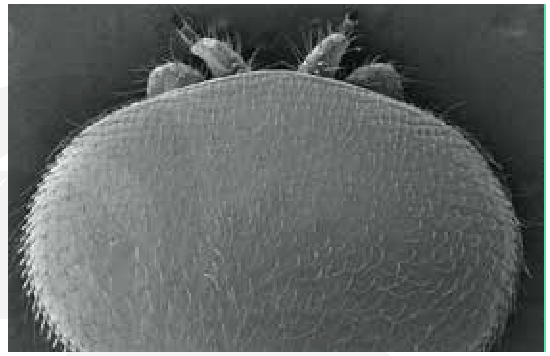
Pests & Diseases of Honeybees



Introduction by
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Honey bees are one of only two insect species managed by humans, the other being the silk worm. Humans have been utilizing honey bees for as long as they have been farming, so this association must have begun over 9,000 years ago. This is famously illustrated by the 8,000 year old cave painting of a ‘bee hunter’ (The Man of Bicorp) collecting honey, a food that remains valued across the world, using a technique that is still exits today high up in the Himalayas.

The Man of Bicorp

This very long human-insect association has resulted in honey bees becoming the most studied and well-known of all insects. In order to keep ‘our’ bees in good health the foremost topic of study has always being understanding what ‘ails the honey bee’. That is, what diseases do they suffer from and how can they be treated. Remarkably, despite hundreds of books and tens of thousands of scientific studies on honey bee diseases, the subject still occupies thousands of researchers both amateur and professional across the world.

Honey bee maladies can be grouped generally into pests and parasites that are external to the bee (e,g Varroa and Tracheal mites, Hive beetles, Wax moths, Hornets etc), and those pathogens that live inside the bee. These include Bacterial, Fungal and Viral pathogens. The severity of each disease is influenced by many other factors such as pesticides, nutrition, temperature stress, and most importantly other diseases, since remaining healthy for bees, as with people is never quite as simple as we would like to think. For example, a single hard working bee may be infected by several viral pathogens in different parts of its body, contain bacterial and fungal infections in their gut, while having their blood extracted by Varroa and tracheal mites, and on top of that providing some of their valuable food to begging small hive beetles. This sounds a bit extreme but in fact it is more realistic than a picture of a bee as always healthy but sometimes being attacked by a single pest or pathogen. However, it is only when a pest or pathogen gets out of control that we see a ‘sick bee’. Furthermore, in honey bees the whole situation becomes even more complicated since we are not interested in the impact of a disease on a single bee, but rather it is the effect on the entire colony that worries the beekeeper.

Remarkably even with all the new molecular tools currently available, the discovery of new major bee diseases is uncommon. So it is likely that we have now discovered and named most of the major honey bee diseases, although new ones will appear from time to time. However, understanding each of the 20 or so major pest and pathogens, and more importantly how they interact with each other and external factors will probably occupy the human race for the next 9,000 years.

Parasitic Mites and Honeybees

The social structure of honeybee colonies provides a favorable environment for intruders that can overcome their defenses. The large population of bees in each colony ensures plenty of hosts for parasitic mites, pollen and nectar storage provide nutrition for scavenger mites, and finally, the bees regulate the colony's internal temperatures, which allows for continued mite survival during the winter months. Consequently, it is not surprising that there are over 100 species of mites associated with honeybees worldwide; of those, three species are parasites of economic importance to Apis mellifera, they include Varroa destructor (varroa mites), Acarapis woodi (tracheal mites), and Tropilaelaps clareae (tropilaelaps mites).

Bee mites are easily dispersed across great geographical distances through human movement of managed hives. In the 1980's the US beekeeping industry was dramatically changed by the introduction of two mites: varroa and the tracheal mite. The state of Hawai'i however, remained free of these bee pests until 2007, when varroa was first recorded on the island of Oahu. The following year the mite was found to have dispersed to the Big Island of Hawaii. As of the time of writing, the varroa mite was the only pest mite that was present in Hawai'i, and the islands of Maui, Kauai, Molokai, and Lanai remained mite free. The tropilaelaps mite is currently only found in Asia.

The biology and life cycle of these three mite species exhibits some similarities and important differences. All three species complete their life cycles within the colony and in close association with their bee hosts (Table 1). The tracheal mites spend the great majority of their lives inside the adult bee body, feeding and reproducing in the respiratory tubes of the bees (trachea). In contrast, varroa and tropilaelaps mites reproduced inside capped bee cells, laying eggs and feeding on the bee pupae. Both of these mites are capable of attaching to the adult bees and can pierce their tissues to feed on their blood (haemolymph), this stage is called phoretic, and is much shorter on tropilaelaps compared to varroa. Tropilaelaps mites have a much shorter life cycle and their numbers can increase very rapidly in a colony.

The damage potential from parasitic mites increases if the species can act as vectors for diseases. Varroa has long been associated with the spread of the Deformed Wing Virus in Apis mellifera, and the subsequent global colony losses. There is evidence that tropilaelaps mites, much like varroa, may also be able to carry a variety of viral diseases that affect bees (Dainat et al. 2009).

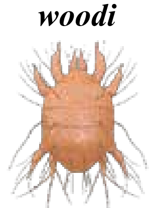
Mite Species	Site of reproduction	Adult mite movement	Bee stage – caste preferred	Disease transmission	Distribution
Acarapis woodi 	Inside tracheal tubes	Stays inside host most of its life	Prefers young adult bees, especially drones	No	Present in the mainland USA
Tropilaelaps clareae 	External parasite of bee pupae	Females can feed on adult bees while locating new brood	Reproduction is limited to bee pupae	Possible viral transmission	Restricted to Asia
Varroa destructor 	External parasite of bee pupae	Females can feed on adult bees (phoretic stage) and can be transported between hives in this manner	Reproduction is limited to bee pupae, strongly prefers drones over worker pupae	Yes, multiple viral diseases, and associated immune system weakening	Present in the mainland USA, on Oahu and the Big Island of Hawaii.

Table 1- Comparative life cycles of three parasitic bee mites, modified from Samataro et al. 2000

SAMPLING AND VARROA MITE THRESHOLDS

When *Varroa destructor* invaded the mainland US, a great effort was made to develop sampling methods that would accurately represent the density of mites and could be related to some measurement of health risk for a honey bee colony. The goal was to find a discreet value that could alert the beekeepers they needed to treat their colonies to reduce the mite population.

These initial studies helped develop sampling tools that are still in use today including brood sampling, adult bee sampling, and passive mite drop. The efficacy of sampling brood versus adults was also examined, especially in those areas where cold climates reduce or completely halt the production of bee brood.

Thresholds for varroa mite infestations were developed, and were used as guidelines for seasonal treatment recommendations. Over time however, these thresholds have been changing, and colonies begin to show signs of disease with fewer and fewer mites. Studies conducted in the UK during the original spread of *V. destructor* showed that the colonies were able to support a large population of mites (an average of 2500 mites per colony was not uncommon). However, as the mite began to acquire and alter viral diseases found on bees, the negative impact of each mite to the colony became larger.

Similarly, during the first few years of the mite invasion to Hawaii a colony showed little evidence of disease even when the proportion of mites to adult bees was: 12 mites for every 100 adult bees. Currently, the recommended treatment threshold has dropped to 3 mites for every 100 adult bees.

Varroa destructor is an ecto-parasite of the common honeybee Apis mellifera. Although only the size of a large grain of sand, it has spread across the world from Asia to Europe and to the mainland US. The mite was detected on Oahu in 2007, and found a year later on the Big Island of Hawaii. Varroa has negatively impacted honeybee health across the world and has radically changed the beekeeping and farming industries of Hawaii.

The Varroa mite is protected by a tough carapace edged with blunt spines, the mite's body is flattened to fit tightly between the abdominal segments of adult bees. Once in place, the mite uses its sharp mouthparts to pierce the soft tissues of bees and feed on their blood. Devoid of eyes, Varroa finds its hosts through scent, hiding within the cells in the hive and using the developing bees to feed its own young. Varroa weakens adult bees and their larvae by feeding on them, but the greatest danger is that the mite is a vector in the transmission of viral pathogens. For example, Deformed Wing Virus, a disease which warps the worker's wings making them unable to fly, and consequently, unable to bring food for the colony, it is more predominant since the arrival of the mite.

Due to the debilitating effects of Varroa's parasitism and the associated transmission of viral agents, the mite is considered a serious threat to honeybee health. Beekeepers on islands without varroa should avoid importing live bees and or bee equipment to reduce the chances of introduction. In fact, import regulations and frequent monitoring are the best defense against bee pests and diseases.

The Hawaii State Apiary Program (created in 2011) is in charge of regulations regarding the movement of colonies, queens, and/or bee equipment across islands. It is imperative that beekeepers and growers respect and follow the importation restrictions that exist in order to reduce the risk that Varroa destructor will spread to unaffected islands, and to avoid that other bee diseases and parasites are introduced to Hawaii.

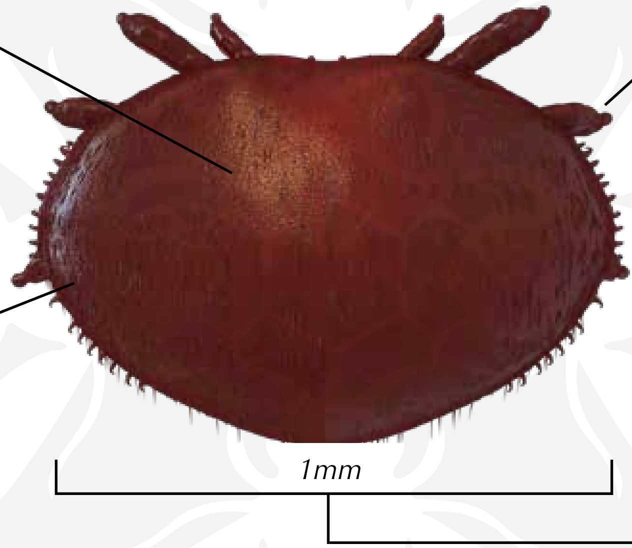
The Hawaii Apiary Program website contains information on state and county beekeeping ordinances.

http://hdoa.hawaii.gov/pi/ppc/apiary-program-hawaii-beekeepers-registry/

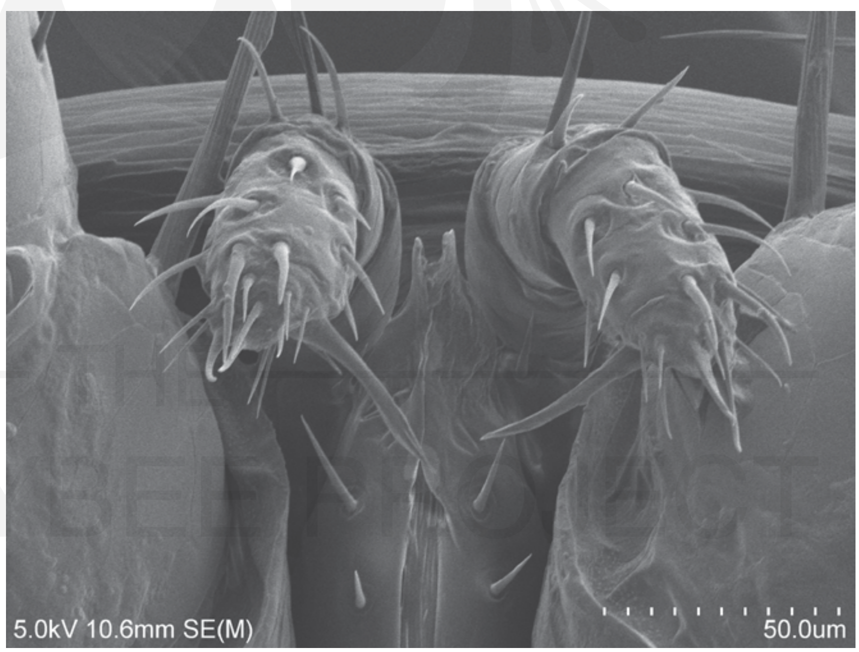
It is important to contact the state if you encounter large losses or have a serious disease outbreak in the bee yard.

Various stages and sexes of the varroa mite.

The varroa mite (*Varroa destructor*) is considered one of the biggest threats to bee health. The mite was introduced to Europe in the 70s and to the mainland US a decade later. The global spread of the mite has been linked to major colony losses and to a large decline in the health of managed honeybees. Varroa cannot be eliminated once it is established, but the impact of the mite can be reduced through better management and understanding of the mite and bee biology. This booklet is meant to provide information and advice for Hawaii and the Pacific Islands, and to encourage those islands that remain varroa-free to exercise extreme caution when dealing with bee movements into their territories.

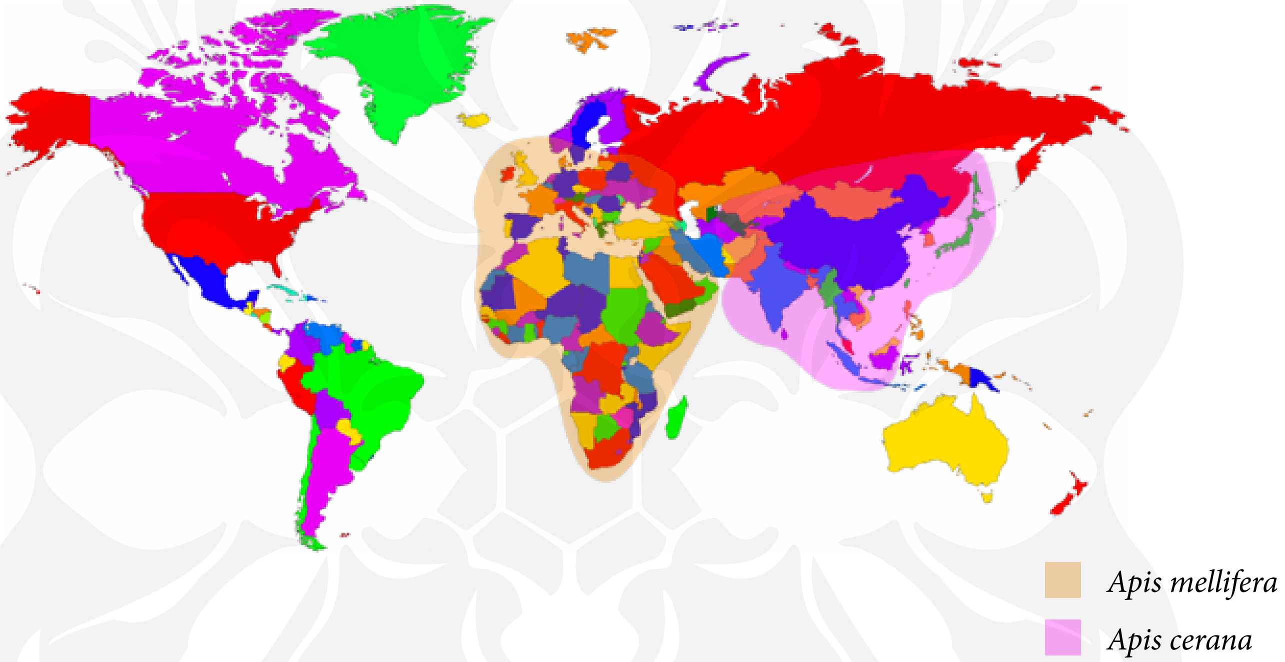


Varroa destructor is an ectoparasite of honeybees and it feeds on the blood (hemolymph) of developing and adult bees. Only the size of a pin-head, the mite can insert its mouth parts between the plates that make up the abdomen of the adult bee, and can cause injuries to developing pupae during the capped stage.

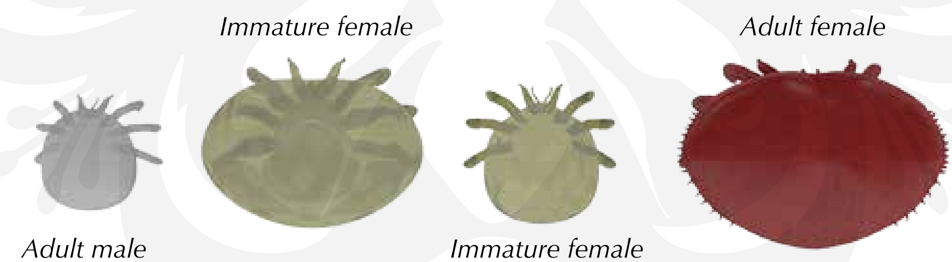


Varroa Origins

Varroa destructor co-evolved with the Asian honeybee, *Apis cerana*. The mite that attacks the Asian bee is called *Varroa jacobsoni*. During the mid-1900's colonies of *A. mellifera* were transported into Asia and came into contact with the Asian honeybee and it's parasitic mite. Two variants of the Asian mite were able to "jump host" to the European honeybee, and became known as *V. destructor*. The Asian honeybee evolved with the mite and seems able to handle the parasitic pressure better than the European bee.



Varroa Reproductive Biology



The mite is entirely dependent on honeybees and it can only reproduce utilizing bee brood. The female mites have 2 life phases, one involves when mites may feed on adult bees, and this is called the phoretic stage. During the phoretic phase the mite may "ride" the bee by sliding between the plates that make up the abdomen, insert her mouthparts and feed on the adult bee. The mite can be moved within the colony to brood areas, or can be transported to other colonies by drifting bees or bees that robbed a colony.

The reproductive stage of the mite life cycle is linked to developing bees. The female mite must enter the cell of a fifth instar larva, and remain with the bee after the worker bees cap the cell and the larva enters the pupal stage. Once the cell is capped the bee larvae will consume the remainder larval food and spin a cocoon. The mite must crawl from the bottom of the cell to avoid being left trapped between the cocoon and the wall of the cell.

The female mite that enters the cell is often called a "foundress" and she will produce one male and multiple females. The first egg is the one that will develop into a male mite; this will be the only male offspring she will lay in that cell. The following eggs are devoted to female offspring and are laid on 30 hr intervals. If the foundress is alone in the cell, her son will mate with his sisters, if there are multiple foundresses, mating between males and females from different mother mites can take place.

Males do not survive outside the cells.

Female mites have a strong preference for drone brood. Male bees are larger and take longer to develop thus allowing for the foundress to lay more eggs and have more daughters that will complete development before the bee is ready to emerge from its cell. However, mites can, and do, reproduce in worker bee cells. Upon emergence of the bee, whether drone or worker, the male and any remaining immature female mites die.

Varroa mites live two to three months in summer or tropical conditions, and a female can complete three to four breeding cycles during her lifetime.

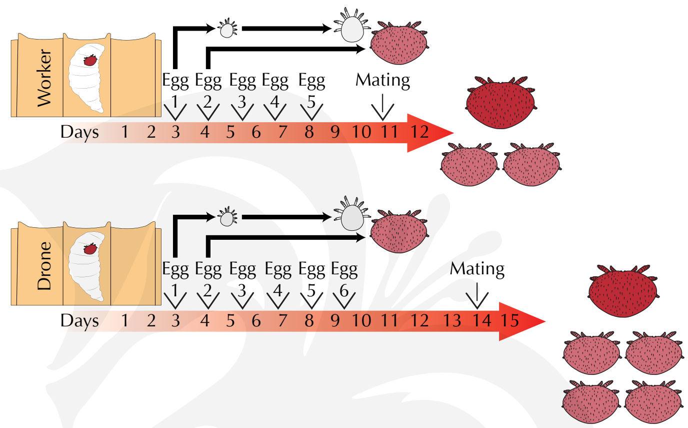


Diagram modified from Rosenkranz, Aumeier, and Ziegelmann, 2010.

Varroa and Deformed Wing Virus (DWV)

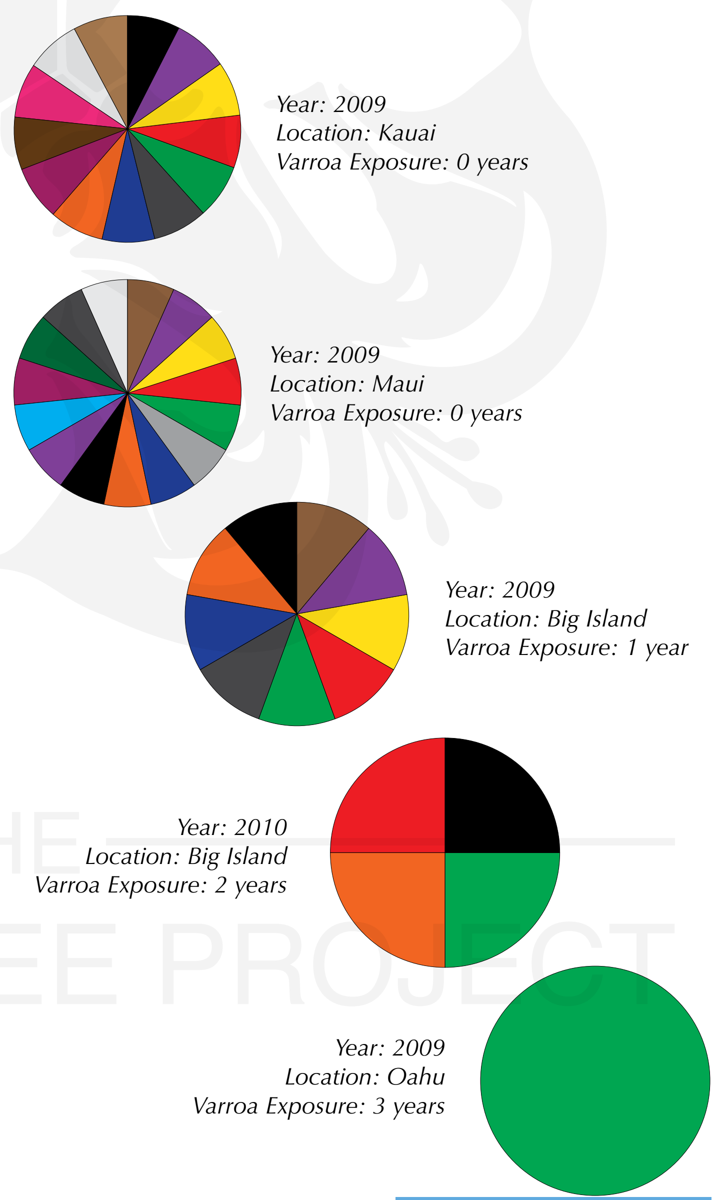
The arrival of the varroa mite to Hawaii in 2007 caused large colony losses on Oahu and on the Big Island of Hawaii. The viral diseases transferred by the mite, in particular DWV, have reduced the populations of managed and feral bees on these islands.

Work conducted in Hawaii showed that the virus quickly spread across the infected islands, and that the DWV is now present in all honeybee colonies on Oahu and Big Island.

Viruses are small and genetically very variable. Prior to the arrival of the varroa mite, Hawaii's bees had a diverse suite of viruses, including many forms of DWV. However, the pre-varroa levels of DWV were really now, and the virus had a number of benign variants. When the mite arrived, it acted as vector of a specific variant of the virus, called Type A. This variant became very abundant and all colonies began developing symptoms due to the high viral levels. It is not known why or how Varroa destructor was more likely to transmit one variant over the many that existed. Nor it is clear why this variant became established within the hives.

Type-A DWV has been associated with large-scale losses of colonies worldwide, and there is a strong link between high numbers of mites and high viral levels in the colonies. The negative impact of the mite and DWV on bee health and colony survivorship has fueled many scientific studies in the last decade or so. We are also continually learning more about possible interactions between disease expression in relation to bee diet and pesticide exposure.

Diversity of DWV Strains in Hawaii over Time



What We Know So Far:

Facts:	Impacts:
Varroa mites transmit many viruses. Some are more dangerous than others. DWV, SBV, X and X are among the more important bee viruses.	Most colonies infected with varroa and DWV which do not receive treatment will likely die within 6 months to 2 years.
Better nutrition reduces impact of diseases in bees.	Bees that have been fed a nutritious diet (made of a diversity of pollen), and larvae that have not experienced food limitations (no pollen shortage) during development are better at fighting infections.
The negative impact of DWV is greater when the mite transmits the virus during the pupal stage.	Bee pupae parasitized by varroa have lower adult weight, shorter life span, and may exhibit deformed wings.
Varroa arrival to Hawaii resulted in a change in DWV types and abundance.	Majority of feral colonies died. Beekeepers lost a large number of managed colonies.
Infection with multiple pathogens are much more dangerous.	Higher mortality when colonies have Other viruses?
The varroa mite is the most effective vector for DWV. However, DWV can be transmitted in many ways, some don't include the mite: Vertical transmission (sperm, eggs) Horizontal transmission (feeding, food, feces)	Once the mite has invaded a colony there is always a baseline amount of DWV circulating in the hive.
Pesticides accumulate in the hive.	Pesticides reduce the ability of the bee to fight off infection
Female mites feed on adult bees to prepare for reproduction. They appear to prefer young nurse bees.	The mites are feeding on the bees that are in charge of feeding the young larvae, there are possible, but yet unstudied, effects on adult bees and larvae.

Treatment Options

Given the large negative impact of varroa and DWV on bees, it is clearly important to examine how to monitor and control the mite. One unfortunate reality in varroa control is that there is no good threshold to determine when to treat. When the mite first invaded Hawaii in 2007, and the DWV levels in the colony were relatively low, colonies with 12-15 mites/100 adult bees were still healthy. Overtime, the viral ecosystem changed, and now almost every bee in a colony is infected with the Type A variant of DWV. Under these conditions, the number of mites, vectors and amplifiers of the virus, need to be lower to avoid colony losses. As of 2016, we recommend treatment when mite levels range between 5-6 mites/100 adult bees.

There are a number of treatments available for mite control that can be divided into 4 groups based on the strategy or tool used to reduce mite levels.

Bee Genetics:

Varroa sensitive hygiene *(by Danielle Downey)*

Honeybees are known to uncap and clean out pupae that are infected with diseases or parasites, including wax moth larvae and/or small hive beetle. Breeding for VSH focuses on selecting a natural trait that is similar to the other cleaning behaviors of infected brood in honeybees.

The cleaning behavior is a coordinated effort of several individual bees. The first step in the VSH behavior is the uncapping of a cell. Bees tend to be more sensitive to infected pupae that are about 1 to 5 days post capping. If the uncapped pupa is dead, it will be removed. If the pupa is alive, different outcomes are possible. The nurse bees can sometimes remove the foundress mite or the mite might escape from the cell on her own. The immature stages of the mite may die during uncapping or removal. The cell may then be recapped and the pupa continues its development, minus the mite. The uncapping behavior of the nurse bees results in a failed reproductive attempt for the foundress mite.

The USDA, ARS Honey Bee Breeding, and Genetics and Physiology Laboratory has been working on selecting bee genetic lines that promote this behavior. Colonies with high levels of VSH behavior tend to reduce the fertility of the mites by interrupting their reproductive cycle within the capped cells. This behavior, although inherited by the workers in the colony, can be lost over time when the daughter queens mate with drones that do not come from VSH colonies.

Hawaii's climate supports year-round brood production, which sadly creates perfect conditions to produce many mites, has also perfect conditions to breed and select bees with a selective behavior against mite infestation. A large-scale research project is ongoing in Hawaii; and it is the result of a partnership between public and private organizations: the Hawaii Island Honey Company, USDA-ARS Baton Rouge, and the non-profit bee research organization Project Apis m are now working together to produce bees with high levels of mite resistance and also desirable traits for beekeepers, including calm temperament, high productivity, large populations and high quality brood patterns. Bee breeding is a long and slow process, but Hawaii is an excellent place to do this project.

Biomechanical:

Drone Brood Removal

Varroa destructor foundress mites attacking A. mellifera colonies have a higher reproductive output in drone brood compared to worker brood. Based on the studies cited above, foundress mites produce an average of viable female offspring/cell in drone brood compared to, 0.7 - 1.0 viable female offspring/cell in worker brood. As a result, the Varroa mite has developed a stronger preference (8-11 fold higher) for drone cells over worker cells. Despite the mite's higher reproductive output in drone brood, drone production in temperate climates is highly seasonal and drones constitute an abundant resource for mite reproduction only during a short part of the year. In Hawaii, however, the warm subtropical climate results in production of drone brood year-round, thus allowing Varroa mites to utilize drone brood even during the winter season.

Drone brood allows female mites to produce more offspring and as such the cells are in high demand. In Hawaii about 20% of infested contained three or more female foundress mites (Ito, in preparation) making drone cells a magnet for mite reproduction. Beekeepers use this natural attraction to remove mites from their colonies by encouraging drone production and removing the drones from the colony and taking the mites with them.

This process is called "Drone Brood Removal" (DBR) and Tyler Ito fro the UH Honeybee Project assessed the efficacy of this biomechanical system of mite control in Hawaii.

The majority of studies on drone brood removal (DBR) have been conducted in temperate regions, where brood production is highly seasonal. There is little information on the abundance and seasonality of drone production in tropical regions or on the effectiveness of DBR in environmental conditions similar to Hawaii. The project involved the use of Pierco Drone Comb to encourage the construction of drone cells.

The study colonies displayed great variability in their energetic investment in drone production. In fact, the number of males per drone frame varied greatly among colonies in the same apiary, suggesting that drone production is influenced not only by environmental factors but also by colony characteristics, possibly such as colony strength, resident queen age, and/or colony age. For those colonies that produced large numbers of drones (>1000) the culling of these bees resulted in a significant decrease on the mite population (Ito's thesis). Although DBR is only able to target mites in drone cells, the drone comb was able to trap and remove 48% of the colony's total mite population (1262.25 adult mites/frame). However, due to the amout of work involved and the inconsistency between hives in drone production, this method is most suitable for small-scale or hobbyist beekeepers that only have a few colonies.

Organic Acids and Oils

Organic compounds, specifically formic acid, oxalic acid, and thymol are some of the most commonly used alternative methods of V. destructor control. Organic acaricides can be effective, relatively easy to apply (depending on the product and the delivery method, but less so than synthetic chemicals), and have a low risk of residue build up or development of mite resistance.

The effectiveness of organic compounds can vary depending on several factors, such as climatic conditions, application method, colony strength, and concentration of the chemical. Therefore, it is important to evaluate the efficacy and secondary effects on colony health in subtropical regions, such as Hawaii, where ambient temperature is relatively high throughout the year.

"Mite Away Quick Strips" (MAQS®), is formic acid embedded in a gel. The vapors from the pad fumigate the hive and then dissipate without altering honey quality. The pros to using this chemical are that it can penetrate through cap cells, killing many of the mites inside the cells, especially the males and the developing female mites. Because of the deep reach of the formic into the capped cells, it is not necessary to keep the product in the hive for extended periods in wait of emerging mites. There are no residues from this treatment and there is no evidence of chemical resistance developing in the mite populations in Hawaii.

The cons of using MAQS have been associated with some degree of brood burn. This is when bees die during emergence (see pic) and when brood is removed by nurse bees. This reaction seems more intense the first time the product is applied, and surprisingly, colonies seem to react less extremely in subsequent treatments with MAQS. One of the biggest challenges for Hawaii's beekeepers is to find cooler daytime temperatures when to apply the treatment according to label instructions and making sure there are enough bees to contribute to ventilation of the hive. Another problem sometimes linked to MAQS is queen loss. It is somewhat difficult to assess what may be happening in a colony prior to treatment, especially if queens are not marked. Queen loss or queen replacement after treatment could be the response of the hive to very different situations. In our experience, queen loss defined as the disappearance of a queen within a week of the treatment is very rare. Queen replacement or supersedure within 1 to 2 months following treatment is more common. Queen replacement can be due to an overall improvement in the colony, subsequent population increase and swarming. The departure of the old queen could, mistakenly, be interpreted as queen loss. In general, the colony impacts of formic acid treatments are manageable if the beekeeper visits the hives frequently, and instructions regarding ambient temperature and minimum colony size requirements are met during product application.

Apilife VAR® and **Apiguard®** are two trade names for varroacides based on thymol. This essential oil has long been used to fight varroa. Apiguard, which is currently registered for use in Hawaii, consists of a gel matrix, which is placed on top of the bars of the hive. The chemical works through contact as well as a fumigator. The recommended treatment duration is 4 weeks and during this period the beekeeper must remove the supers to avoid contamination of the honey. In Hawaii, hot humid days challenge the beekeeper and the bees, and the impact of fumigants can discourage beekeepers. Finding a balance between cooler day temperatures and strong bee populations to circulate the gases is essential to reducing brood or queen losses with this treatment. As with formic acid, thymol can result in brood death and queen loss, but as with formic, there are no chemical residues on wax. As mentioned earlier, thymol can taint the taste of honey so removing honey supers is imperative during treatment.

Synthetic Acaricides

Beekeepers have, and continue to use, synthetic acaricides for V. destructor control. These chemicals are relatively easy to apply, inexpensive, and there is no immediate impact to the bees during treatment. However, there have been growing concerns about long-term adverse effects on colony health due to the build-up of residues in the hive. In addition, there is data suggestion that the efficacy of some of these chemicals is declining due to mite resistance. Some of the more commonly synthetic miticides used in Hawaii include fluvalinate, coumaphos, and amitraz. These three chemicals work by contact, that is the bee has to come into direct contact with the strip as she walks in the hive. The bees spread the chemical throughout the hive and to each other. Consequently, the pesticide only affects the mites found feeding on adult bees (phoretic stage of the mite) and not those inside the capped cells. To be most effective the pesticide has to be within the hive for over two weeks to ensure mites emerging from the cap cells are also eliminated. The need for prolonged exposure can interfere with honey production in some areas.

The chemical **fluvalinate**, commercially known as **Apistan®**, is a synthetic pyrethroid that is applied as plastic polymer strips containing 10.25% fluvalinate. The strips are hung between the frames of the hive so that bees come into contact with the chemical as they move through the brood chamber, spreading the chemical throughout the hive. Originally fluvalinate was very effective as a mite control, but more recently, reports from Europe and the continental United States indicate that mites are becoming resistant to fluvalinate.

Coumaphos, an organophosphate, is another synthetic chemicals approved for varroa mite control. Coumaphos is commercially known as **Checkmite+®**, which also comes in the form of plastic polymer strips, and is applied the same way as Apistan. Coumaphos was very effective at controlling Varroa, however, the mites develop resistance to this chemicals within a few years. This chemical has been studied in Europe and the continental US and the general consensus its use has many drawbacks, including a strong decrease in its effectiveness for mite control and negative impact of pesticide residues on the health of queen and drones.

Amitraz, a chemical belonging to the class amandine, has also been approved for mite control in Hawaii. The product is sold under the name **Apivar®**, which consists of plastic polymer strips embedded with amitraz. As with the other two synthetic acaricides it hangs between the frames of the brood box. However, unlike fluvalinate and coumaphos, amitraz is unstable in honey and wax and therefore degrades quickly leaving very little residue in the colony, thus making it a more appealing option for beekeepers. Apivar has been used successfully used in Hawaii to treat small or weakened hives that may not meet the criteria of strong bee population that is needed for other treatments including formic acid and thymol.

No Treatment and the development of mite resistant stock

The selection of genetic lines to promote particular traits takes a long time and effort. Local beekeepers are encouraged to select among the colonies for traits that they prefer: productivity, low mite numbers, tameness, etc. There is however a big difference between a beekeeper selecting local stock and choosing not to treat for mites.

The proponents of no-treatment argue that the colonies will self select and that the weaker hives will die out. The remaining colonies will then constitute their selected stock for the future. Although intuitively this idea makes sense, and selection of favored traits in domesticated animals is commonplace, mite resistance is most likely not based on a simple trait.

The challenge derives from the many complex interactions between the bees' genetics, varroa, viral and bacterial diseases, diet, and pesticide exposure. These interacting factors may obscure real patterns, and can produce variable results even under strictly controlled circumstances.

The owners a no-treatment apiary may be philosophically/economically prepared to loose a large number of hives, with the expectation that they can build on the next generation of genetically superior colonies. However, this assumes that the process culled only weak hives and that only strong, genetically superior colonies survived. This assumption may not be true; there is great variation within colonies of a single apiary, for example some may have older queens or some may have been exposed to more pesticides. These differences are not genetically based but can lead to differential results if the colonies are not treated against the mite. Basically, colonies with good genes but an older queen or recently in contact with pesticides may be lost during a no-treatment program, and the "selected stock" may still be very susceptible to the mite.

The European honeybee encountered the mite only recently in its evolutionary history, and although resistance may be possible, it is not something that can evolve naturally or be developed quickly. The most reputable laboratories and projects that have been selecting traits for Varroa resistance have been working at this for a long time.

There is undoubtedly a great value to conserving honeybee genetic diversity, promoting locally adapted queens, and selecting for behaviors that reduce Varroa levels, however, we strongly urge beekeepers to treat against the mite, using options that fit their philosophy. Not treating will not only lead to colony losses, but also releases more pests into the environment and may negatively affect nearby beekeepers and farmers.

Queen Breeding in Hawaii

(by Lauren Rusert)

Along with the year-round brood production in honey bee colonies in the tropics, Hawaii's climate allows for year-round queen bee production. Hawaii produces an estimated 25-50% of the queens used by beekeepers on the mainland U.S. and about 75% of the queens used in Canada, valuing at about $10 million annually. Although these may seem like high numbers, the demand for these early-season queens exceeds supply. Queen bees from Hawaii are a critical resource for all North American beekeeping and the myriad of fruits, nuts, vegetables and seeds that rely on honey bee pollination. This can be seen with the 800,000 acres of almonds starting to bloom in February, beekeepers heading to California depend on early queen availability from Hawaii. Queen necessity within the state is also just as important for beekeepers to rebuild from any losses.

Because Hawaii is free from many pests that are present in other parts of the world, importation of queens and other bee resources is limited. With the demand exceeding supply and strict importation laws, it is difficult for local beekeepers to purchase queens. Within Hawaii, queen bees cannot be imported or moved from islands where Varroa is established (Big Island and Oahu) to Varroa-free islands (Kauai, Maui, Molokai, Lanai), limiting the supply even further. In Hawaii as of 2016 there are approximately twelve queen breeders state-wide, some having been present for over 30 years. With the rich history of queen breeding, the queens produced are held to high standards.

Alcohol / Soap Shake

How It Works

The alcohol or soap shake targets phoretic mites that are attached to adult honeybees. Mites are dislodged and killed, then separated from the honeybee sample. This method sacrifices approximately two hundred bees from the colony. Although killing bees may seem difficult you will need to sample a large enough number of adult bees to detect a recent or low level mite infestation. The advantages of this method is that it is quick and accurate, especially when brood levels are low and the majority of the mites can be found feeding on the adult bees.

What You Need

A measuring cup, 200 ml of alcohol, either isopropyl or ethyl or alternatively, 3/4 cup of water-dishwashing soap solution, a wide mouth mason jar large enough to hold about 2 cups of fluid, the jar should have a 2 piece lid with a screw ring and a flat metal part which can be replaced by a wire mesh screen (#8, 3mm).

How To Conduct The Test

Brush or shake approximately two hundred bees into the jar containing 3/4 cup of alcohol or dishwashing detergent soap solution. To ensure collecting enough bees for the test, shake workers into a bucket, then scoop up the bees with the measuring cup (1/2 cup = 200 bees). Shake jar vigorously for one minute. Filter contents through a fine mesh sifter or a wire mesh screen and check for mites. To increase the detection power of the test rinse the bees with water to dislodge mites that may still be attached to the wings and/ or other body parts of the bees. Filter the contents again and look for additional mites.

Interpreting Your Mite Levels

Mite levels are expressed as mites/100 adult bees. For example, if the total mite count in the sample is 32 mites, the mite/adult bee ratio is 16/100. In Hawaii, where mite populations can continue to grow year round, it is recommended that treatment be applied to a colony if the mite to bee ratio is 12 or higher.

Powdered Sugar Shake

How It Works

Powdered sugar shake, like the alcohol shake method described previously, can be used to dislodge mites from adult bees. However, unlike using alcohol or soap, powdered sugar is a nonlethal method and will not kill the bees in the sample. Coating the bees in powdered sugar will stimulate grooming behavior in bees, thus removing mites. In addition, it seems that powdered sugar may cause the mites to temporally lose their grip from the adult bees. Please note that NOT all of the mites in the sample will necessarily be removed from the bees. Approximately 10% or more of the mites may remain on the bees, so this method tends to underestimate the infestation level and is not an ideal method for Varroa detection in areas where the mite is not present.

What You Need

A wide mouth Mason jar, metal screen #8 (3 mm), bee brush, powdered sugar, a plastic tray or container, preferably white or at least light colored.

How To Conduct The Test

Modify the cover of a wide mouth Mason jar by replacing the lid with the wire mesh screen and keeping the screen in place using the screw ring of the original lid. Brush or shake approximately 200 bees into the Mason jar. Pour 1 teaspoon of powdered sugar through the cover of the wire mesh. Roll the jar ensuring each bee is coated in powdered sugar. Invert it and shake vigorously into a container (white is preferable). Count the number of mites that fall. Open the jar, and pour out bees in front of the hive entrance.

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Brood Sampling

How It Works

When colonies are producing large amounts of brood, especially drones, approximately 80% of varroa will be found within the capped brood cells. Taking a random sample of the larvae in the capped cells can be used to detect the presence of mites in a colony. Since varroa mites prefer drone cells over worker cells, sampling drone brood can give an accurate estimate of the infestation level. However, at low level infestations, detection of the mite can be limited by the number of cells sampled. Drone sampling is obviously limited by the reproductive cycle of the colony.

What You Need

An uncapping fork tool.

How To Conduct The Test

Use a capping scratcher to remove 50 – 100 drone pupae. If no drone cells are available, worker pupae can be sampled. Search for mites on each individual pupae or cell. Feces (white spots) can also be present in cells containing mites. Since mites prefer to utilize drone cells this sampling method can facilitate the detection of varroa mites. Once the frame is used and the drone larvae are capped, remove the frame and sample larvae with a capping scratcher.

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Mite Fall

How It Works

Varroa mites will fall off of honeybees due to death, or by honeybee grooming. This passive mite fall can be used as a detection method as well as a means of monitoring the varroa levels in a colony. A sticky board is placed below a screen mesh allowing for daily or weekly counting of varroa mite. To increase mite fall for detection of a new or low infestation, powdered sugar, or an acaricide can be used in conjunction with the screen bottom.

Install a screen bottom board (#8, 3mm wire mesh) with a sticky board below the screen. A poster or plastic board can be covered with any sticky substance (Tanglefoot, Crisco, or Vaseline) and be used to trap mites after they fall through the screen. After one to seven days have passed, remove the board and examine it for mites. Leaving the board under the screen for over a week can result in lots of hive debris accumulating on it and can make detection difficult.