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Varroa Destructor in North Florida

Honey bee vitality is geographical. What happens in the north doesn't necessarily happen in the south, east, or west. Regional variances in climates, seasons, and individual practices demand that we not approach beekeeping from a single perspective, but to consider many possibilities as it relates to honey bee mortality. Considering this, though, we must also be aware of overall trends relating to honey bee health, production, and decline. Some recent data suggest that 2020 colony attrition rate in the United States is the highest on record since such records were kept with a combined staggering loss of 43.7% of colonies during the April 2019-April 2020 collection period (Watters & Cutlip, 2020). Varroa might have had a hand in the higher levels of colony loss this year.

History of varroa

Varroa destructor, also called the varroa mite (or simply varroa), and formerly known as *Varroa jacobsoni*, is an ectoparasitic mite that feeds on the fat body of honey bees and their pupae (Ramsey et al. 2019). Originally, the *Varroa destructor* mite (referred to hereafter as varroa) was limited to its native geography in Asia and hosted on *Apis cerena*. During the 1950s, it spread from its original host, *A. cerana* to the Western honey bee (*Apis mellifera*) in Japan, and again a decade later in Hong Kong (Traynor et al., 2020). From these locations, varroa spread into Europe (1977), the USA, and Canada (1987) and eventually the majority of the world. Varroa is considered a major contributor to colony collapse disorder, or CCD (Boecking & Genersch, 2008). The incidences of varroa mite infestations in feral honey bees are high with some believing that infestations in managed colonies are the results of their interactions with feral bees (Graystock, 2016).

The varroa mite is almost exclusively found as a parasite on honey bees. Females lay their eggs in uncapped brood cells and the young feed on developing bees. An inspection of a hive's brood cells is thus a reliable means of detection (see the image to the right). Female mites also parasitize adult bees, hiding in between the insects' first abdominal segments. Identifying varroa populations in managed colonies is important, yet oftentimes overlooked.

Implications

Apiculture is incredibly important to agribusiness throughout the world. In the United States alone, domestic apiaries produce about 152 million pounds of honey and import up to three times that amount. The National Agricultural Statistical Service, a service through the USDA, reports that about 327 million pounds of honey are consumed in the US, with an economic honey sale industry valued at about $1.9 billion annually (Matthews et al., 2019). This does not include apiculture employment or indirect apiculture benefits. Take for instance the U.S. agricultural GDP. It is valued at about $1.109 trillion and is largely dependent upon pollination, an indirect contribution made by the apiculture industry (Kassell, 2020).

Identification

Varroa mites are very small and even to the trained eye, they can be difficult to see on honey bees. When people tell us that they didn't see any mites during their hive inspections, it always brings us to a pause. There are only a few recognized ways to determine the presence of mites, and we will discuss those in a bit, but rarely is visual identification a good indicator of varroa presence.

There are two stages of varroa lifecycle – the phoretic stage and the reproductive stage. The phoretic stage is where the mites typically migrate from bee to bee and colony to colony. Honey bee drones are the preferred source of transportation (and feeding), but any honey bee, even the queen, is a potential host. The mites migrate by hitching rides on honey bee, spreading the mite population within a colony and between colonies. United States feral colonies

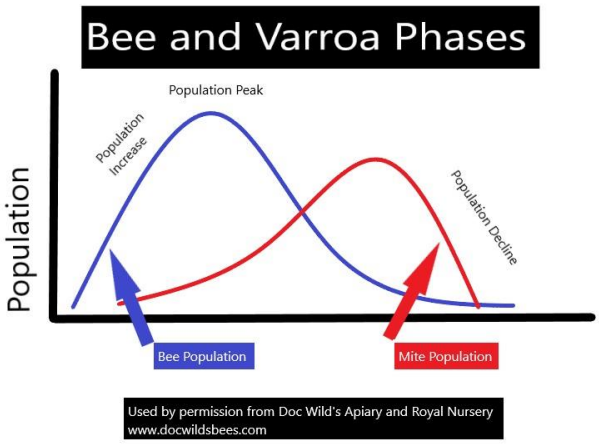
were once almost completely decimated by varroa mite infestations, and over the last decade, some reports indicate a reappearance of feral colonies outside of swarm season. The phoretic stage usually last about a week, and by some accounts, begins as early as 5 days into the lifecycle and as late as 11 days. It is during this time that the mites are most vulnerable to chemical control. The other life stage is one of reproduction. Mites propagate under the wax capping of brood cells, and most methods of chemical approach cannot penetrate the capping. A mature female mite will hide in a cell, usually under the larvae's food supply. Varroa have a special snorkel-like appendage called a peritreme that allows them to breathe while submerged in brood food. Here, she will hide while the honey bee caps the cell. Soon after, the honey bee larva spins a cocoon, thus advancing to a prepupa stage. It is at this point that the varroa will begin to feed and lay eggs (the mite usually waits until about 70 hours after capping to lay eggs). The first egg the mite lays will be unfertilized. As with honey bees, an unfertilized egg becomes a male. About once a day thereafter, the female will lay a fertilized egg which will becomes daughters. The male's mouthpart is modified into sex organs, thus rendering the male mite unable to feed - he will eventually die as a result. Before dying, he will mate with a newly emerged female mite, ensuring the continuance of the lifecycle. Males are much smaller and lighter colored than their female counterparts and are not sclerotized.

Female mites are sclerotized and are reddish-brown. Their appearance is oval, about 1-1.5mm in length and 1.5-2mm wide. Whereas male mites are rarely observed outside of a cell, the female mites can be found on honey bees, feeding or hitching a ride (phoretic stage). Females are about twice the size of male mites and it is the females that feed on adult bees. There used to be a belief that varroa fed on the bee's hemolymph (blood), but that assumption has since been proven wrong. In fact, the mite feeds on the bee's fat (Ramsey et al. 2019). This weakens the bee, but the real problem isn't with low bodyfat stores, it is with the diseases that varroa vectors.

Female mites prefer drone comb to reproduce in. One of the thoughts for this is because drone honeybees take the longest time to pupate. From egg to emergence, it's about 24 days, as opposed to 21 days for worker honeybees and 16 days for a queen. Drones are large as well and require more food, an added benefit to the mite.

Indications and disease

The most accurate method of detecting varroa mite infestation is by counting the number of mites present in a colony. While year-round monitoring is necessary, mite populations explode in the summer and peak after the bee colony begins to draw down. The most effective form of mite counting results in the death of the bees, therefore, counting all of the bees and mites in a colony is not possible. We'll cover sampling methods and techniques in the next section, but there are other indicators of a mite infestation. A colony with heavy mite infestation is prone to collapse (colony collapse disorder, or CCD) or absconding, so if a colony does fail, the colonies in the nearby area should be closely monitored and treated for mites. Because strong neighboring colonies rob failing varroa infested colonies, they too will become infested with mites.



As a result of varroa feeding, affected honey bees experience weight loss, but noticing this may be difficult, especially for new beekeepers. Other indicators are often present that includes morphological malformation and pathological behavior. These latter conditions are a result of viruses vectored by the mite and as a result, over the last few years, have inspired greater interest in honey bee virology. Loosely explained, viruses are microorganisms that contain a nucleic acid (RNA or DNA) wrapped in protein. They are unable to replicate on their own and thus are dependent upon a host to multiply. A virion, or virus particle, is injected into a host cell and hijacks the cell's organelles to replicate itself. Viruses tend to be host-specific, and the process within the host continues until the cell or organism dies, or the virus is defeated. Within the honey bee colony, many viruses are potentially transmitted when the bee is in its larval or pupal stage, and if you consider how the mite reproduces, it would make sense that these sub-adult bees are the media for virus growth. Usually, viral symptoms are not observable until the bee emerges as an adult (it is important to add, as with humans, the absence of a symptom or set of symptoms does not preclude an

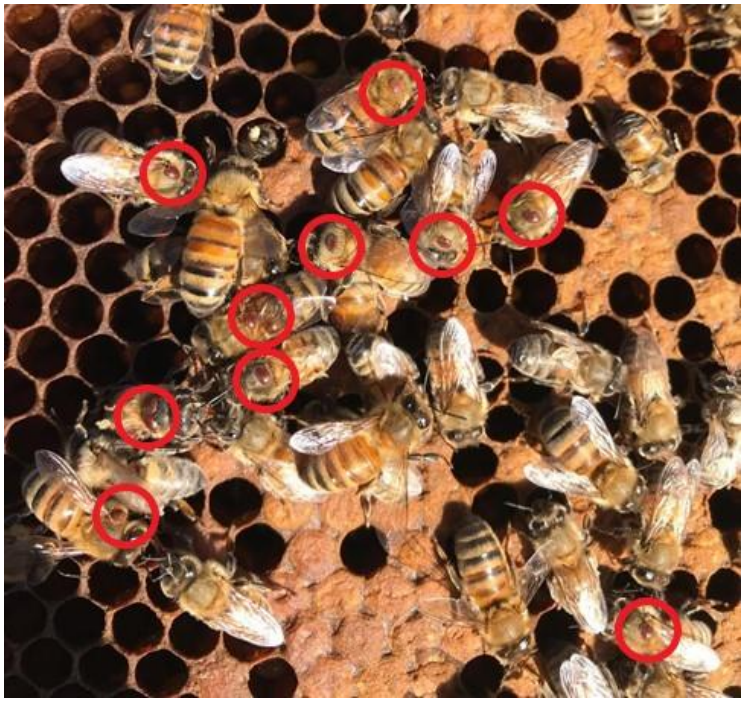
infection). A good source of information on honeybee virology is the Bee Informed Partnership. This organization hosts data and collection surveys to assess honey bee health in the United States.

Perhaps the most commonly identified viral symptom is that of the Deformed Wing Virus (DWV). As the name implies, DWV mutates the honey bee's wings resulting in an undeveloped, diminished appearance. The wings look like two wet semi-clear socks on the bee's back. This renders the bee unable to fly. The colony may reject any bees with this virus by kicking them out. Even if the affected bee were to remain in the colony, the bee will have a diminished lifespan. Varroa destructor virus-1 is a disease similar to DWV in appearance. In some regions of the world, it outperforms DWV and is particularly devastating, at least in Europe, during the winter months. Then we have acute bee paralysis and chronic bee paralysis viruses. Acute bee paralysis viruses (sometimes called Israeli paralysis) have the same symptoms as chronic bee paralysis. It is transmitted via varroa mites and nurse bees feeding the young during the larval stage. Chronic paralysis virus is identified by certain symptoms and is largely classified into two syndromes. Syndrome 1 includes trembling (shivering like appearance), dislocated wings (k-wing), and congregation on the grass outside of the hive. Syndrome 2 results in a wet appearance. The bees will look like they are coated in oil, be shiny from lack of hair, and darkened in appearance.

There are, of course, other viruses associated with varroa, but our aim wasn't to write on virology. The importance of including some discussion on viruses was to underscore the importance of controlling varroa.

Monitoring

It is first important to gauge the mite level in a colony. You cannot do this by just looking at your bees! To properly monitor for varroa, take a sample of the bees and mites using one of the following methods: alcohol wash, sticky traps, or powdered sugar roll. There is a fourth sampling method using ether, but due to the inherent risks associated with using ether, we've elected to not include it in this discussion. We cannot overstress the value and importance of monitoring for varroa enough. Should the mite population be too high, your colony may be dead already without you and the bees even realizing it. A colony may look vibrant and active, but colony death has already started (see image to the right). Our advice is to monitor (sample) no less than 6 times a year. We prefer to sample every two months, and in the north Florida/south Georgia/southeast Alabama regions, we encourage everyone too, especially during the productive months. It's argued that varroa monitoring and control is the single most important aspect of honey bee husbandry a beekeeper can perform to ensure the livelihood of their colonies and to maintain a healthy, productive apiary.



Mite levels within a colony are discussed as thresholds. Ideally, you want no more than 3 mites per 100 bees, or 3% population of mites. Colonies with mite populations that exceed the 3% threshold are more likely to collapse before the beekeeper may even know it. A 2% increase above this threshold, or 5 mites per 100 bees, can be fatal to the colony. Even 3% can spell doom to a dormant overwintering colony, so once again, we cannot express enough times the importance of monitoring.

Sample size. You want a sample size of approximately 300 bees. You do not need to count the bees individually during collection from the hive. A ½ cup (a kitchen measuring cup is what we use) equals about 300 bees. You want to get bees from all over in the hive, especially the brood area, so refrain from selecting from a single frame. Holding the cup with the open end pointed up, and holding the frame at an angle, scoop from top to bottom. You are aiming to gently caress the backs of the bees with the lip of the cup. This may seem counterproductive, but it works, and for whatever reason, the bees do not seem to mind it. As the cup moves across their backs, the bees just tip into the cup with really little fanfare. The trick is to move slowly so you are not triggering any alarm pheromone

release. You are also looking to ensure that you are not taking the queen, as most of these methods result in the death of the bees being sampled. Some people like to cage the queen, but how you protect her is optional. Take some bees from a few different frames, and when the ½ cup is full, you know you have about 300 bees. Another way to accomplish this is to shake some frames into a bucket. Shake enough bees into the bucket until there are a few inches of bees in there, then scoop out ½ cup.

Alcohol wash. This is, in our opinion, the way to go. We use 95% ethanol alcohol, but you can use rubbing alcohol as well (isopropyl). Get a 16-ounce wide mouth mason jar and fill it ¼ way up with alcohol. Do this before you collect your bees and have the lid for the jar handy. Once you get your 300 bees, dump them into the jar, and close the lid. Once the bees are in there, and the lid is closed, shake the jar vigorously for about a minute. This will dislodge all the mites from bees' body. Dump the mixture into a sieve. We use a honey screen. The upper screen catches the bees and the lower screen captures the mites. You can also use cheesecloth – just pick out the bees. Count the mites. If you want to, you can count the bees for a more accurate result.

Powdered sugar roll. This method is not as accurate as an ethanol wash. The upside to this method is that it does not kill the bees. You will use a wide mouth mason jar for this as well. Instead of a lid, you will replace it with some #8 hardware cloth (#8 cloth has 1/8" holes – big enough for mites to drop through, small enough bees don't). Place a couple of tablespoons of powdered sugar into the jar. Again, you want to use a ½ of bees (about 300), so dump them into the jar with the powdered sugar. Roll the jar around. Gently shake it. You want the sugar to tumble (think: dryer) onto the bees, covering them for about 2 minutes. The sugar will dislodge the mites. You can dump the sugar out (a lunch tray or flat piece of cardboard is good) and count the mites. The bees will not be harmed and will clean themselves after.

Sticky boards. These are used in conjunction with screened bottom boards. Screened bottom boards have the majority of their surface made with #8 hardware cloth. As the bees clean the hive and groom each other, pests and other debris falls through the screened bottom and stick to the sticky board. Hive beetle larva, wax moths, wax moth larva, ants, and varroa are common to see on the sticky board. The key with this tool is replacing it when it loses its tack. It is important to remember that screened bottom boards allow access to the sticky boards through the rear of the hive. This is designed to prevent the bees from coming in contact with the sticky surface. Like any other thing, if a bee lands on the sticky board, it will get stuck. Sticky boards are inserted under a hive after its inspection, and retrieved after 72 hours for a varroa inspection. Dated literature indicates that an amount of less than 60 varroa mites are acceptable, but this method is the least accurate and least reliable of them all.

IPTM and treatment

It bears worth mentioning again that there is no one single cure-all for honey bee pests. Diligence, monitoring, and integrated pest management are the keys to successfully reducing pest pressure within a colony. For new colonies, one can use prevention and avoidance to prevent a varroa mite infestation. For existing colonies, there are four dimensions to integrated pest management one can practice: mechanical, biological, chemical, and cultural control. These are all necessary components to a successful IPTM program. We also included a genetic control dimension, specifically to open a discussion on varroa sensitive honey bee genes.

Varroa Mite Prevention. Treat newly obtained package bees with powder sugar before mixing them with other bees in apiary. Dust all of the bees generously with powder sugar while they are still in their box. The bees will clean and remove mites from each other. For established colonies, control swarming to prevent new hives from living within your colony's foraging area and serving as the source population for varroa mites. Lastly, obtain queens and package bees from pest free source.

Varroa Mite Avoidance. Establish apiaries 3 to 5 miles from other existing apiaries to avoid overlapping foraging range, which can result in varroa mites skipping amongst interacting foragers. Coordinate and synchronize management practices. Treat all colonies in an apiary collectively to avoid varroa mite infestation. Lastly, avoid drifting and robbing in the apiary, since this can rapidly spread varroa mites in an apiary.

Mechanical Control. Screened bottom boards are perhaps the most effective form of mechanical control (Rinderer et al. 2003). These screens can be inserted under the honey bee nest and used to trap falling mites. Varroa, both living and dead, regularly fall off their host bees. This may be facilitated by the grooming activity of the bees, but it probably occurs naturally as well (Ellis et al. 2010). Another mechanical method occurs by removing drone brood. With this method the brood nest of each single chamber colony consisted of 8 full-depth worker combs and two full-depth drone combs. Once the drone comb is sealed, remove the frame and replace it with empty drone combs. Be sure to freeze the drone brood for at least 24 hours to kill all of the varroa in its various stages. Drone brood removal will not adversely affect colony health as it relates to the size of the worker population or by honey production (Calderone, 2005).

Biological Control. There are no really good biological controls for varroa mites. There's been work with fungal entomopathogens in the laboratory. Certain strains such as *Metarhizium anisopliae*, *Beauveria bassiana*, *Hirsutella thompsonii* show promise in controlled laboratory settings, but not in actual practice. The issue with these fungi is that they are unstable and will lose their effectiveness rapidly; similarly, the hive's environmental conditions have to be ideal for fungus to work.

Chemical Control. This is the go-to method to quickly knock a mite infestation out. Most treatments have a period of efficacy. The longer the product persists in the hive, the more effective it becomes. Some forms of chemical control are available over the counter from any bee supply store whereas others are simply organic oils or acids available online or in hardware stores.

The manufactured chemical treatments that are on the market and which still appear effective is Apivar and Apiguard ®. Apivar uses the main ingredient of amitraz whereas Apiguard ® uses thymol (the oil from the thyme plant). Varroa mites tend to rapidly develop resistance to acaricides (Rinkevich, 2020) like coumaphos (Checkmite+) and fluvalinate (Apistan) (Elzen et al., 1998; Elzen & Westervelt, 2002). There are concerns that Apiguard ® gel and Amitraz may cause some negative effects on colony development and potentially leave residues in honey products (Floris et al., 2004, Kanga et al., 2019), which is often an argument made by proponents of acid treatments. Research has shown that overuse of any acaricide has the possibility of developing resistance.

Thymol, the key ingredient in Apiguard ®, is a derivative of the thyme plant. It has an incredibly strong and persistent odor. Apiguard ® comes in a gel form and is applied to a medium of some form before being placed into the colony. Sometimes it can be a small tin, a foil-lined cardboard piece, or some other tray. Thymol crystals are available for purchase and can be used as a supplement to other treatments.

That leaves us with acids. Two forms are particularly useful in knocking down the mites. There is oxalic acid and formic acid. By some accounts, formic acid can penetrate the capped brood cells and kill the mites therein. Formic acid is temperature-dependent, though. If it is placed into a hive that is too hot, too much acid will be released and honeybee attrition will be high. If it's too cold, little to no acid will be released and the mites won't be affected. The upside to formic acid is that it is the only treatment for mites that can be used while honey supers are on. Oxalic acid is an organic acid (if you don't like broccoli because of its bitter taste, it's the oxalic acid you are tasting). The organic acid is dangerous in vapor form. It requires the use of an organic acid respirator when applying it. Whereas formic acid is placed directly into the hive on strips, for oxalic acid to work properly, it must be sublimated (changed from a solid directly to a gas). This is done by heating it. One oxalic acid delivery system consists of a wand with a 2-gram tray on the end of it. The other end connects to a battery terminal via a cable. When connected, the tray heats up, and the oxalic acid turns into a white smoky vapor. The tray is inserted into the entrance of the hive and it takes about 5-7 minutes (depending on how charged the battery is) to be sublimated totally. Another method of oxalic acid delivery is through a fogger. There are a number of these propane-heated devices that can be used. We dilute 15g of

oxalic acid and 15g thymol with 100ml of 95% ethanol. We use a Varamorous fogger. Others we know used the ProVap setup. The real difference between these two is the price. Both types of equipment will deliver a controlled amount of vaporized oxalic acid to the colony and hive components. If you are a commercial bee farmer, these propane foggers will allow you to treat a couple hundred hives per hour. We treat our hives at a 5-day interval for 3 treatments (3 times over 15 days) to kill visible and emerging mites. Oxalic acid can be diluted and dribbled into a colony as another means of control. In this application the bees will disburse the acid throughout the colony, reducing the mite population in the hive. Randy Oliver has been researching extended-release oxalic acid treatments that we think are worth watching.

Cultural control. Varroa can only replicate under the sealed caps of the brood. One can interrupt the brood cycle by caging the queen for 24 days (a complete brood cycle). This method removes all developing brood from the colony. No developing brood equates to no developing mites. All of the mites in the colony will be exposed and therefore vulnerable to other control methods. One must be careful when exercising this option, though. Brood interruption can significantly weaken a colony, and it will take about 16-24 days for new bees to emerge. Use brood cycle interruption in tandem with another form of control, such as chemical.

Another form of cultural control is separating colonies in the apiary. This is not a common, or popular, form of cultural control. If it is to be effective, the hives would have to be spread 3 to 5 miles from one another – greater than the foraging range. Most beekeepers don't have enough land to accommodate this, and if they did, working the bee yard might turn into several day events.

Genetic Control. Genetic control is a form of cultural control that introduces a genetic line predisposed to identifying and removing mites. There are many different stock options, the most common being the Minnesota Hygienic bee stock and the Varroa-Sensitive Hygiene bee stock.

Minnesota hygienic bee stock is an Italian bee bred to demonstrate higher levels of hygienic behavior. Recall that hygienic behavior covers the grooming behavior of bees, hive maintenance duties, and brood-rearing. Varroa-Sensitive Hygienic stock, or VSH, are queens that are produced to have overall greater hygienic properties as well. We ordered some VSH stock from Wildflower Meadows in Vista, CA to experiment with. This Italian stock proves to be hygienic and very productive, as it relates to honey. While our trials with Wild Flower Meadow's stock is still under a year, these colonies are thus far outperforming all of our local stock.

Take Away

Our takeaway from this year's mite activity is that it is relatively consistent with past years. Mites continue to develop resistance to acaricide treatments. An integrated approach is necessary to control for the devastating effects of varroa on *A. mellifera*. The use of screened bottom and sticky boards are good for trapping insects that fall or which are removed as a result of grooming. Oxalic acid/thymol treatments are conducted in the spring (5 days apart x3 times) before the supers go on and then again after the supers are removed. If mite levels are high, we will supplement treatments with Apivar in the fall. Remember that one single form of pest management will not be nearly as effective as combining different methods as part of an integrated pest management system.

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