2017

NYS Beekeeper Tech Team Report

Tech Team mission

- *Improve honey bee health*
- *Reduce colony losses*
- *Improve the profitability of the beekeeping industry*

NYS BEEKEEPER TECH TEAM

NEW YORK STATE OF OPPORTUNITY. Agriculture and Markets

Cornell CALS College of Agriculture and Life Sciences

2017 NYS Beekeeper Tech Team Report

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NYS Beekeeper Tech Team

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NYS Beekeeper Tech Team

Overview

The NYS Beekeeper Tech Team (Tech Team) was created in response to the unsustainable colony losses experienced by beekeepers across the state in recent years. The Tech Team works closely with New York beekeepers to improve honey bee health, reduce colony losses, and increase the profitability and viability of beekeeping businesses. The Tech Team meets with participating beekeepers several times a year to conduct applied research and to deliver educational programming. Participating beekeepers manage operations that range in size from a few backyard hives to thousands of colonies.

The program is funded by the New York State Environmental Protection Fund and implemented by Cornell University in collaboration with the New York State Department of Agriculture and Markets.

Tech Team Members

Emma Mullen

As the Honey Bee Extension Associate at Cornell University, Emma is the Senior Lead of the NYS Beekeeper Tech Team. She received a Master's degree from Western University, Canada, where she studied honey bee social behavior. Emma is passionate about communicating scientific research to beekeepers and working with them to implement best management practices that will improve colony health.

Mary Kate Wheeler

Mary Kate grew up in Ithaca, New York and completed a Master's degree in Applied Economics at Cornell. She is passionate about helping farmers achieve their goals and build businesses that are financially and ecologically sound. As the Agricultural Economic Analyst for the Tech Team, she coordinates the Financial Analysis and Business Benchmarking program for beekeepers.

Paul Cappy

As the NYS Apiculturist, Paul Cappy represents the Department of Agriculture and Markets on the Tech Team. Paul has more than 50 years of beekeeping experience and brings extensive knowledge of the beekeeping industry. He leads the NYS Apiary Inspection Program, which improves honey bee health by inspecting beekeeping operations, certifying colonies to cross state lines, and eradicating diseased colonies. He also collaborates with the National Honey Bee Survey to evaluate parasite, pathogen, and pesticide prevalence in NYS and investigate ways to reduce annual colony losses.

Scott McArt

Scott McArt is an Assistant Professor of Pollinator Health at Cornell University and helps coordinate Tech Team research and operations. Research in the McArt lab focuses on the impact of parasites, pathogens, and pesticides on honey bees and wild bees. He is particularly interested in scientific research that can inform management decisions by beekeepers, growers, and the public.

Acknowledgements

The Tech Team is grateful for a close collaboration with the Bee Informed Partnership (BIP). We are fortunate to receive technical support from BIP's Executive Director, Karen Rennich. We appreciate the work of BIP staff Andrew Garavito and John Klepps, who provide assistance sampling colonies and communicating with beekeepers. The University of Maryland Honey Bee Lab provides invaluable parasite and pathogen diagnostic services for our team. We would like to thank Nico Baert at the Cornell Chemical Ecology Core facility for providing pesticide residues analyses. We are grateful to the Empire State Honey Producers Association for supporting and promoting the Tech Team and its programs. Lastly, it has been a pleasure to work with members of our Beekeeper Advisory Board, who help to shape the direction and priorities of the Tech Team. We appreciate the contributions of Advisory Board members Chris Cripps, Christina Wahl, Chuck Kutik, Dan Winters, Earl Villecco, Mark Berninghausen, and Pat Bono.

Executive Summary

- **Beekeepers make an important contribution to New York State's agricultural economy.** In 2017, 28 Tech Team survey respondents harvested a total of 700,000 lbs of honey, valued at over $2.5 million, from 13,500 colonies. This represents approximately 19% of total honey production in NYS[1]. The total value of production for these beekeepers, including honey, other apiary products, nucs, queens, and paid pollination services, exceeded $3.8 million in 2017.
- **New York State honey producers saw yields decline in 2017.** The average yield for survey respondents in 2017 was 52 lbs per colony, down from 64 lbs per colony in 2016. Many beekeepers reported investing resources into splitting and increasing colonies in 2017, rather than maximizing honey yields, to make up for high colony losses over the 2016 - 2017 winter. The decline in honey production between 2016 and 2017 is part of a larger trend showing a fairly steady 43% decline in overall NYS honey production over the past 30 yrs (1987-2017)[1].
- **Winter and summer colony loss rates in 2017 were unsustainable.** On average, New York State beekeepers consider an annual colony loss rate of 19% to be acceptable. Observed colony losses far exceeded that number. Survey respondents experienced a total winter colony loss of 46% (October - March) and a total summer colony loss of 27% (April - September) for the 2016 - 2017 recording period.
- **Unchecked V*arroa* mite populations and associated viral diseases likely contributed to high winter colony losses.** Last year V*arroa* population levels were dangerously high going into winter, when a majority of colonies (62%) had mite counts above the recommended treatment threshold. At the same time, 21% of colonies exhibited symptoms of Parasitic Mite Syndrome (PMS), an advanced stage of infestation by V*arroa* mites and associated viruses. Colonies with mite levels above the treatment threshold are projected to die within 1 to 2 years, while colonies showing symptoms of PMS are expected to die within a few weeks or months.
- **Beekeepers perceive V*arroa* mites to be a serious threat to colony health.** V*arroa* mites and V*arroa*-transmitted viral diseases were the two most common beekeeper-identified causes of winter colony losses in 2017. Fully 60% of beekeepers consider V*arroa* to be a serious or extremely serious problem in their operation.
- **Beekeepers monitored more frequently and treated more aggressively for V*arroa* in 2017.** Between 2016 and 2017, the percentage of operations that reported monitoring for V*arroa* mites more than doubled, from 36% to 89%. Those that monitored for mites were significantly more likely to apply a V*arroa* treatment to their colonies. The percentage of beekeepers that used at least one chemical treatment to control V*arroa* increased from 73% to 86%. Use of amitraz, a highly effective V*arroa* treatment with relatively few side effects to honey bees, more than tripled from 11% of survey respondents in 2016 to 36% in 2017.
- **V*arroa* mite populations were controlled more effectively in June and August 2017.** Average V*arroa* mite levels were lowest in June (1.4 mites per 100 bees), when honey bee population and brood levels were also lower. Mite levels increased significantly in August (2.4 mites per 100 bees), yet they remained lower than the levels recorded in September 2016 (6.3 mites per 100 bees). Just 19% of colonies in June and 24% of colonies in August had V*arroa* mite levels above the recommended treatment threshold.
- **Honey bees are exposed to numerous agrochemicals, yet acute pesticide kills are rare.** Residues of 34 different pesticides were detected in wax samples taken from honey bee colonies in September 2016. Colonies contained 5.5 different pesticides, on average, yet no colony had pesticide levels high enough to trigger concerns about acute toxicity. Coumaphos is a persistent miticide in wax and was detected in 51% of colonies. It is known to negatively impact bee health and to synergize with other pesticides. Beekeepers should limit exposure to pesticides when they can, especially insecticides, persistent miticides, and pesticide synergists (including EBI fungicides), to reduce the risk of chronic, sublethal, and synergistic effects. Only one beekeeper reported observing symptoms of an acute pesticide kill in 2017.

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Introduction

Honey bees in New York State face more challenges than ever before, and colony losses continue to occur at unsustainable levels. Between 42-68% of New York's colonies have died each year since 2010[2]. Parasites, viruses, pesticides, nutrition, and management practices all shape honey bee health outcomes. The complexity of factors that influence colony health and productivity makes it difficult for beekeepers to diagnose specific health problems in their colonies and respond accordingly. Nonetheless, beekeepers throughout the state are eager and determined to evaluate colony health and use management practices that promote healthy, productive bees.

When beekeepers receive information about their colony health and performance, they are in a good position to make informed management decisions. Knowing exact *Varroa* mite levels, *Nosema* spore counts, virus infection levels, and pesticide residues takes the guesswork out of identifying issues that may present vague or inconsistent symptoms. Coupling these data with resources and expert recommendations allows beekeepers to proactively manage their operations using effective, evidence-based practices. The NYS Beekeeper Tech Team was founded to foster this approach.

The Tech Team empowers beekeepers to understand and respond to their colony health problems. The Tech Team works with beekeepers across New York State and inspects a sample of colonies from each participating operation. In the process, the Tech Team documents parasite infestations, pathogen levels, pesticide residues, and management practices of individual hobbyist, sideliner, and commercial beekeepers. Each beekeeper receives a detailed colony health snapshot of their own operation, along with values from similar operations for comparison. Recommendations based on individual test results inform production decisions and support proactive planning for improved pest, disease, and pesticide management. Sharing this information with beekeepers is critical to mitigating colony losses and enhancing the stability and profitability of the New York State beekeeping industry.

The main objectives of this report are to (1) present results from the 2017 Tech Team research that investigates parasite, pathogen, and pesticide levels and beekeeper management practices, (2) compare results from 2017 with 2016 to identify trends over time, and (3) interpret results and identify major findings to support decision making for improved management and colony health.

Methods

Sample Selection & Colony Inspection

In 2017, the Tech Team inspected 320 colonies belonging to 34 beekeepers across 22 counties in New York State. The sample included 8 hobbyists (apiarists who manage 1 - 49 colonies), 13 sideliners (50 - 499 colonies), and 13 commercial beekeepers (500+ colonies). We inspected 1 colony from each hobbyist (8 total), 4 from each sideliner (52 total), and 20 from each commercial beekeeper (260 total). Colonies were inspected once in the first two weeks of June and again in the last two weeks of August. All 320 colonies were sampled for *Varroa* mites and *Nosema* spores in both periods, while a subset of 190 colonies were sampled for viruses and pesticides in August.

Colonies were selected semi-randomly in each apiary, and tagged with a unique identification number. The Tech Team inspected the same colonies during both time periods, except when a colony was dead or too weak to sample, in which case a replacement was selected. At least three brood frames were visually inspected for evidence of honey bee pests, parasites, and pathogens. In the event that American or European foulbrood symptoms were observed, a Vita Bee test kit was used to verify the infection. If the colony tested positive for American foulbrood, the state apiculturist was contacted immediately in compliance with New York State apiary laws.

This report also uses colony health and management data gathered by the Tech Team in September 2016. Sampling and analysis procedures are described in the *2016 NYS Beekeeper Tech Team Report*[3].

Laboratory Analyses

Varroa. Approximately 300 bees were collected from the brood nest of each colony and shipped in a saturated saline solution to the University of Maryland Honey Bee Lab. At the lab, the samples were shaken and washed to dislodge mites from the bees' bodies. A technician counted the number of bees and mites in each sample, and calculated the exact number of mites per 100 bees.

Nosema. One hundred worker bees were reserved from the 4 oz *Varroa* sample. The bees were crushed to release *Nosema* spores from their guts. The crushed sample was mixed with 100 mL of deionized water, and 4 μl of the resulting solution was pipetted onto a hemocytometer. Using a microscope with 400x magnification, a technician counted spores covering an area equal to 20% of the hemocytometer. This count was converted to the number of millions of spores per bee.

Viruses. A 50 mL vial was filled with bees from the brood nest, immediately frozen on dry ice, and shipped to the University of Maryland Honey Bee Lab for processing. RNA extraction and quantitative PCR was performed on each sample to measure viral loads for 6 viruses: acute bee paralysis virus, chronic bee paralysis virus, deformed wing virus, Israeli acute paralysis virus, Kashmir bee virus, and Lake Sinai virus 2. Black queen cell virus and slow bee paralysis virus were sampled in 2016, but not in 2017; black queen cell virus was no longer cost effective to sample as it is nearly ubiquitous in honey bee colonies, and it has been determined that slow bee paralysis virus is not yet present in the US.

Pesticides. Three grams of the oldest available wax was collected from the brood nest, and immediately frozen on dry ice. Pesticide residues in the 2017 wax samples will be analyzed and reported in 2018. In 2016, the Tech Team collected wax samples from 198 colonies. The Cornell Chemical Ecology Core Facility extracted and analyzed pesticide residues from these samples in 2017. Levels of 41 chemical compounds were analyzed: 19 insecticides (including 6 neonicotinoids), 17 fungicides, 2 herbicides, 2 miticides, and 1 pesticide synergist. The full list of compounds is provided in the *2016 NYS Beekeeper Tech Team Report: Pesticide Residues*[4].

Beekeeper Management Survey

All participating beekeepers received a comprehensive survey covering production, management practices, colony losses, and operation characteristics. A total of 28 beekeepers completed the survey, resulting in a 82% response rate.

Industry Overview

The 28 respondents to the 2017 Beekeeper Management Survey managed a total of 16,000 colonies in 2017, which represents 20% of the estimated 80,000 total colonies kept by beekeepers in New York State. The total value of their production in 2017, including production of honey, other apiary products, nucleus colonies, queens, and pollination services, exceeded $3.8 million.

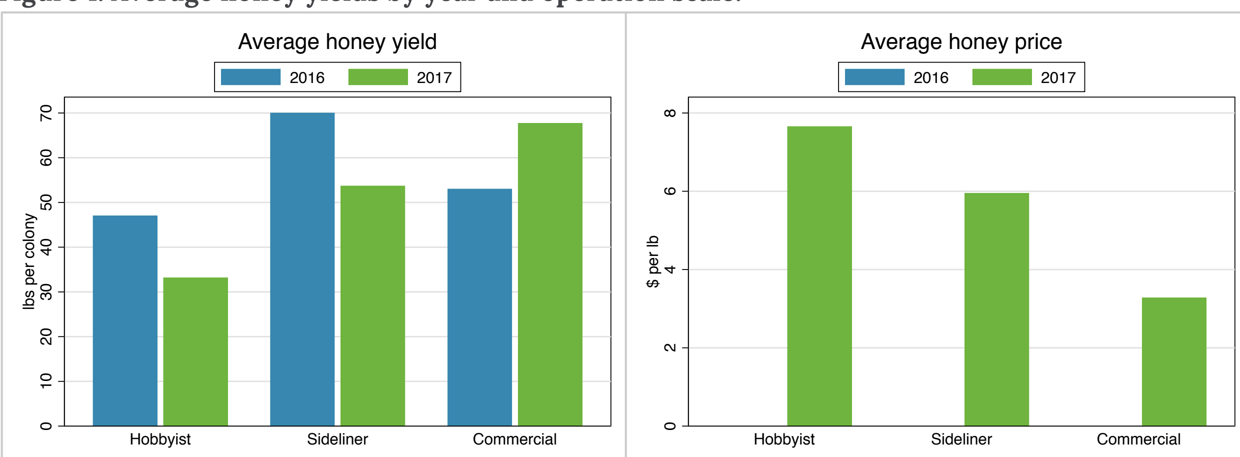
Honey Production

Survey respondents harvested 700,000 lbs of honey in 2017, valued at $2.5 million. The average yield of 52 lbs per colony was slightly lower than in 2016 (64 lbs per colony), suggesting that 2017 was a less productive year for honey producers. Many beekeepers reported investing resources into splitting colonies, rather than maximizing honey yields, to make up for high winter losses.

Commercial beekeepers reported higher honey yields and lower honey prices relative to sideliners and hobbyists in 2017 (Figure 1). The difference in price is unsurprising, as commercial beekeepers tend to rely on wholesale markets to sell large volumes of honey, while many sideliners and hobbyists pursue direct-to-consumer and value-added marketing strategies.

Honey revenue per colony, a measure of economic productivity, was calculated for each operation as the total honey revenue divided by the number of honey-producing colonies. Honey revenue was $355/colony for hobbyists, $347/colony for sideliners, and $234/colony for commercial operations, on average. There was no significant relationship between scale and honey revenue per colony.

Figure 1. Average honey yields by year and operation scale.



Note: Data on honey prices were not collected in the 2016 survey.

Other Apiary Products

Survey respondents produced beeswax (64%), cut comb (29%), propolis (14%), and pollen (11%) in 2017. The total value (volume) of production was $70,233 (11,453 lbs) for beeswax, $25,789 (3,083 4-inch squares) for cut comb, $53,725 (328 lbs) for propolis, and $7,650 (380 lbs) for pollen.

Nucleus Colonies & Queens

A total of 8 operations (29%) reported producing nucleus colonies for sale in 2017. The average sale price was $140 per nuc, and the total value of nucleus colonies produced by survey respondents was $377,815. Just one beekeeper reported selling queens in 2017.

Pollination Services

Seven survey respondents (23%) reported sending a total of 7,621 colonies into commercial pollination for 11 agricultural crops across 5 states in 2017. Table 1 shows the number of colonies sent to pollinate each crop, the state where pollination occurred, and the average reported price per colony. The total value of 2017 pollination services is estimated at $728,123.

Table 1. Paid pollination services in 2017.

Crop	Number of Colonies	State	Average Price Per Colony Reported by Tech Team Beekeepers	Average Price Per Colony Reported by NASS*
Almond	1,650	CA	$165.00	$171.00
Apple	1,559	NY	$87.40	$69.90
Blueberry	2,238	GA, NC, NJ, NY	$67.50	$88.20
Cherry	50	NY	$98.33	$55.00
Cranberry	1,000	NJ	not reported	$77.90
Cucumber	300	NY	$125	$62.70
Melon	200	NJ	not reported	$78.10
Pear	24	NY	$125	$53.10
Pumpkin	300	NY	$125	$76.80
Squash (summer & winter)	300	NY	$125	$74.10

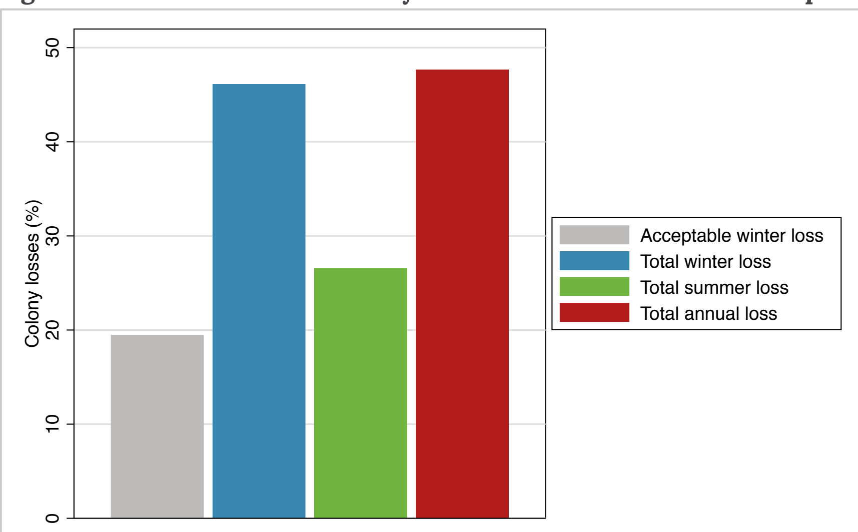
*USDA National Agricultural Statistics Service data[5] is based on prices in the Northeast for all crops except pear (prices available only for the Northwest) and almond (prices available only for California).

Colony Losses

High colony losses are a major concern and management challenge for beekeepers in New York State. The Tech Team calculates winter, summer, and annual colony losses based on colony counts reported by beekeepers. Winter losses cover the period from October 1, 2016 to April 1, 2017; summer losses cover the period from April 1, 2017 to October 1, 2017; and annual losses cover the period from October 1, 2016 to October 1, 2017. For a given period, the loss rate is calculated as the total number of colonies that died in the period divided by the total number of colonies kept during that period, using the method established by the Bee Informed Partnership (BIP)[6,7].

Figure 2 shows total winter, summer, and annual colony losses for 26 beekeepers that completed the Tech Team's 2017 Management Survey. Beekeepers reported losing 7,755 out of 16,821 colonies between October 2016 and April 2017, resulting in a total winter loss of 46%. The same beekeepers lost 4,156 out of 15,665 colonies between April 2017 and October 2017, producing a total summer loss of 27%. The total annual loss rate for the 2016 - 2017 year was 48%, which is 2.5 times greater than the average loss rate that beekeepers considered to be acceptable (19%). Thus, 2017 was a difficult production year for many beekeepers in New York State.

Figure 2. Total 2016 - 2017 colony loss estimates for NYS beekeepers.

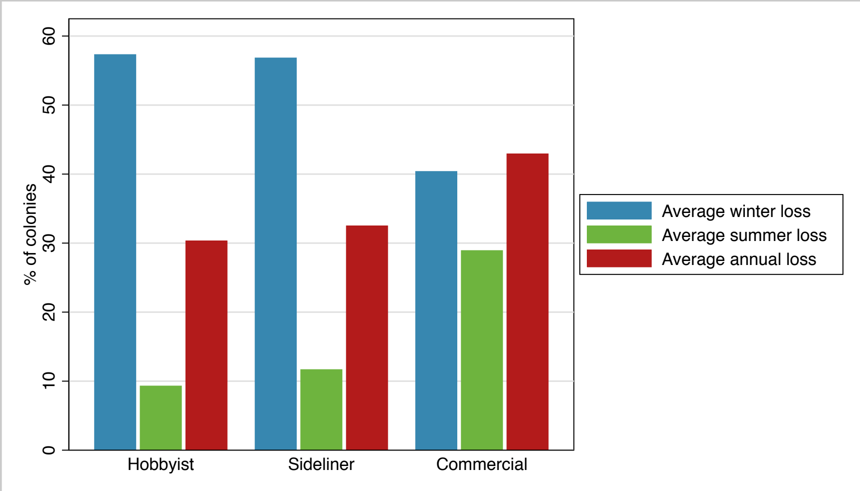


Note: Total winter loss (blue bar) covers the period from October 1, 2016 to April 1, 2017. Total summer loss (green bar) covers the period from April 1, 2017 to October 1, 2017. Total annual loss (red bar) includes total winter and total summer losses from October 1, 2016 to October 1, 2017. The acceptable winter loss rate (grey bar) is the average percentage of acceptable yearly colony losses declared by the survey participants in 2017. Colony loss rates are calculated following BIP methods[6,7].

Colony losses reported in 2017 were higher than the colony losses in 2016[3]. However, the survey questions used to elicit colony loss data changed in 2017, so we cannot directly compare loss rates from the two years. The Bee Informed Partnership reported similar annual colony loss rates for New York State in the 2015 - 2016 and the 2016 - 2017 beekeeping years[2]. Figure 3 presents average colony losses for hobbyists, sideliners, and commercial beekeepers.

Winter loss rates were similar across operations of different scales, yet commercial beekeepers had higher summer losses (29%), on average, compared to hobbyists (9%) and sideliners (12%). Differences in management practices may help to explain this trend. Commercial beekeepers are more likely to move bees multiple times a year, as they commonly overwinter bees in southeastern states before transporting bees to New York and other states to pollinate agricultural crops. Migratory beekeeping is associated with exposure to agrochemicals[8,9], reduced worker lifespan[10], and increased physiological stress[10]. Furthermore, colonies that provide pollination services may also be exposed to poorer nutrient environments (depending on the crop)[8]. These factors may play a role in the increased summer colony losses experienced by commercial beekeepers.

Figure 3. Average 2016 - 2017 colony loss estimates by operation scale.



Note: Average winter loss (blue bars) covers the period from October 1, 2016 to April 1, 2017. Average summer loss (green bars) covers the period from April 1, 2017 to October 1, 2017. Average annual loss (red bars) includes total winter and total summer losses from October 1, 2016 to October 1, 2017.

Table 2 summarizes beekeeper opinions about the primary causes of colony losses in their operations between October 2016 and October 2017. The most commonly reported causes of winter colony death was *Varroa* mites, followed by viruses and/or *Varroa*-transmitted diseases. Varroa mites were also the second most commonly reported cause of summer colony death. These data suggest that beekeepers widely regard *Varroa* mites and associated viruses as a serious threat to colony health, particularly during the winter season. In fact, 60% of beekeepers that we surveyed consider *Varroa* mites to be a serious or extremely serious problem in their operation.

Table 2. Beekeeper-identified causes of winter and summer colony loss.
What factors were the most prominent cause(s) of winter/summer colony death in your operation?

Causes of Winter Loss	% of Beekeepers	Causes of Summer Loss	% of Beekeepers
Varroa mites	61%	Queen failure	43%
Viruses	29%	*Varroa* mites	25%
Nosema	18%	Pesticide exposure	14%
Queen failure	18%	Viruses	11%
Adverse weather	14%	Swarming	11%
2016 drought	11%	Brood diseases	7%
Pesticide exposure	11%	Inadequate nutrition	7%
Inadequate nutrition	11%	Adverse weather	7%
Moisture	4%	Nosema	4%
Brood diseases	4%	Robbing	4%
Colony Collapse Disorder (CCD)	4%	Colony Collapse Disorder (CCD)	4%

Note: This table shows the percentage of beekeepers that listed each cause of colony death. Columns do not add up to 100% because some beekeepers listed multiple causes.

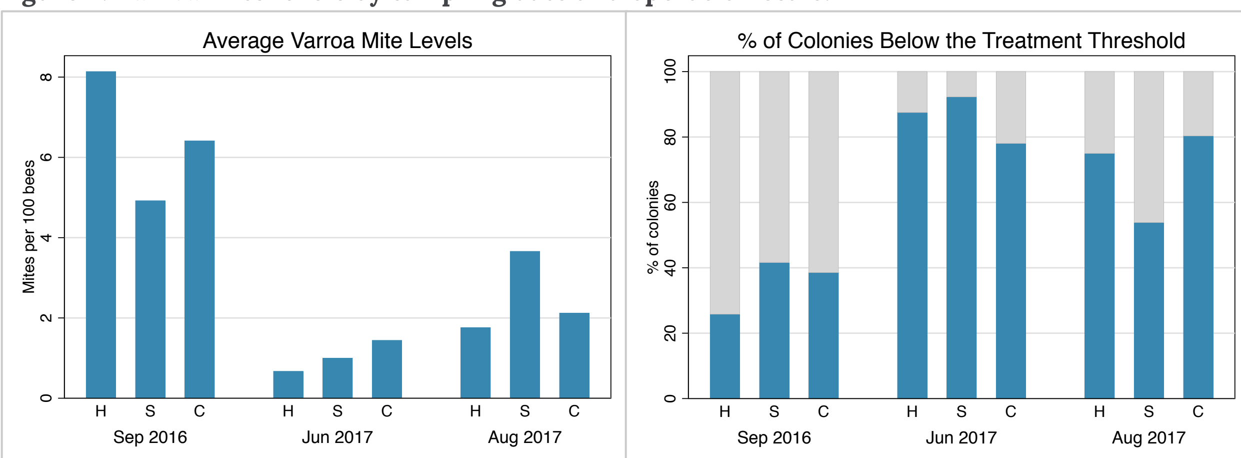
Pests and Diseases

Varroa Mites

Our data illustrate *Varroa* mite population levels by operation scale for September 2016, June 2017, and August 2017 (Figure 4; left panel). Average *Varroa* levels were highest in September (6.3 mites per 100 bees) and lowest in June (1.4 mites per 100 bees). This is not surprising, as the seasonal dynamics of *Varroa* mite populations are well documented in New York State, where *Varroa* levels most often peak in September and October[11] and are low in spring. Moreover, we find no clear relationship between operation scale and average *Varroa* mite levels. This result affirms that management of *Varroa* mite populations is a major challenge for beekeeping operations of all sizes.

The right panel of Figure 4 shows the percentage of colonies with *Varroa* mite levels below the recommended treatment thresholds. In New York State, best management practices call for using a *Varroa* treatment if mite levels reach **2 mites per 100 bees in the spring**, or **3 mites per 100 bees in the** fall[12]. Levels above these thresholds predict colony mortality within 1-2 years. In September 2016, fewer than half of colonies (38%) had mite levels below the threshold, suggesting that beekeepers were not effectively controlling *Varroa* mites at that time. In contrast, a majority of colonies in June (81%) and August (76%) had mite levels below the threshold.

Figure 4. *Varroa* mite levels by sampling date and operation scale.



Note: H = hobbyist; S = sideliner; C = commercial beekeeper. The *Varroa* treatment threshold is 3 mites per 100 bees in August and September, and 2 mites per 100 bees in June. The percentage of colonies below the treatment threshold is shown in blue, while the percentage of colonies above the treatment threshold is shown in gray.

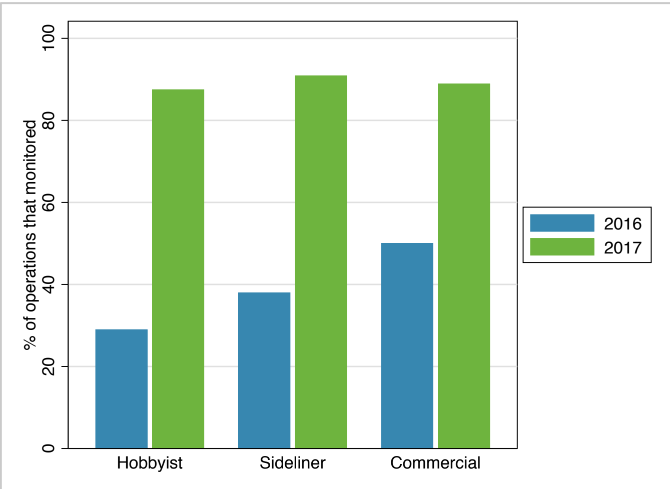
Varroa populations follow a seasonal pattern, making it difficult to draw conclusions about changes in management efficacy by comparing mite levels from different times of year. Yet if we compare September 2016 to August 2017, we see impressive reductions in *Varroa* populations for hobbyists and commercial beekeepers, but more modest gains for sideliners. In August, just 54% of sideliner colonies had mite levels below the treatment threshold, compared to 75% of hobbyist colonies and 76% of commercial colonies. This observation could be explained by variation in labor availability and mite treatment preferences across the three groups. If sideliners prefer more natural chemical treatments relative to commercial beekeepers, yet have less time available per colony relative to hobbyists, they may struggle to maintain rigorous *Varroa* monitoring and treatment practices.

The high levels of *Varroa* in September 2016 prompted the Tech Team to sample colonies earlier (in August) in 2017. This change in sampling time provided beekeepers with notice of early autumn *Varroa* issues before they reached a point where they are exceedingly difficult to manage. **It is critical that beekeepers continue to monitor colonies in September and October**, when mite levels peak in New York. Low mite levels in August do not guarantee that mite levels will remain low in the following months before winter.

Varroa Monitoring and Treatment

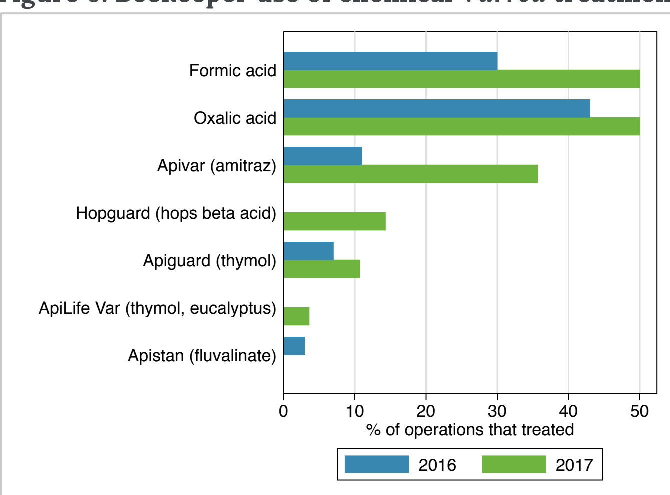
Monthly monitoring for *Varroa* mites is recommended to all beekeepers in New York State as a basic component of any management strategy to control *Varroa*. In 2017, 89% of survey respondents monitored for *Varroa* mites using one of three reliable methods: powdered sugar shake (43%), alcohol wash (39%), and/or ether roll (14%). This is a dramatic increase from 2016, when only 36% of beekeepers surveyed by the Tech Team reported monitoring for *Varroa* mites. Figure 5 presents the percentage of operations that monitored for *Varroa* in 2016 and 2017 by operation scale.

Figure 5. Adoption of *Varroa* monitoring by year and operation scale.



Not only did *Varroa* monitoring rates increase in 2017, but also the percentage of operations using chemical *Varroa* treatments. In 2017, 86% of respondents used one or more chemical treatments to control *Varroa* mites, compared to 73% in 2016. Figure 6 presents the percentage of operations using each of 7 different chemical treatments by year. In 2017, the percentage of beekeepers using formic acid (50%), oxalic acid (50%), amitraz (36%), and Apiguard (11%) increased relative to 2016. Beekeepers also reported using two new treatments in 2017: Hopguard (14%) and ApiLife Var (4%). None of the operations we sampled reported using Apistan (fluvalinate) or coumaphos in 2017.

Figure 6. Beekeeper use of chemical *Varroa* treatments by year.



Interestingly, there was a significant relationship between *Varroa* monitoring and using chemical *Varroa* treatments. Beekeepers that monitored for *Varroa* in 2017 were significantly more likely to use a chemical *Varroa* treatments compared to those that did not monitor. While this finding does not necessarily indicate causality, it reinforces the importance of monitoring to any management strategy that involves using chemical treatments to control *Varroa* mites.

Alternating treatments is recommended to improve the overall efficacy of *Varroa* management and reduce the risk that mites will develop resistance to a given treatment. In 2017, the number of different chemical *Varroa* treatments used within a single operation ranged from zero to four, and varied significantly with operation scale. Sideliner and commercial beekeepers used two different chemical treatments to control *Varroa* mites, on average, while hobbyists used just one.

Viruses

There are at least 20 viruses that are known to infect honey bees throughout the world. The Tech Team quantified the levels of six that are routinely tested across the US: deformed wing virus (DWV), acute bee paralysis virus (ABPV), chronic bee paralysis virus (CBPV), Israeli acute paralysis virus (IAPBV), Lake Sinai virus 2 (LSV-2), and Kashmir bee virus (KBV). At low levels, viruses do not cause symptoms in honey bees, but at high levels bees can exhibit a variety of symptoms. The exact infection levels that initiate symptoms in honey bees are not well known for honey bee viruses. Table 3 describes the symptoms of each of the six viruses tested.

Table 3. Honey bee virus symptoms.

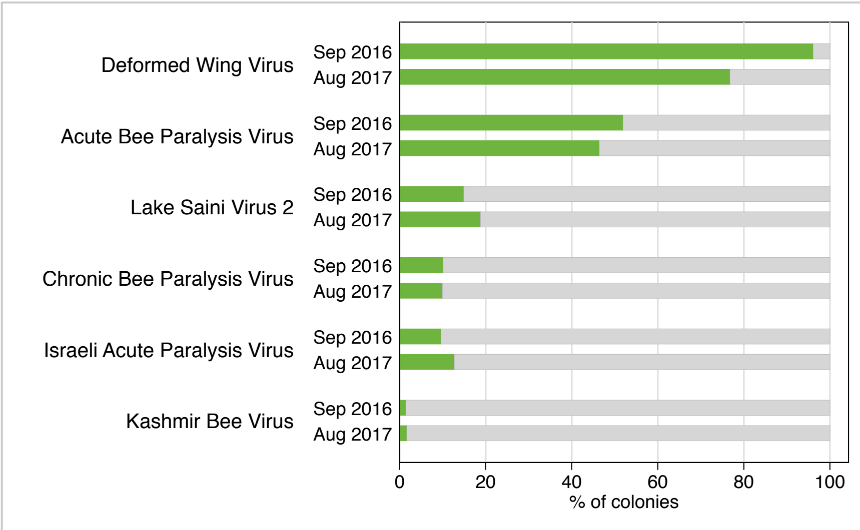
Virus	Main identifying symptom(s)
Deformed wing virus	• Deformed wings, sometimes accompanied with an abdomen that appears bloated and shortened
Acute bee paralysis virus	• Trembling • Crawling
Kashmir bee virus	• Death within days, no other observable symptoms
Israeli acute paralysis virus	• Shivering wings • Disorientation • Crawling • Darkened bodies and hair loss
Chronic bee paralysis virus	• Bloated appearance with trembling/crawling behavior • Black, hairless, greasy, and shiny in appearance
Lake Sinai virus 2	• No known symptoms

Four of the viruses sampled are known to be transmitted by *Varroa* mites (DWV, ABPV, IAPV, KBV) and preliminary evidence suggests LSV-2 may also be spread by *Varroa*. This means that a mite can carry the virus in its own body after feeding on an infected honey bee and transmit it to a different bee. Often, these viruses do not show any symptoms until *Varroa* mites are present in the colony to exacerbate the infection. For these viruses, the best defense against high infection levels is to maintain low levels of *Varroa* mites **for the entire year**. If *Varroa* levels are not managed all summer, and then a mite treatment is finally applied in autumn, the colony can still die from the high virus load despite the fact it has low mite levels entering winter. The seasonality of these viruses is expected to follow that of *Varroa* mites.

Figure 7 presents the prevalence of each virus in honey bee colonies in 2016 and 2017. DWV and ABPV infections remain very common in honey bee colonies (87% and 49% of colonies infected in 2017, respectively). Prevalence of both of these viruses is lower in August 2017 compared to September 2016. This decrease is likely a reflection of the lower *Varroa* mite levels detected at this time, as both viruses are positively associated with *Varroa* levels[3]. Nonetheless, the pervasiveness of these viruses indicates they continue to be a major concern for honey bee health in NYS.

Analyzing the presence of different viruses across operation scale revealed that Israeli acute paralysis virus was significantly more likely to occur in commercial colonies, and commercial colonies had significantly higher infection levels of acute bee paralysis virus compared to hobbyist and sideliner colonies. No other viruses were more or less likely to occur based on operation scale.

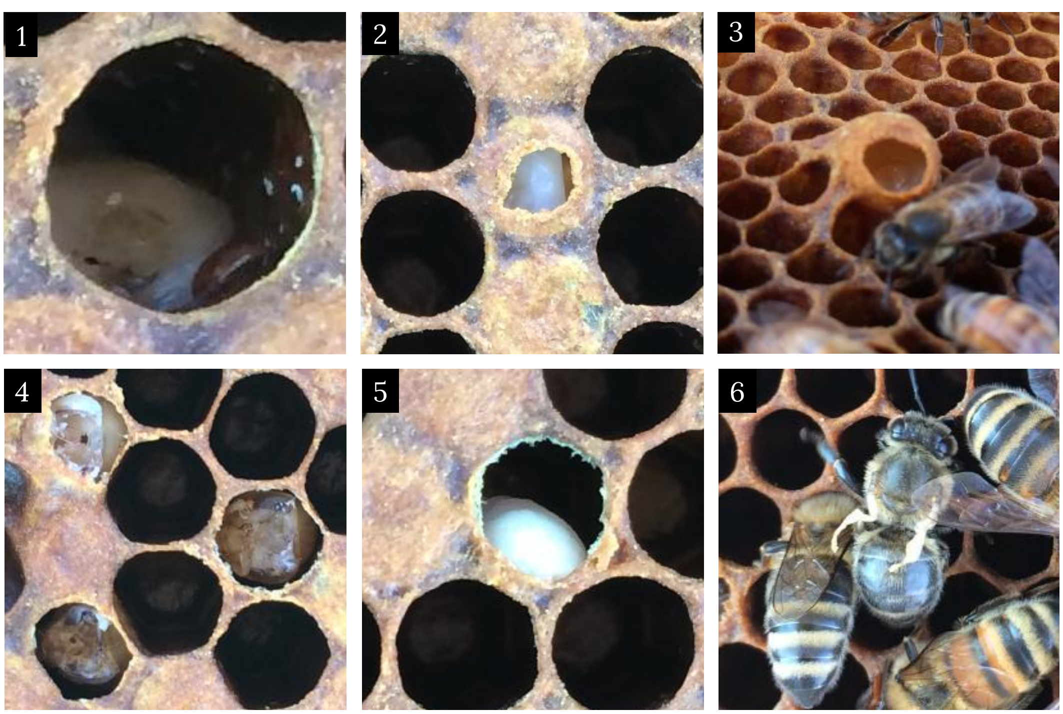
Figure 7. Prevalence of honey bee viruses by sampling date.



Parasitic Mite Syndrome

Parasitic Mite Syndrome (PMS) is the most advanced stage of a *Varroa*/virus infestation and results when colonies have not been adequately controlled for mites. Treating for mites at this stage of the infestation is not always effective, as damaging levels of viruses can kill colonies. PMS has varied symptoms, but is most often characterized by high mite levels, diseased brood infected with one or more viruses, and adults with deformed wings. Brood and adult bees may also have mites visible on their bodies. Hygienic behavior is observed as spotty brood, perforated cappings (cappings that have been partially or completely chewed off, revealing "bald" brood beneath) and chewed down brood.

Figure 8. Symptoms of parasitic mite syndrome: 1) mites present in brood cells, 2) perforated cappings, revealing "bald brood", 3) queen supersedure, 4) chewed down brood, 5) dead larvae of various ages, and 6) deformed wings

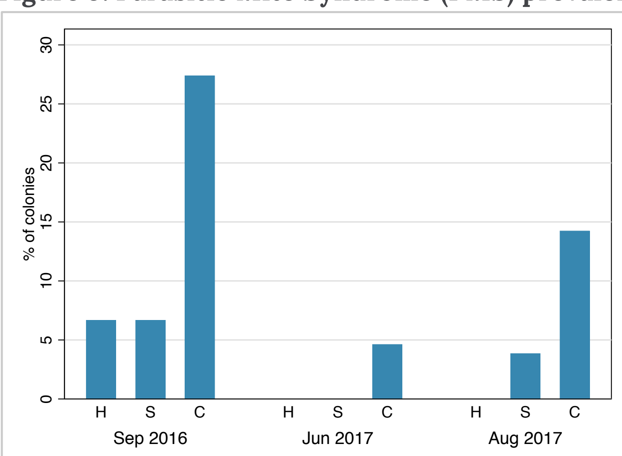


Parasitic Mite Syndrome follows *Varroa* population cycles, usually becoming evident in late summer. PMS symptoms are typically observed from July through October in New York State. Once a colony has developed this advanced syndrome, it can quickly collapse in a matter of weeks or months. Figure 9 presents the prevalence of PMS across time and operation scale. PMS prevalence was highest in September 2016 (occurring in 21.3% of all colonies), lowest in June 2017 (3.8%), and increased again in August 2017 (12.2%). Thus, PMS incidence was highest during peak *Varroa* season. Unsurprisingly, colonies with PMS had significantly higher *Varroa* mite levels (6.4 mites per 100 bees, on average) compared to colonies with no symptoms of PMS (2.6 mites per 100 bees).

As expected, the presence of Parasitic Mite Syndrome was positively related to both the presence and the intensity of honey bee viruses. Colonies with symptoms of PMS exhibited significantly higher levels of infection by DWV, ABPV, CBPV, IAPV, and LSV-2. Furthermore, two of the less common honey bee viruses, IAPV and KBV, were significantly more likely to occur in colonies with symptoms of PMS.

The Tech Team observed an astonishingly high rate of Parasitic Mite Syndrome among commercial beekeepers in September 2016 (Figure 9). At this time, PMS affected 27.4% of commercial colonies, meaning nearly one third of commercial colonies faced a high risk of dying from *Varroa* mites and associated viruses in the coming weeks or months. The prevalence of PMS in commercial colonies was lower in August 2017 (14.2%), but still concerning. These numbers demonstrate the urgent need for commercial beekeepers to regularly monitor for *Varroa* mites and treat colonies when mite levels exceed the treatment thresholds. It is advisable for beekeepers to inspect colonies in New York State for symptoms of PMS from July through October.

Figure 9. Parasitic Mite Syndrome (PMS) prevalence by sampling date and operation scale.



Note: H = hobbyist; S = sideliner; C = commercial beekeeper.

Interestingly, while *Varroa* mite levels did not differ significantly across operation scales, the presence of Parasitic Mite Syndrome did. Colonies managed by commercial beekeepers were significantly more likely to have PMS compared to colonies managed by hobbyists or sideliners. This reflects the complex interactions between *Varroa* mites, viruses, and beekeeper management practices. While *Varroa* mite levels provide an acute indicator of recent management and treatment choices, PMS reflects a cumulative impact of exposure to *Varroa* mites and associated viruses over one or more beekeeping seasons. Thus, although our data suggest that commercial beekeepers are no less effective at controlling *Varroa* mites compared hobbyists or sideliners, overall commercial colonies exhibit a greater chronic exposure to impacts of *Varroa* and viruses.

Nosema

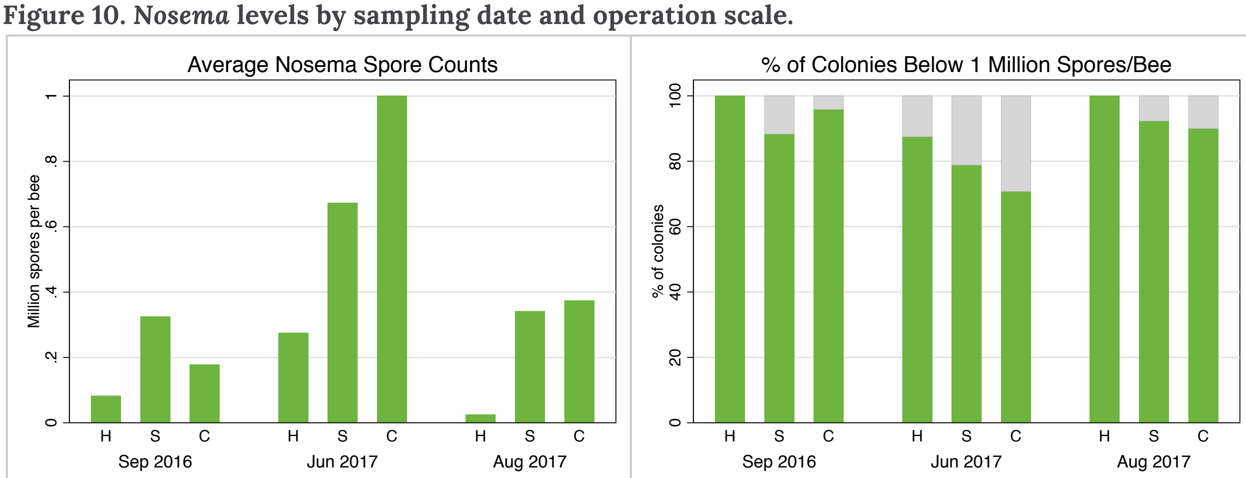
Nosema apis and *Nosema ceranae* are gut parasites that infect adult honey bees. Bees become infected when they consume spore-containing fecal matter. Both parasites can kill colonies that are unable to clear the infection. Observed symptoms include a slow spring population build up, reduced honey production, reduced brood production, and adult population dwindle. Other than these general effects, colonies infected with *Nosema* are often asymptomatic. In colonies that do die from the disease, the majority of adults die far from the hive. Inside the hive, there may be a few dead bees on the bottom board with only a few young bees and the queen remaining. Although *Nosema apis* is associated with dysentery, this symptom is not seen with *Nosema ceranae*.

In New York, *Nosema ceranae* has displaced *Nosema apis* almost entirely. Fewer than 1% of Nosema-infected colonies tested in 2013 by the state apiary inspection program were from *Nosema apis*, while 96.8% were *Nosema ceranae*[13]. Because infections in NYS are predominantly *Nosema ceranae*, the Tech Team analysis does not differentiate between the two species.

Some institutions in the US and Canada recognize the treatment threshold for *Nosema* to be 1 million spores per bee[12,14,15]. This treatment threshold suggests that if the average spore count in a colony sample is 1 million spores per bee or greater, the beekeeper should apply a fumagillin treatment. However, in reality there is no well-established treatment threshold for *Nosema*, and fumagillin is not always effective for controlling *Nosema cerenae*. Beekeepers who use fumagillin to control *Nosema* should re-test their colonies in 6 months to evaluate treatment efficacy. In many cases, otherwise healthy colonies are able to recover from *Nosema* infections without intervention. If colonies succumb to the infection, equipment should be properly disinfected through freezing (a minimum of 4 days), gamma radiation, acetic acid fumigation, or heating woodenware to 120°F for 24 hours to 140°F for at least 15 minutes (note this temperature melts wax).

Figure 10 shows average *Nosema* spore counts (left panel) and the percentage of colonies below one million spores per bee (right panel) by operation scale and sampling period. Past data from the NYS apiary inspection program[16] has not found a consistent seasonal cycle for *Nosema* infection. However, Tech Team colony sampling identified higher *Nosema* levels in spring compared to autumn. On average, Nosema infections were significantly higher in June 2017 (0.93 million spores per bee) compared to September 2016 (0.20 million spores per bee) or August 2017 (0.36 million spores per bee). More than a quarter (27.5%) of colonies in our sample had *Nosema* spore counts higher than one million spores per bee in June 2017. However, the percentage of colonies with *Nosema* spore counts above the treatment threshold dropped to 9.4% in August 2017. These results suggest *Nosema* infections did not pose a critical threat to colony health during these time periods and in the apiaries sampled.

Figure 10. *Nosema* levels by sampling date and operation scale.



Note: H = hobbyist; S = sideliner; C = commercial beekeeper. The percentage of colonies below the treatment threshold is shown in green, while the percentage of colonies above the treatment threshold is shown in gray.

The Tech Team recommends biannual monitoring (spring and fall) of *Nosema* levels in apiaries that show *Nosema* symptoms. Just four Tech Team Management Survey respondents (14%) reported monitoring for *Nosema* in 2017, and they all sent samples to the USDA Bee Research Laboratory in

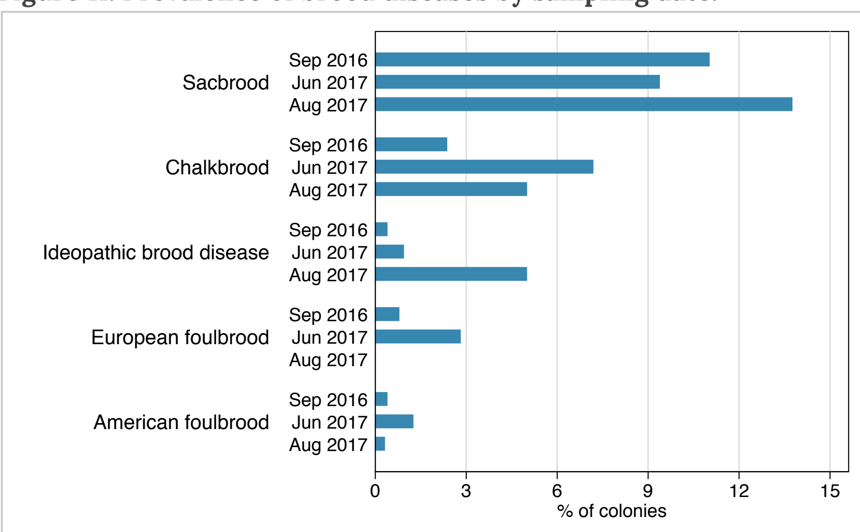
Beltsville, MD. Three of the four beekeepers that sent samples to the USDA Bee Research Lab reported finding *Nosema* levels higher than 1 million spores per bee. Colonies that have high infections should be moved to an isolated apiary until the infection clears so as to not pose a risk to nearby healthy colonies.

Brood Diseases

Honey bee brood is susceptible to a variety of viral, fungal, and bacterial infections. Sacbrood is a viral brood infection that is diagnosed through visual observation of pointy-headed, sac-shaped larvae. Sacbrood was the most common brood disease observed across all three sampling periods, peaking in prevalence in August 2017 with 14% of colonies infected (Figure 11). As with other viruses, sacbrood is managed through proper nutrition, maintaining low *Varroa* mite levels, and sustaining strong colony populations. In mild infections, bees can prevent a major outbreak by removing diseased larvae through hygienic behavior in the early stages of infection. If a colony experiences a larger outbreak (with at least 5% of brood cells visibly infected), the beekeeper should discard brood frames that contain many infected cells and requeen the colony, ideally with hygienic stock.

Chalkbrood is a fungal brood disease most prevalent in spring, as it thrives in cool, moist conditions. Tech Team observations align with the seasonality of the disease; the highest prevalence occurred in June 2017, when 7% of colonies were affected. Chalkbrood is not regarded as a highly detrimental disease as infections usually clear up in the summer as the temperature rises. If infections do not clear up on their own, requeening (ideally with hygienic stock) may help a colony overcome the infection. If more than 10–20% of brood cells on a single frame are infected, beekeepers should remove those frames and replace them with frames of drawn comb or foundation.

Figure 11. Prevalence of brood diseases by sampling date.



American foulbrood (AFB) is the most contagious and destructive bacterial disease that honey bees can contract. The Tech Team discovered a total of six AFB-infected colonies across the three sampling periods, including four in June 2017 and one in August 2017. Visual diagnosis was verified through either an AFB Vita test kit or by sending a sample to the USDA Bee Research Lab in Beltsville, MD for confirmation. The state Apiculturist was notified of all infections so that proper destruction protocols could be followed. American foulbrood is often misconceived as a historical disease that is no longer present. This is not the case – beekeepers must stay vigilant about inspecting and testing their colonies. They should conduct three AFB inspections of every colony each year. Beekeepers must familiarize themselves with proper inspection techniques and in recognizing early symptoms of infection. It is the law in NYS to report all infected colonies to the state apiculturist.

European foulbrood (EFB) is another destructive brood disease. The Tech Team observed 11 colonies with EFB across the three sampling periods, including two colonies in September 2016 and nine colonies in June 2017. In some cases, European foulbrood can be difficult to differentiate from other brood diseases. In ambiguous cases, diagnosis can be made by using an EFB Vita test kit or by sending a sample the USDA Bee Research Laboratory in Beltsville, MD for a free analysis.

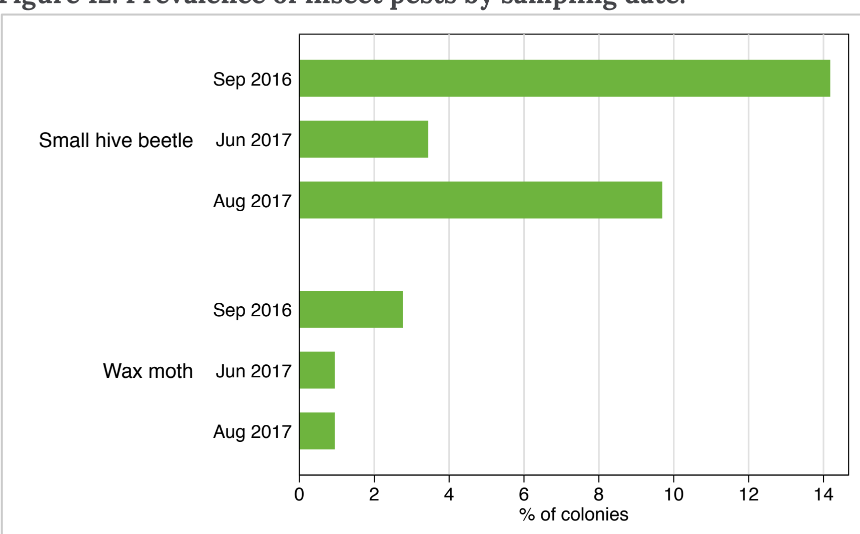
The foulbrood diseases and parasitic mite syndrome can also be confused for a different brood disease called idiopathic brood disease syndrome (IBDS). With this syndrome, unhealthy larvae can adopt a variety of appearances: they can be sunken or twisted in their cells, white or discolored, or they can take on a brown "molten" appearance similar to the symptoms of American foulbrood or European foulbrood, though the liquefied larvae do not rope out. This brood disease is not caused by *Varroa* mite infestations and it can be present with or without mites. It is not yet known what causes IBDS, though a variety of viruses may partially contribute. While this syndrome is uncommon, the Tech Team did observe it in colonies across all three sampling periods.

Insect Pests

Small hive beetles and wax moths are fairly common insect pests in honey bee colonies in New York State. Both are opportunistic pests that typically exploit weakly populated colonies. Maintaining healthy colonies with strong populations and only supering colonies when the colony population dictates is the best way to prevent infestations. Neither pest kills colonies. Intense small hive beetles infestations, however, can damage a honey crop and equipment. Their destruction is most often observed when honey supers are not promptly extracted. High wax moth infestations can also damage equipment when it is stored improperly.

The Tech Team noted the presence of adult and immature stages of these insect pests during colony inspections. Of the two pests, small hive beetles were more common than wax moths, and were found most often in autumn compared to spring (Figure 12). The prevalence of small hive beetles was at its highest in September 2016, when 14% of colonies were infested. Wax moths were less common, yet were similarly most prevalent in September 2016 when 3% of colonies were afflicted.

Figure 12. Prevalence of insect pests by sampling date.



Pesticide Exposure

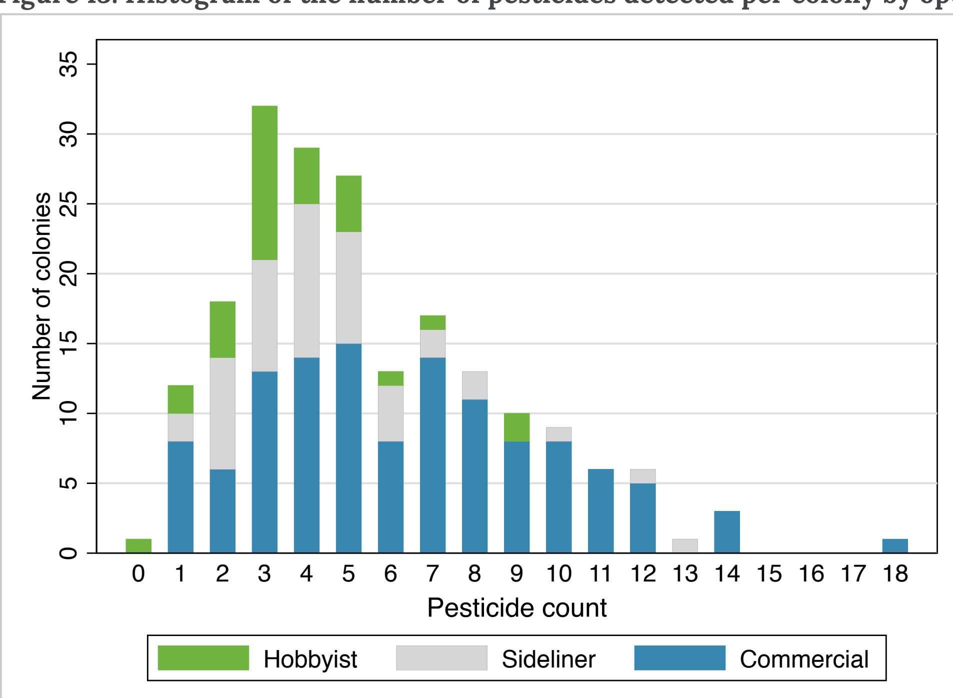
Pesticides enter beeswax from 1) the storage of contaminated pollen and nectar, 2) contact with bees' bodies after they have been foraging in treated landscapes, and 3) miticides applied by beekeepers. "Pesticide" is an umbrella term that applies to insecticides (used to kill insects), herbicides (used to kill weeds), fungicides (used to kill fungi), and miticides (used to kill mites).

There are various ways to measure whether a pesticide harms honey bees. The most common method is to measure acute toxicity, or the dose needed to kill a population of bees in a short time period (most often 24 hrs). Acute toxicity only captures lethal effects from brief exposure. In contrast, chronic toxicity refers to the accumulated effects on bees resulting from long-term exposure. Lastly, sublethal toxicity refers to all non-lethal health impacts. Each results in different effects on bee health. Symptoms of acute pesticide toxicity, for instance, include twitching, crawling, paralysis, and death. Some symptoms of chronic or sublethal toxicity include impaired queen fertility, brood development, learning and memory, reduced queen and worker lifespans, reduced honey production, and increased susceptibility to disease.

When researchers investigate the impact of pesticides on bees, they typically study how a single pesticide affects bees. With a growing understanding of the multitude of pesticides bees encounter in the environment, researchers now recognize the need to investigate how pesticides may be interacting with one another in order to understand the overall risk to bees. For instance, some pesticides interact synergistically, meaning they magnify the toxicity of other compounds.

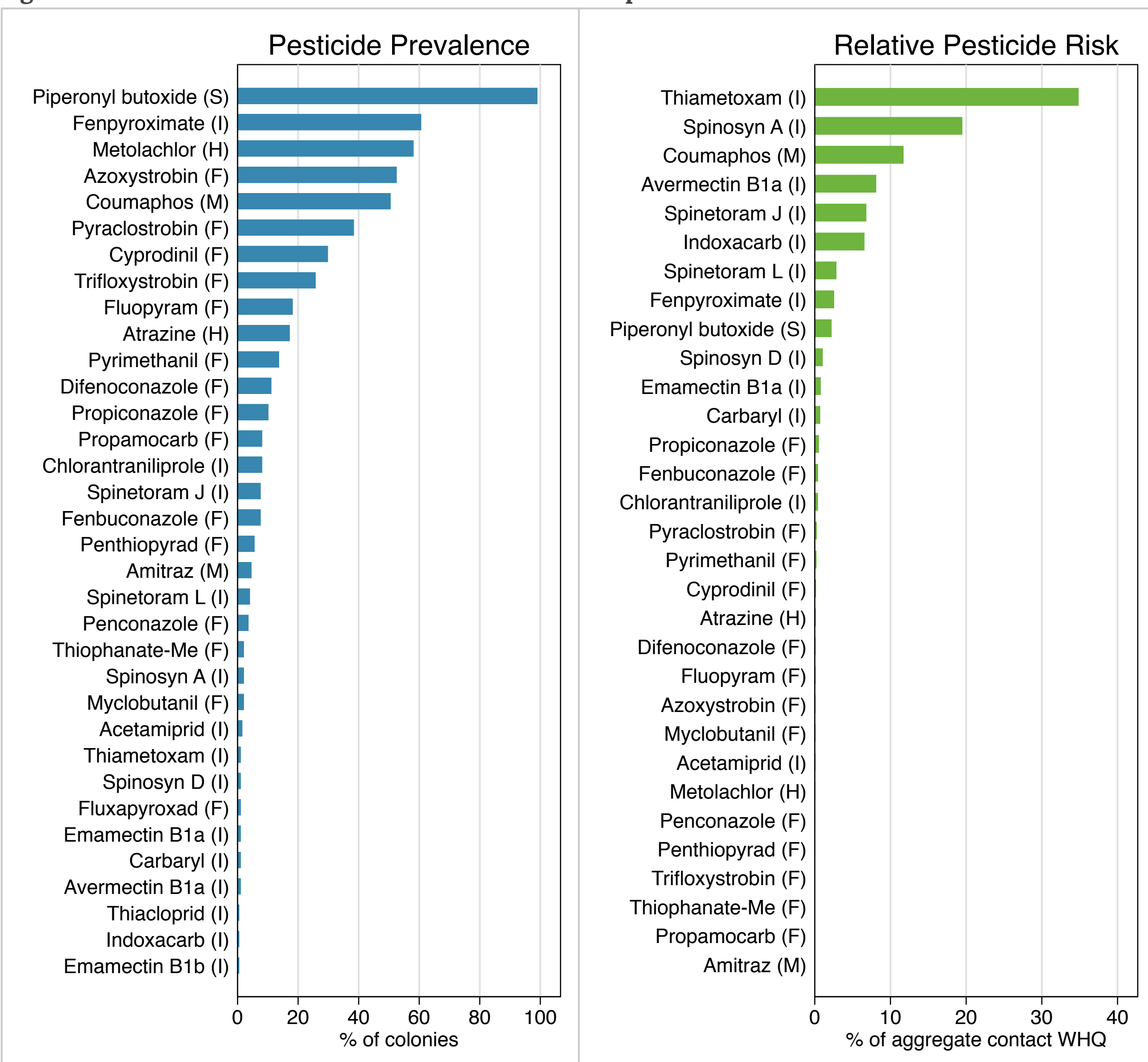
The Tech Team tested 198 wax samples collected in September 2016 for residues of 41 pesticides, and 34 of these pesticides were detected. This analysis revealed that it is common for colonies to contain several different pesticides at any given time; on average, colonies contained 5.5 different pesticides. The highest number of pesticides found in a single colony was 18, while zero pesticides were detected in just one colony. Figure 13 presents a histogram showing the number of colonies for each observed pesticide count. Commercial beekeepers had significantly more pesticides per colony, on average, compared to hobbyists. This may be a result of commercial beekeepers' increased tendency to place colonies in commercial pollination, as proximity to agricultural lands (and often multiple crops within one year) can expose colonies to a diverse array of pesticides.

Figure 13. Histogram of the number of pesticides detected per colony by operation scale.



To communicate the acute risk pesticides pose to honey bee health, the Tech Team computed "relative risk" values that integrate pesticide prevalence, concentration, and acute toxicity into a single measure. The relative risk values were constructed as follows: (1) contact wax hazard quotient (WHQ) values were calculated for each pesticide and each wax sample by dividing the pesticide concentration (ppb) by its contact LD_{50} value.[1] (2) The total WHQ for each pesticide was calculated by summing that pesticide's contact WHQ values from all 198 wax samples. These sums ranged from 0 to 1113 (thiamethoxam). (3) An aggregate contact WHQ was constructed for the entire sample by adding up the total WHQ values of all the different pesticides. (4) The percentage contribution of each individual pesticide to the overall pesticide risk was calculated by dividing the total WHQ for each compound by the aggregate WHQ for the sample. The three largest contributors to overall acute pesticide risk were thiamethoxam (35%), spinosyn A (19%), and coumaphos (12%).

Figure 14. Prevalence and relative risk of 34 detected pesticides.



Note: WHQ signifies wax hazard quotient. Letters in parentheses indicate pesticide class. F = fungicide; H = herbicide; I = insecticide; M = miticide; S = synergist.

[1] The LD_{50} is the amount of a compound that, given all at once to a sample of bees, causes half of them to die within __ hours. Thus, compounds with smaller LD_{50} values have higher the acute toxicity.

It was interesting to find that pesticide prevalence was not associated with risk. In other words, the most common pesticides found in colonies tended to have lower toxicity levels and therefore posed a relatively low acute health risk to honey bees. This relationship is illustrated in Figure 14, where the prevalence of the 34 detected pesticides is shown on the left, and their relative contribution to the overall risk of acute toxicity to honey bees is shown in the right. For instance, thiamethoxam was very uncommon but presents the highest acute risk to bee health. Alternatively, piperonyl butoxide was extremely prevalent, but individually it poses a low acute risk to bee health.

Overall, **none of the pesticides we tested appeared at or above levels of concern** for acute pesticide poisoning. However, these compounds may cause subtler chronic, sublethal, or synergistic effects on honey bee health. Furthermore, synergistic interactions among the different pesticides within the colonies could increase or decrease the level of concern, yet it is currently impossible to predict the direction and magnitude of all possible interactions. It is important to note that calculations of acute risk to bee health do not consider risk from these other avenues.

Insecticides

Wax samples were tested for 19 insecticides, including 6 neonicotinoids. Just 14 insecticides, including 3 neonicotinoids, were found. Most insecticides were rare, appearing in fewer than 5% of colonies. The neonicotionids detected were extremely rare: we detected acetamiprid in 3 colonies, thiamethoxam in 2 colonies, and thiacloprid in 1 colony. The only insecticide found in more than 10% of colonies was fenpyroximate, which is used to control insect pests on blueberries, strawberries, cucumbers, peppers, and greenhouse crops in New York State. Fenpyroximate was present in 61% of colonies.

Insecticides are specifically designed to kill insects, the animal class to which honey bees belong. For this reason, insecticides tend to be more toxic to honey bees relative to other agrochemicals. It is therefore unsurprising that, despite being rare, insecticides contributed more to the overall acute pesticide risk than any of the other pesticide classes (Figure 14). Moreover, one beekeeper in our study reported observing symptoms of acute pesticide toxicity in 2016, and a different beekeeper experienced a pesticide poisoning event in 2017.

Fungicides

We tested for 17 different fungicides and detected 16. Fungicides were more widespread than insecticides, as 8 different fungicides each appeared in more than 10% of colonies. Azoxystrobin was the most common fungicide, appearing in 53% of colonies. This broad-spectrum fungicide is widely used to control many different fungal diseases in fruit, vegetable, and grain crops.

Although fungicides were relatively common, they are responsible for a very small portion of the overall pesticide risk facing honey bees due to their relatively low toxicity (Figure 14). However, these risk calculations do not account for possible synergistic effects whereby exposure to fungicides may increase the toxicity of other compounds. Synergistic effects occur when one chemical blocks a bee's ability to metabolize, or break down, other toxic compounds.

Synergistic effects can be quite large. For instance, the fungicide propiconizole (detected in 20 colonies in the sample) is known to increase the toxicity of acetamiprid by a factor of 105 and thiamethoxam by a factor of 559[17]. Propiconizole is one of a group of fungicides known as EBI (ergosterol biosynthesis inhibitor) fungicides, which affect the metabolism of insects, including honey bees. Other EBI fungicides include penconizole (detected in 7 colonies) and myclobutanil (detected in 4 colonies). Of the 6 colonies tested, 2 of them contained neonicotinoid residues and myclobutanil, possibly presenting a basis for synergistic effects. EBI fungicides are also known to increase the toxicity of pyrethroid insecticides to honey bees[18].

More research is needed to understand the full range of synergistic effects of multiple pesticides in field settings. However, existing evidence suggests that beekeepers should take precautions to limit EBI fungicide exposure if they can, especially when colonies may also be exposed to insecticides.

Miticides

Miticides are applied directly to honey bee colonies to control *Varroa* populations, so it is not surprising that they are among the most common pesticides present in North American beekeeping operations[19]. We tested wax samples for two miticides: coumaphos and amitraz. Coumaphos is the active ingredient in CheckMite+®, which was approved in New York State in 1999 as a treatment for *Varroa* mites, and later for small hive beetles. This treatment is no longer recommended because *Varroa* mite populations are now largely resistant to coumaphos and coumaphos negatively affects honey bee health. Coumaphos is highly persistent in beeswax, and does not break down when wax is melted and processed into foundation. Studies show that coumaphos in wax can harm the development and fertility of queens and drones[20-22].

None of the beekeepers that we sampled used coumaphos in their operations in 2016 or 2017. Yet coumaphos was the fifth most common pesticide in wax samples, appearing in 51% of colonies in 2016. In colonies where coumaphos was detected, the average concentration was 81 ppb and the maximum was 603 ppb. One study found that levels in wax immediately following CheckMite+ application are high enough to impact queen weight and fertility[21], but this study (and others[20,22]) examine effects from higher residue levels (49,700 ppb – 1,000,000 ppb) than those determined in New York State wax. Among the 34 pesticides detected in the sample, coumaphos was the third largest contributor to the total pesticide risk. To reduce coumaphos levels in their colonies, beekeepers should avoid using coumaphos as a mite treatment. Replacing old combs with fresh foundation can gradually reduce coumaphos levels, as the amount of coumaphos in commercially recycled foundation becomes diluted over time.

Amatraz is the active ingredient in Apivar®, a common *Varroa* mite treatment in New York State. In 2016, 3.2% of hobbyists, 15.4% of sideliners, and 25.0% of commercial beekeepers in the sample used amitraz. The use of amitraz increased in 2017, when 14.3% of hobbyists, 36.4% of sideliners, and 50% of commercial beekeepers applied this miticide to their colonies. In 2016, amitraz residues were detected in just 9 colonies, representing 5% of the sample. Amitraz has a short half-life and breaks down quickly in the wax, which helps to explain the low frequency of detection[23]. The rarity of amitraz in the sample, combined with its relatively low toxicity to honey bees, places it at the bottom of the list for its contribution to overall pesticide risk.

Herbicides

Wax samples were tested for two common agricultural herbicides. Metolachlor was detected in 58% of colonies, while atrazine was found in 17% of colonies. Both compounds have relatively low toxicity to honey bees and contributed very little to the overall pesticide risk. While beekeepers are keenly interested in measuring glyphosate levels in honey bee colonies, at this moment in time Cornell is not able to detect this compound.

Pesticide Synergists

We tested wax samples for a common pesticide synergist, piperonyl butoxide (PBO), which was nearly ubiquitous. Fully 99% of colonies tested positive for PBO, with an average concentration of 6 ppb and a maximum of 108 ppb. Although PBO has a relatively low toxicity to honey bees, its widespread prevalence contributed to it being the ninth largest individual contributor to overall pesticide risk (Figure 14, right panel). However, this analysis does not account for synergistic effects; therefore, the total risk attributed to PBO is likely underestimated.

Like most synergists, PBO increases the toxicity of other compounds by impairing an insect's ability to metabolize those compounds. PBO is commonly used in conjunction with pyrethrin, pyrethroid, and carbamate insecticides. However, PBO also increases the toxicity of neonicotinoids. One study showed that exposure to PBO produced a 6-fold increase in acetamiprid toxicity, and a 115-fold increase in thiamethoxam toxicity[17]. The Tech Team found that all 6 colonies that had neonicotinoid residues also contained PBO, so synergistic effects may possibly be occurring in these colonies.

Managing Pesticide Exposure

Beekeepers may feel powerless when it comes to reducing pesticide exposure. They may have little control over their apiaries' proximity to agricultural fields, and providing pollination services may be a focal part of their business. While it is nearly impossible to prevent bees from being exposed to pesticides, there are several measures beekeepers can take to reduce the degree of exposure.

Pollination Services

Pollination contracts allow beekeepers and growers to agree on, and record, which pesticides will be applied to crops and when. Contracts can also outline how much time a beekeeper requires to be notified of a pesticide application. While many beekeepers are unable to move their colonies in the event of a highly toxic pesticide application, if they are able to, they should. Colonies can be replaced in the crop after 72 hours (or longer if the residual toxicity is higher). The Dyce Lab's *Sample Pollination Contract* is a great template to use as a starting point for beekeeper-grower negotiations. Following pollination services, beekeepers can help colonies recuperate by placing them in natural areas and providing pollen patties if they appear nutritionally stressed.

Reducing Miticide Residues

Beekeepers can reduce miticides residues in their hives by preferentially choosing miticides that do not persist in wax for an extended period (e.g., Apivar® and natural chemicals). They should only use registered mite treatments and apply them according to the label directions. It is dangerous and unlawful to introduce non-registered or homemade miticides into a honey bee colony.

Rotating old combs for fresh foundation can gradually reduce coumaphos levels in hives, as the amount of coumaphos incorporated into foundation becomes diluted over time. Beekeepers could consider using plastic foundation, as it contains less recycled wax than does wax foundation. If they wish to paint additional wax onto their plastic foundation, they should use light-colored wax collected from their own colonies. Depending on their production goals, some beekeepers can allow honey bees to draw their own wax.

Conclusions

Beekeepers in New York State continue to suffer high colony losses, especially over the winter. Diagnosing and managing colony health issues is difficult due to the breadth and complexity of factors that influence honey bee health and productivity. The NYS Beekeeper Tech Team supports beekeepers to achieve better colony health outcomes by inspecting a sample of their colonies twice a year and by reporting *Varroa*, *Nosema*, virus, and pesticide levels for those same colonies. The Tech Team also helps beekeepers interpret their colony health reports and develop research-based management strategies that respond to their individual needs and production goals.

This report documents the productivity of beekeeping operations enrolled in the Tech Team program and draws on data from colony health inspections to explore the status of critical threats to honey bee health in New York State: pests, parasites, pathogens, and pesticides. The report briefly discusses management implications to help alleviate these threats throughout. Beekeepers can find additional management resources, including a detailed guide for developing an Integrated Pest Management (IPM) plan to control *Varroa* mites, online at *www.pollinator.cals.cornell.edu*.

Last year the *2016 NYS Beekeeper Tech Team Report* cited *Varroa* mites as one of the most widespread and critical threats to beekeepers in New York State. Controlling *Varroa* mites and associated viruses remains a top concern for beekeepers in 2017. The Tech Team was pleased to observe a dramatic increase in *Varroa* monitoring rates this year among beekeepers in the program. *Varroa* monitoring is an essential component of any IPM plan, since knowing the exact mite level within a colony is necessary to making an informed decision about whether or not to treat. Interestingly, beekeepers who monitored for *Varroa* were significantly more likely to use one or more chemical *Varroa* treatments.

Beekeepers treated more aggressively for *Varroa* mites in 2017, when the percentage of operations using at least one chemical treatment rose to 85%, up from 73% in 2016. The use of amitraz (trade name Apivar®), a highly effective *Varroa* treatment, more than tripled from 2016 to 2017. Beekeepers also reported using a greater variety of chemical treatments in 2017. The increased use of chemical *Varroa* treatments generally, and of amitraz specifically, is highly encouraging. Relatively low *Varroa* mite levels in August 2017 suggest beekeepers were more effective at controlling *Varroa* mites in 2017. Without mite counts from September or October 2017, it is not known for certain whether *Varroa* levels remained low going into winter. However, we anticipate that beekeepers in the Tech Team program may see lower colony losses over the 2017 - 2018 winter due to improved *Varroa* management.

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