and queen selection records.

Specifically, we will discuss:

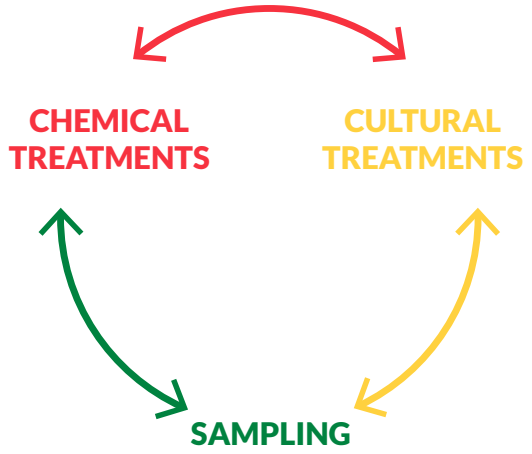
### Monitoring (Sampling)

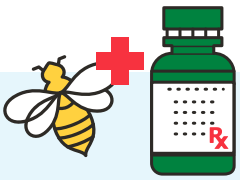
### Chemical Control Methods

- Formic® Pro or Mite-Away Quick Strips™ (formic acid)
- HopGuard® 3 (hops beta acids)
- Apiguard® (thymol)
- Api-Bioxal® (oxalic acid)
- Apivar® (amitraz)

### Cultural Control Methods

- Breeding
- Brood Breaks
- Indoor Storage




**Products registered by the EPA for mite control MUST:**

- Prove that they are effective, and at what application level
- Show proof that the product will not enter the food chain at levels above established tolerances when used according to label specifications
- Show that they will NOT harm target animals (honey bees, in our case) at maximum label rates
- Show that they will not harm the applicator (the beekeeper) when applied according to the label
- Include legal directions for use on the label
- Must include appropriate advisory statements to further ensure product safety
- Must specify purity of ingredients

It is illegal to market unregistered chemicals or medications for use in a beehive. The use of such products (i.e., "off-label use) is also illegal.

## Monitoring (Sampling)

EFFECTIVENESS AND TIMING:

Mite sampling (also called "monitoring") should begin in early spring and then continue regularly throughout the active bee year. Mite numbers tend to increase rapidly later in the year as colony populations decrease. Sample up to 8% or 10% of selected colonies in an apiary, or until a treatment threshold is reached. Initially, choose random colonies to sample. Follow the same colonies over time for a better understanding of the growth of the mite population and the effectiveness of treatments. Record the mite counts on the hive or in a yard book. Consider doing additional, targeted sampling of weak colonies or those showing low adult to brood populations (especially in early fall), as these colonies may be more at risk of a high mite infestation. Counts can be conducted more efficiently when colonies are gathered together for staging or at convenient treatment "windows." Sample from different populations within an operation; for example, colonies from different loads or different stocks.

The most effective and rapid sampling is washing samples of 300+ adult bees (approximately ½ cup) with 50%-95% concentration alcohol. Early season sampling may undercount mite levels because mites can be hidden in capped brood; high variability of colony counts is common. Post-treatment sampling can confirm effectiveness of control effort.

### Percent mite infestation calculated using the 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.*

**Resample post-treatment:** Mite sample should be 1%-2% (3-6 mites per 300 bees) or less. If higher, consider further control. The time period for post-treatment sampling varies by the product used.

THRESHOLD

Do not allow Varroa mite numbers to exceed acceptable thresholds, as reducing mite populations/mite control becomes more difficult at higher infestation levels. Mite thresholds that drive treatment decisions should vary by season. The table below shows treatment thresholds recommended by the Honey Bee Health Coalition in the Tools for Varroa Management guide. Establish seasonal thresholds you are comfortable with. NOTE: Mite number is converted to a percentage by expressing the number of adult mites in a sample per 100 bees.

PROS:

- Essential part of Integrated Pest Management (IPM) approach
- Allows tracking of increase in mite populations in colonies/apiaries
- Knowledge of effectiveness of mite suppression/control effort

CONS:

- Time consuming to collect and remove mites from adults

COST:

- Time and labor, which depends upon frequency of sampling and efficiency of the sampling/washing system
- Sampling tool and alcohol. Alcohol can be reused if the mites are removed

LESSONS LEARNED:

Monitoring provides an estimated number to help beekeepers make an informed decision on the need for mite treatment. Monitoring helps provide an accurate cross-section assessment of the operation or for individual apiaries. Elevated counts can indicate lack of genetic uniformity with stock selection efforts. When outliers are found, they should receive special attention with higher counts indicating the need for greater attention. Monitoring the same colonies at different times during the year, versus random colony selection, helps understand seasonal mite numbers. Post treatment monitoring confirms treatment effectiveness.

# Chemical Control Method

## Formic® Pro or Mite-Away Quick Strips™ (formic acid)

### EFFECTIVENESS AND TIMING

Formic® Pro or Mite-Away Quick Strips™ utilize naturally-occurring organic acids and can be effective in controlling mites during the honey flow. By lowering mite loads at this time, they prevent colonies from being damaged or dying before honey can be removed. If mites get out of control between the time honey supers are added and when they are taken off, colony damage and loss is inevitable and fewer strong colonies are available for almond pollination. That pollination revenue is increasingly important to commercial beekeepers.

Treatment with formic acid may create a brood break which will effectively keep mite reproduction from taking place for weeks until mite numbers reestablish from other colonies. These brood breaks result from damaged brood or queens which stop laying for a period of time. The short brood break buys time until fall when mites can be treated with other materials approved after the honey crop has been harvested.

### PROS:

- A registered material that may be used when honey for human consumption is on the hive
- Effective at killing mites at all stages, including underneath wax cappings
- May create a brood break because the product can kill brood in all stages
- Causes colonies to "clean house" and exhibit a great deal of energy in restarting brood rearing

### CONS:

- Expensive
- An invasive intervention
- 5% to 25% queenlessness following treatment expected, especially if temperatures are high and ventilation is not provided
- Challenging, labor intensive process to put strips into hives with honey supers, especially with high stacks of heavy honey supers
- A corrosive acid
- Personal protective equipment (PPE) required

### APPLICATION METHOD:

In pollination colonies, inserting the strips between the brood boxes is easier and checking back for whether the colony is queen right does not involve handling a lot of heavy boxes. In honey producing operations, pulling supers at mid-flow can create an opportunity to insert strips and create a brood break, while foragers will continue to collect honey after a short interruption.

Beekeepers can put in two strips at one time, thereby avoiding the need to come back a second time to put in an additional strip. This does increase the possibility of queen loss. A good practice is to use five-frame nucs to requeen any colony that turns up queenless after the treatment.

### COST:

- Product: $5 for 2 strips
- Labor to install: perhaps $1 per hive. Necessary to open colonies to treat and remove pads.

After the 14-day treatment, the strips need to be removed and hives should be checked to determine if they are queen right. Beekeepers may experience roughly 20% queenlessness, which can be corrected by installing 5-frame, queen right nucs that have been prepared in advance.

### LESSONS LEARNED:

Treating while the honey flow is still going, well before supers are removed, seems to buy some time by reducing mite population growth. Hives still need to be monitored after honey is harvested. As brood rearing for winter colonies ramps up, mite loads can grow again. And colonies in surrounding apiaries may be spreading their mites into neighboring colonies. A best-case scenario would be to not have to treat again until brood rearing ceases.

For beekeepers who are full season pollinators, colony numbers and constant colony quality is important and "repair and rescue" of colonies is a year-round priority. The extra cost of this colony maintenance is more than repaid by more colonies of rentable quality in February for almond pollination.

# Chemical Control Method

## HopGuard® 3 (hops beta acids)

HopGuard® 3 is an extract of hops and natural food-grade ingredients impregnated into a corrugated cardboard/plastic strip designed to be hung over frames. The newest formulation, HopGuard® 3, stays moist longer (2 weeks vs. 5 days for HopGuard® II) and thus increases efficacy over HopGuard® II. HopGuard® 3 is NOT yet registered (as of 2020) in Canada (only HopGuard® II is permitted in Canada).

### EFFECTIVENESS AND TIMING:

It is an effective treatment in January before bees go to almond pollination, including for colonies coming out of cold storage. It can eliminate up to 95% of phoretic mites for spring splits, package bees or nucs (April/May).

It can be used during honey flow and will knock down mites in August/September/October. Efficacy can be anywhere from 50%-85%, depending upon level of infestation and amount of brood and colony size. Two sequential treatments should be followed by a different miticide if mite numbers remain above acceptable infestation level.

### PROS:

- Low cost
- Easy to use hanging strips
- Can repeat treatment

### CONS:

- Kills only phoretic mites
- Not ideal when there is a large amount of brood present or when temperatures are higher
- Messy to use

### APPLICATION METHOD:

Use one strip for each five frames of bees. Strips should be tented over brood frames and spaced one or more frames apart. For medium frames, hang strips over 2 adjacent frames (do not cut). Best used between 52 and 92°F (11-33°C); increase colony ventilation at higher temperatures. Remove and discard strips 10-15 days following application; discard any liquid left in packaging. Maximum of 4 treatments per year.

### COST:

24 strip package is $52. One strip per five frames. Necessary to open colonies to treat and remove following treatment period.

### LESSONS LEARNED:

HopGuard® 3 is most effective when hives are broodless. It is also effective for packages. In Canada, Hopguard® II is often used as bees are removed from indoor overwintering.

# Chemical Control Method

## Apiguard® (thymol)

### EFFECTIVENESS AND TIMING:

Apiguard® (thymol) utilizes a naturally-occurring alcohol and is a slow-release mite treatment that targets phoretic mites. Apiguard® comes in a 6.6-pound (3 kg) tub, enough to treat 60 hives at 0.23 oz (50 g) each and in convenient premeasured doses. The beekeeper applies the treatment twice, two weeks apart. Where mite infestations are high, a third dose is sometimes used after the second week. Some beekeepers in hotter conditions apply lower doses a week apart. When temperatures are above 77°F, Vita recommends reducing the dose to 25 g per hive and spreading out the doses over three applications. You will have less brood damage and it will be easier on the bees.

Beekeepers report success with Apiguard® in the fall in both northern climates (e.g., North Dakota) and in moderate climates (e.g., California). Two treatments can reduce mite levels significantly. Apiguard® can be used in the spring, but it stops queens from laying eggs for three to seven days, depending on the temperature. In the fall, when queens are already laying fewer eggs, Apiguard® treatment does not decrease egg-laying as much.

### PROS:

- Long history of effective use
- Can be used in rotation with other treatments
- Easy to apply

### CONS:

- Fairly expensive; requires two doses per hive
- Smell can cause bee "bearding" in hot weather
- Can cause some queens to fail if hot weather (95OF or higher) occurs within 2 or 3 days after treatment
- Can crystallize if not used promptly after opening
- Leaves high residue in combs
- Should not be applied during honey flow; may affect taste of honey

### APPLICATION METHOD:

Use premeasured doses or scoop Apiguard® out of the tub with a plastic scoop or hive tool, or use the syringe provided in the box. Put it on a silver paper card provided in the box. This is a slow release mite treatment that you apply twice, two weeks apart.

Make sure the temperature is below 90-95OF and above 60OF. Normal treatment is two applications of 50 g per hive, two weeks apart. According to the manufacturer, when temperatures are above 77OF (25OC), it is possible to use a half-dose of Apiguard® (25 g per hive), followed by a second 25 g dose one week later, and get a very good mite kill. Where mite infestations are high, a third 25 g dose is sometimes used. On colonies with five frames or fewer, the manufacturer recommends using the smaller 25 g dose.

When possible, have the same person apply treatments to ensure a uniform dose each time. It is necessary to open colonies to apply and to remove pads following treatment.

### COST:

About $1.50 per hive for one 50 g treatment, or $3.00 per hive after the needed two doses.

### LESSONS LEARNED:

Apiguard® is a good tool in the Varroa mite treatment tool kit. It is well-suited for rotation with other treatments. It is ineffective at both low and high temperatures.

# Chemical Control Method

## Api-Bioxal® (oxalic acid)

Oxalic acid dihydrate is a naturally-occurring organic acid. The only legally licensed product is Api-Bioxal®. While there may be other sources of oxalic acid, the Honey Bee Health Coalition does not recommend using non-registered products and application methods.

### EFFECTIVENESS AND TIMING:

Oxalic acid is a flash treatment to eliminate phoretic mites once per generation of bees. It is most commonly used during winter months (November-January). Additionally, it may be used for broodless splits and swarms once hived. It can be used in combination with cold storage both before and upon colony removal. It may be relatively ineffective as a fumigant when brood is present, because, according to the manufacturer, it does not control Varroa mites in capped brood.

Package bee producers use a mist application of oxalic acid on caged (package) bees or when hiving packages. When a colony is broodless, such as a swarm, a single drizzle or fumigant (sublimation) application is effective.

As with any treatment option, repeated exposure to oxalic acid could lead to mite resistance, but none has yet been detected.

### PROS:

- Inexpensive
- More than 90% effective on phoretic mites
- Vaporization method does not require opening the colony

### CONS:

- A corrosive acid
- Potential fire hazard from vaporization heating unit
- Effectiveness is reduced when brood is present
- Requirement for personal protective equipment (PPE), including respirator

### APPLICATION METHOD:

**Drizzle (solution method):** Mix 35 g of oxalic acid dihydrate into 1 liter of 1:1 sugar water (weight: volume).

Apply 5 ml per seam, up to a maximum of 50 ml, with syringe (single annual treatment). This method requires opening the hive during periods of dormancy (e.g. winter), when the colony may be vulnerable.

**Mist:** Mist treatment for packages uses the same mixture as drizzle. According to the manufacturer, bees must be starved following mist application.

**Fumigant (vaporizer method):** Heat 1 gm oxalic acid dihydrate per brood chamber to between 315-370OF sublimation (gaseous form), following manufacturer's directions of vaporizer. Temporarily close entrances to the colonies. Personal protective equipment (PPE) is required when mixing and for drizzle application, including protective glasses, gloves, long sleeves, pants, socks and shoes.

### COST:

Oxalic acid treatment costs less than $0.50 per colony, not including purchase of an applicator and PPE. Treatment requires less than 5 minutes per colony.

### LESSONS LEARNED:

Oxalic acid application is only effective when little or no brood is present. Repeat applications necessary during active bee season. Controls phoretic mites only.

# Chemical Control Method

## Apivar® (amitraz)

Apivar® is the only amitraz product registered for use in the U.S. for the control of Varroa mites. It is formulated as a sustained release plastic strip that is hung between the frames. Bees rub against the strips as they work in the hive to distribute the miticide throughout the hive, thus bringing Varroa mites in contact with amitraz.

### EFFECTIVENESS AND TIMING:

Apivar® kills phoretic mites only, but the strips are left in the hive for up to 56 days; therefore, as new bees emerge, the mites that have reproduced in brood cells become vulnerable to the control.

Apivar® is an important option for early in the season, while hives are growing. Apivar® strips are not allowed in hives while honey supers are on. The efficacy of Apivar® is dependent on application and timing. It is not a quick-kill product, it needs to be used over an entire brood cycle. As a part of an integrated pest management plan, Apivar® is best used in rotation with other products discussed in this guide.

### PROS:

- A registered product that has a controlled dose and is easily applied
- Safe for bees and beekeepers when instructions are followed
- Can remain in the hive for up to 56 days, spanning several brood cycles without requiring repeated visits to the hive
- Valuable in situations where mite pressure from surrounding hives is present, and when hives are building prior to a honey flow
- Effective while brood is present

### CONS:

- Ineffective in situations where a quick knockdown of mites is required
- Must be in the hive for a long time to come in contact with phoretic mites as they become vulnerable outside the brood
- Labor to remove strips from treated colonies after 42-56 days
- Prohibited from use when honey supers are present
- May not provide sufficient control if mite counts are high after honey harvest; additional treatments with other products will likely be required

### APPLICATION METHOD:

Apivar® strips must be placed properly within the brood area or the bee cluster and in sufficient numbers. Use one strip for every five frames of bees, up to two strips for each brood box (maximum of four strips for large colonies). Placement in the hive is important. Poor results have been noticed when strips are placed above, below, or away from the brood area.

### COST:

Apivar® strips cost about $2.50 each when bought in bulk. The cost is therefore $5 to $10 per hive, plus labor to install and remove and dispose of strips. Strips can be installed and removed by unskilled labor.

### LESSONS LEARNED:

Apivar® is effective in protecting hives with relatively low mite counts. It is commonly used during or after almond pollination as hives and splits are growing, but still unsupered. Product efficacy has been disappointing when used if high mite levels are reached after honey is removed, leaving insufficient time for alternative treatments before a strong winter cluster can develop.

Strips left in the hive longer than recommended can contribute to development of resistance to product by the mites. Bees in the brood area must come in contact with Apivar® strips to disperse the chemical. Therefore, using Apivar® while bees are dormant would likely not be effective since the bees are not actively moving around the hive.

The label specifies that depleted strips should not be reused and should be disposed of properly.

# Cultural Control Method

## Breeding

Breeding efforts to instill the best characteristics of gentleness, productivity and winter hardiness in honey bees have been going on for generations. However, efforts to select bees for Varroa mite resistance and hygienic behavior have been taking place only for a few decades.

EFFECTIVENESS:

Ultimately, having colonies that control mite levels on their own and reduce or eliminate the need for treatments, such as amitraz, is the goal of the entire beekeeping industry. If Varroa mites could be reined in as a cause of colony loss, beekeepers would be able to concentrate on other management issues. It would also eliminate one source of contamination in hive products. However, the VSH trait (one form of colony resistance to mites) is not dominant and can be quickly diluted. Every time a queen is replaced through supersedure or swarming, the daughter queens, due to open mating, may not carry the VSH genes at a high level. Beekeepers may still have to monitor and treat if the majority of hives within the operation are from stock bred to resist mites.

There are a number of projects and programs with the goal of producing colonies that can keep mite levels low. Colonies headed by queens from the Hilo Queen breeding project, for example, maintain lower mite populations. However, field trials so far have shown that there is some work to be done to ensure the colonies, and queens sold from these colonies, have characteristics that are needed in commercial operations. The programs are promising, but queens can be expensive and availability is limited.

The weak link in any breeding program is management of drone congregation areas. If mite-resistant queens are replaced through supersedure or swarming, the new queen that mates with unselected drones may produce workers that do not show the trait at high enough levels for the colony to actually resist mites. Commercial beekeepers may want to consider including a drone frame in every colony they select for hygienic behavior in order to flood drone congregation areas.

*A marked queen.* Photo Credit: Bee Informed Partnership

Consider contacting the following programs for diversifying stock:

- Hilo Queens (USDA Baton Rouge Bee Lab)
- Purdue Mite-Biter Queens from Heartland Honey Bee Breeders Cooperative
- Russian Queen Bee Breeder Program

## Breeding Continued

Mite resistance will be a long-term commitment, and it will take a number of years before significant operational-level mite resistance is achieved. Requeening with mite-resistant stock will become even more critical. Raising your own queens from mite-resistant queens over a number of years will result in drone populations with the same trait that will be available for mating, which will help the entire operation or population to reach a level necessary to control mites.

PROS:

- Lower mite levels all year and fewer, or possibly no, treatments required
- Avoids possible contamination of hives and products
- Reduces virus issues associated with mite vectors
- Saves time and money needed for repeated treatments
- Avoids possible resistance issues to chemical treatments

CONS:

- Not enough mite-resistant queens to meet demand
- Continuing problems with inconsistent productivity
- Honey production from mite-resistant colonies may be reduced
- Resistant stocks not uniformly accepted by the queen production industry

COST:

The cost of mite-resistant queens and queen cells varies widely. If successfully managed, there could be savings in treatment costs. Reducing chemical applications could improve the quality of hive products. Greater overwintering percentages may also improve returns to the business in almond pollination.

However, there are significant labor costs required to vigilantly maintain the stock at a high level. Commercial beekeepers currently spend a lot of money on queens. Much of that cost goes to re-establishing dead colonies. They will probably spend even more to install and maintain mite-resistant stock at a meaningful level. The difference will be that a larger percentage of the outfit will be available to produce income, especially for the most lucrative activities (i.e., almond pollination).

LESSONS LEARNED:

Installing truly mite-resistant stock in a commercial operation is a long-term effort. It will require significant changes in management systems, greater worker expense, and greater dependence on a skilled workforce.

Until truly mite-resistant queens are widely available in the market, commercial beekeepers who raise their own queens can improve mite resistance in their apiaries. They can select queen mothers from multiple hives (e.g., over 10 colonies) that consistently show low mite levels, and allow those colonies to produce drones. It is important to pay attention to the drone populations in the mating yards. Over time, significant improvements can be realized.

Even with mite-resistant stock, beekeepers should continue monitoring Varroa mite levels, because the trait can be diluted quickly.

# Cultural Control Method

## Brood Breaks

Creating a brood break is an important part of any IPM strategy as it reduces the opportunity for mites to reproduce and offers a window for additional controls. There are multiple ways to create a brood break; including requeening, caging the queen, (as well as cold storage—see section above). Brood breaks work with colonies' natural inclination to become broodless during the winter and can give the beekeeper another opportunity to apply Varroa treatments targeting phoretic mites.

### EFFECTIVENESS AND TIMING:

The effectiveness of brood breaks in reducing mites is largely anecdotal. When timed with chemical treatment after all or nearly all capped brood has emerged, brood breaks can provide effective colony mite knock down.

In the spring, some beekeepers are investigating the practice of moving colonies to cold storage following pollination of almonds in order to create a brood break and discourage swarming. Colonies are treated for mites immediately on removal from cold storage.

### PROS:

- Part of an Integrated Pest Management treatment plan
- Can be incorporated into regular management of dividing/equalizing colonies
- Can be combined with colony requeening utilizing improved mite control capabilities
- Possible swarm control with spring movement to cold storage

### CONS:

- Careful timing to integrate chemical use
- Time needed to find the queen in each colony
- Due to lack of a broodless period, possibly less effective in warmer climates

### APPLICATION METHOD:

Brood break can be achieved in a number of ways:

- Queen sequestration
- Queen removal and replacement with queen cell or adult queen
- Indoor storage (see below)

For maximum effectiveness, brood break should be combined with chemical control of phoretic mites. Oxalic acid (drizzle or vaporization) and Hopguard® would be the optimal chemicals to use, but any approved miticide will be effective.

Use of some varroacides (e.g. formic acid or thymol) may result in inadvertent brood breaks.

### COSTS:

Management time to find queens and then subsequently requeen colonies. Cost of acid for treatment when capped brood emerges.

### LESSONS LEARNED:

"One or two or maybe more [brood breaks] throughout the year is a key factor in controlling mites, and yet you're going to forgo something if you do that…colony population reduction caused by the brood break will affect package and honey production." (Russell Heitkam)

Splitting all colonies after almonds, and again after apples, lowers mite counts due to the brood break created. (Chris Hiatt)

Photo Credit: Api-Mo.Bru (www.apimobru.com)

## Indoor Storage

Indoor storage is not a new method, but new technology makes it more practical on a large scale. Traditionally used for overwintering, indoor storage is being expanded to creating brood breaks during the active growth season.

### EFFECTIVENESS AND TIMING:

After mite control in early October, move colonies into an indoor facility before horizontal (hive to hive) reinfestation can occur. Colonies remain in facility for 3 to 4 months before movement to California or other locations for pollination.

Putting bees in cold indoor storage, even in warm climates, limits unnecessary foraging when food is not available. Indoor storage can also create brood breaks, which helps to reduce Varroa levels by reducing mite reproduction and offering an opportunity for treatment of phoretic mites.

Consistent cooler temperatures keep bees in clusters and reduce winter feeding needs.

### PROS:

- Reduced colony feeding needs
- Can reduce swarming
- Creates a brood break
- Opportunity to combine cold storage with miticide treatment

### CONS:

- Expense of facility and backup power, including specialized expertise
- Possibility of extensive colony loss if electric power fails
- Need to move large number of colonies from field to facility and vice versa in a short time
- Need to remove dead bees

For more information, see the publication from Project Apis m: "Indoor Storage of Honey Bee Colonies in the United States."

### METHOD:

Cold storage might include construction of a new facility or modification of produce sheds (e.g. onion/potato) or large agricultural structures (e.g., dairy barns, fruit storage, tobacco storage barns). Need to maintain constant temperature of 40-45°F with air circulation and total darkening.

Rented space is another option which may be more cost-effective for smaller operations that may not need an entire building.

### COST:

New facility cost of $120/ft$^2$ (see beekeeper case studies). Costs of modified agricultural structures will vary.

### LESSONS LEARNED:

A beekeeper should visit an existing facility before constructing or modifying a new facility.

Indoor facilities require continuous power to maintain a constant temperature of 40-45°F with air circulation. Beekeepers should carefully review both the pricing and reliability of their electric provider. It is also recommended to review ten years of prior data on reliability from the electric provider and when the power went out, for how long, how often, and during what kind of weather. If the grid is not reliable, consider a different electricity provider. Install a backup generator capable of providing 25% of the power required. Expect the refrigeration to run constantly to compensate for heat generated by bees and to remove carbon dioxide. Removing dead bees is important to avoid spreading pathogens. Ensure proper spacing of colonies to benefit from air flow.

Photo Credit: John Miller, Miller Honey Farms, Gackle, North Dakota

## CONCLUSION

This guide is intended to show how some commercial beekeepers are having success without resorting to frequent off-label Varroa treatments. Commercial beekeepers can transition away from the chemical roulette of unregistered products if they are willing to use a variety of strategies discussed in this guide, including adoption of mite-resistant stock. Relying on off-label chemical treatments for Varroa control may have worked in the short term; however, the long-term risks to the beekeeping industry cannot be overstated. Chemical resistance has the potential to leave beekeepers with exploding mite populations and nothing to stop the surge.

# *The choice is yours...*

Photo Credit: George Hansen

Photo Credit: D.M. Caron

# APPENDIX

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RESOURCES

Integrated Pest Management:
https://nifa.usda.gov/program/integrated-pest-management-program-ipm

Technical Transfer Team, Bee Informed Partnership:
https://beeinformed.org/services/tech-teams/

Project Apis m, "Indoor Storage of Honey Bee Colonies in the United States":
https://www.projectapism.org/indoor-storage-guide-for-honey-bees.html

Bee Health Collective:
https://www.beehealthcollective.org/

Bee Informed Partnership Publications:
https://beeinformed.org/citizen-science/publications/

Hilo Queens (USDA Baton Rouge Bee Lab):
https://www.hilobees.com/

Purdue Mite-Biter Queens from Heartland Honey Bee Breeders Cooperative:
https://hhbbc.org/

Russian Queen Bee Breeder Program:
http://www.russianbreeder.org/

HONEY BEE HEALTH COALITION

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