A deadly honey bee parasite

The Varroa Mite

bee care

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Honey Bees – *small Insects, big Impact*

Big tasks for little insects: The work honey bees do is of great importance to human beings. Many crops, for instance, depend to some extent on pollination by bees and other insects. Honey bees, in particular, are crucial for pollination of numerous crops that are important for food production. That is why it is vital to protect and improve bee health. Although the number of honey bee colonies has increased across the globe in the past 60 years, bee health issues remain a challenge in some regions of the world.

One of the main causes, and one of the honey bee's worst enemies, is a tiny mite known as ***Varroa destructor***. Currently, only a handful of effective ways exist to protect bees from this mite. However, by combining the few effective control measures with good beekeeping management practices, it is possible to reduce the harm caused by *Varroa* and to control the impact of this parasite.

If an article or image is marked with this sign, you can download it via the following link:
www.beecare.bayer.com/varroa

We hope this material will prove useful for your *Varroa* training courses.

Varroa mite attached to an adult bee showing signs of a Deformed Wing Virus (DWV) infection

Varroosis:
Infestation of Honey Bee Colonies

The tiny but highly dangerous *Varroa destructor* mite is the most destructive enemy of the Western Honey Bee (*Apis mellifera*). The parasite has now spread to almost every part of the world – except Australia. Mite infestation of honey bee colonies has hit Europe and North America particularly hard, and the parasite is a serious threat to bee health. In these regions, a bee colony in a mite-infested beehive will typically collapse within three years if there is no human intervention.

Different development stages of the *Varroa* mite in a bee colony brood comb

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Besides the threat posed by the *Varroa* mite itself, there is also the danger of infections with various mite-vectored diseases that have become more widespread and weaken honey bee colonies. The parasitic *Varroa* mite – much like ticks – transmits viral diseases that can become more virulent and often prove fatal to adult honey bees and their brood.

Finding solutions to combat this mite is difficult because, despite a number of promising ideas, it has not yet been possible to develop simple and long-lasting treatments to control this parasite. Moreover, no stable *Varroa*-resistant strain of the Western Honey Bee has yet been bred.

Distribution
of the Varroa Mite

The *Varroa* mite originated in Asia, where it was first discovered on the island of Java in Indonesia over 100 years ago. The Dutch zoologist Anthonie Cornelis Oudemans named the species ***Varroa jacobsoni***.

The mite was a parasite of the Asian Honey Bee (*Apis cerana*). Over millions of years, an equilibrium had developed between the parasite and its host. *Varroa* parasitization is less severe in *A. cerana* as drone brood cells are mainly infested and adult bees can fend off the mites through intensive hive-cleaning habits, thus minimizing the harm to the colony.

When the Western Honey Bee (*Apis mellifera*) was brought to Asia by beekeepers, their beehives also became infested by the *Varroa* mite. Infested hives then brought the parasite to Europe where it has continued to spread since the late 1960s and has subsequently reached the Americas and Africa. In 2000, genetic investigations revealed that *Varroa jacobsoni* actually comprises two distinct species. Both originated in East Asia and were parasites of *A. cerana*. However, the one that colonized a huge region beyond Asia on its new host *A. mellifera* was discovered to be different from the true *V. jacobsoni* and was subsequently named ***Varroa destructor***. The fact that no equilibrium has yet had a chance to develop between *V. destructor* and its new host *A. mellifera* explains the severity of *Varroa* infestations in beehives containing Western Honey Bee colonies.

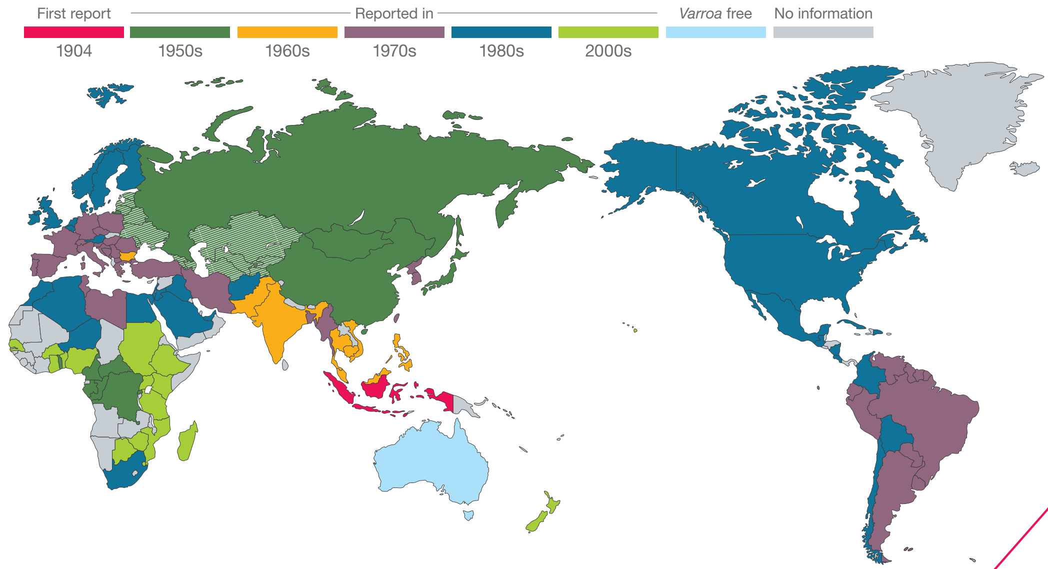
Varroa destructor is now found not only in large areas of Asia but also in Europe, the Americas and Africa – and even in New Zealand and Hawaii. Australia is the only continent the mite has not yet spread to, mainly due to intensive biosafety protocols at the borders.

Mite migration

// The Varroa mite originated in Asia but has now spread to most continents and threatens the Western Honey Bee almost everywhere.

// So far, only Australia has managed to keep the parasite out.

Varroa global spread



Varroa destructor originated in Asia but has since spread towards the west and east, and now threatens the Western Honey Bee over almost all of the planet.

Source: adapted from Webster TC, Delaplane KS 2001, Mites of the Honey Bee

Biology
of the Parasite

Body structure

Although the parasite's name – *Varroa destructor* – more or less says it all, this tiny arachnid is not much larger than a millimeter in length and lacks hearing and sight. The mite has four pairs of legs as well as piercing-sucking mouthparts. It uses the numerous sensory hairs all over its body as receptors to detect its environment. The *Varroa* mite's flattened shape and the suckers (apoteles) on its feet enable it to better grip the bee's body. It uses its mouthparts to pierce the bee's exoskeleton. It was generally thought that it sucks the bee's hemolymph, a body fluid similar to blood, but recent research has suggested that it primarily feeds on the bee's fat body.

// **Body structure:** *idiosoma* (main body section) and *gnathosoma* (mouth and feeding parts).

// The mite has four pairs of legs and piercing-sucking mouthparts.

// The hairs on the top and bottom of the mite's body are used as mechano- and chemo-receptors.

// The parasite feeds on the hemolymph and/or fat body of adult bees and their brood.

Gender differences

Male and female mites differ significantly. Male *Varroa* mites are more rounded and yellowish-white. Measuring only 0.7 - 0.9 mm, they are also markedly smaller than females, which are approximately 1.1 mm long and 1.6 mm wide. Females are more heavily sclerotized with a harder outer layer (cuticle) and are dark reddish-brown in color.

The mouthparts of females are much more pronounced than those of males. This means that only females can penetrate honey bee brood and the exoskeleton of adult bees. The male mite is confined to the brood cells and feeds on the bee brood at the feeding spot created by the female mite. For this reason, only females can survive outside the brood cells. The function of male mites is limited to mating with their sister mites in the brood cell.

Female *Varroa* mite (right) and male below

Varroa mite at the entrance of a brood cell

Download the image from **www.beecare.bayer.com/varroa**

Female morphology

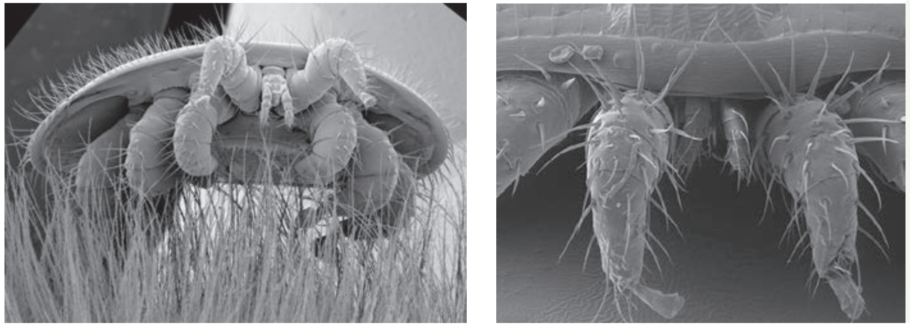
- // 1.1 mm long, 1.6 mm wide
- // flattened body
- // dark reddish-brown in color
- // heavily sclerotized (hard, protective outer layer)
- // the chelicerae (mouth parts) are formed by three segments, two teeth are situated at the end of their jaws

Male morphology

- // 0.7 mm long, 0.9 mm wide
- // rounded body
- // yellowish-white in color
- // can only survive in capped brood cells

Sensory perception

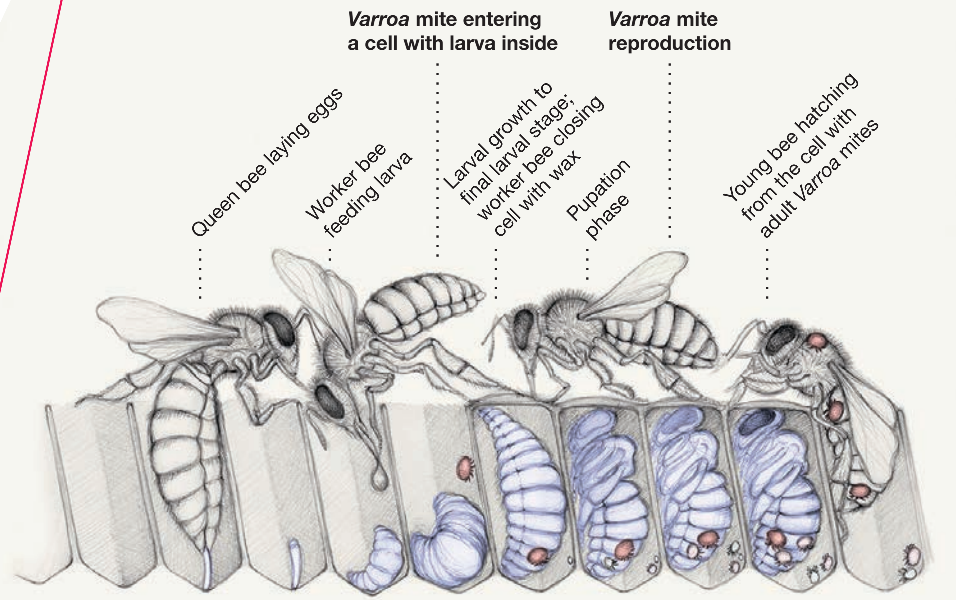
The *Varroa* mite finds its way by differentiating between light and dark, as it cannot see or hear. As the receptors on its sensory hairs are highly developed, the mite can detect differences in temperature, moisture and chemical stimuli. Its acute sense of touch helps it to find its way around the beehive and pick up the smallest vibrations. It uses its front legs, much as insects use their antennae, to sense its environment. Research has also shown that the *Varroa* mite can smell and taste through a sensory organ located in a small cavity on its front legs. The mite's highly responsive sensory system enables it to locate the brood cells in the beehive.



Electron microscope image of a *Varroa* mite showing in close-up detail the *Varroa* mite's mouthparts situated between the front legs.

The front legs of Varroa destructor contain an olfactory sense organ that enables the parasite to smell and taste. It uses its front legs like antennae to sense its environment.

Reproduction Process *of the Varroa Mite*



Development of *Varroa* mites in a comb cell

The *Varroa* mite parasitizes both adult honey bees and their brood. Female *Varroa* mites can survive outside the brood cells by attaching themselves to adult bees. However, the parasite only reproduces in the sealed brood cells of the honey bee. Shortly before the brood cells are capped, female *Varroa* mites enter them and crawl to the bottom of these cells. They protect themselves from the bees which care for the brood by hiding under the larvae and immersing themselves in the liquid brood food. Once this food is depleted by the honey bee brood, the *Varroa* mite feeds directly on the bee larva. The parasite has strongly adapted to its host in its parasitic behavior.

Egg-laying in the brood cell

The scents emitted by the bee larva and the capping of the honeycomb cell with wax by worker bees activate *Varroa* egg development (*oogenesis*) in a female mite – approximately six hours after the female *Varroa* mite enters a brood cell. Once the oogenesis is complete – approximately three days after the brood cell is sealed – the female mite starts to lay eggs. The first egg is not fertilized and always develops into a male. At daily intervals the mite lays the remaining four to five fertilized eggs, which become female mite offspring. The **nymphs** are white and take six days to mature into adult female mites while passing through various development stages. Males need about seven days to mature.

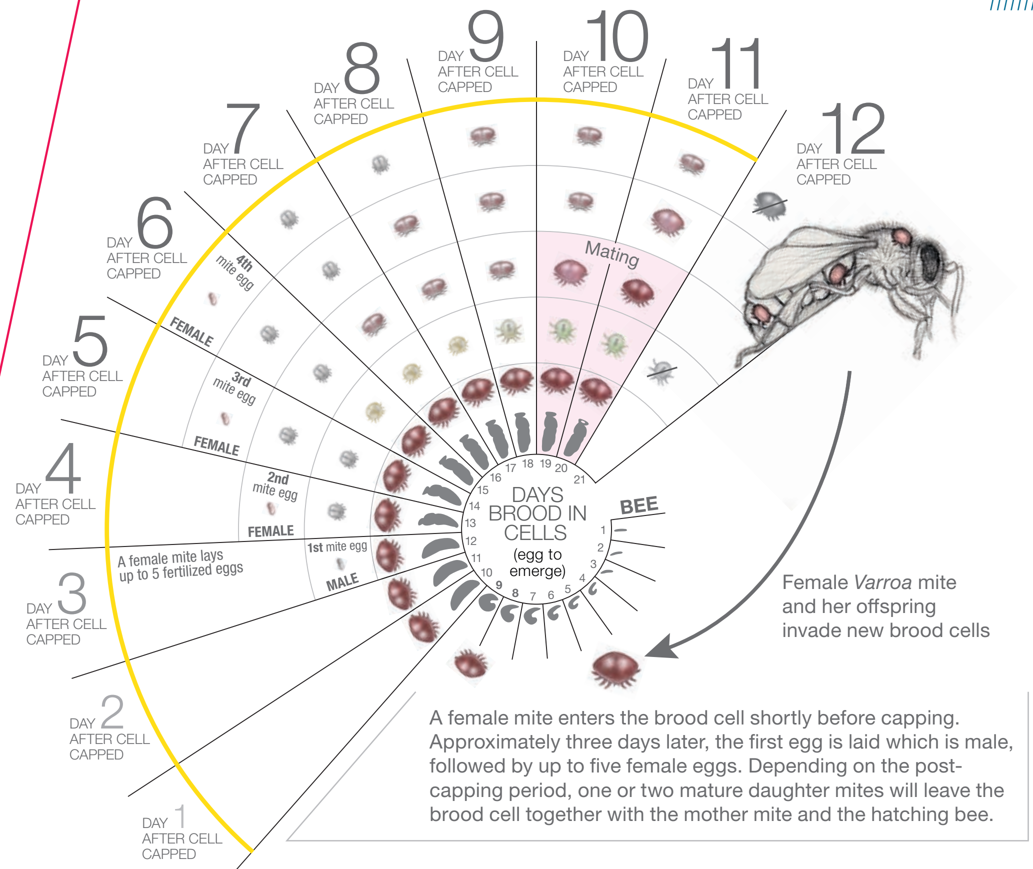
As the juvenile mites are unable to feed themselves, the mother mite pierces a hole into the bee pupa to create a communal feeding site for her offspring. During the development phase, the mother mite has to invest a lot of energy into maintaining the communal feeding site, as it is the sole source of food for the developing mites.

Mating behavior and reproductive success

After the young female mites have successfully reached maturity, mating of male and female mites proceeds efficiently and purposefully in the brood cell. Mating with each of the female mites needs to occur before the bee hatches, as males and unmated females die after the bee emerges from the cell. To complete the mating process, the mites remain in the cell with the developing worker brood for twelve days – and up to 14 days with the drone brood.

The longer development period of 24 days for drone brood means their cells are preferred by *Varroa* and, therefore, drone cells are typically infested five to ten times more often than worker brood cells. The mating behavior shows that the *Varroa* mites have optimally adapted their feeding and reproduction to the beehive environment. This enables parasite infestation to at least double every three to four weeks during the honey bee breeding season.

A honey bee drone brood cell is infested five to ten times more often than a worker brood cell.

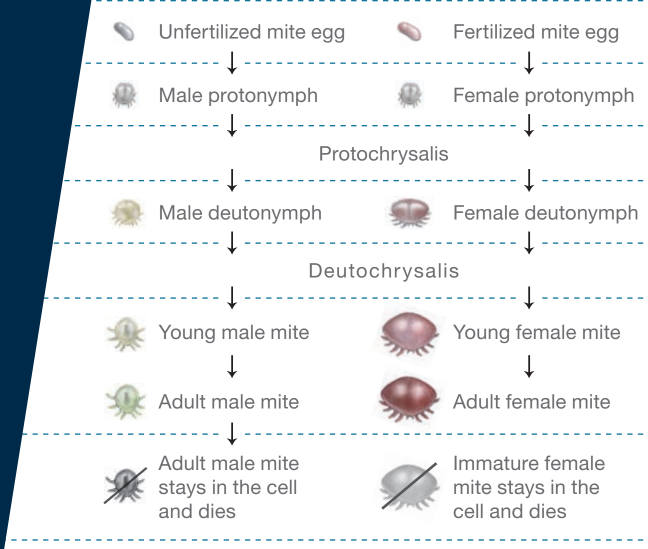


A female mite enters the brood cell shortly before capping. Approximately three days later, the first egg is laid which is male, followed by up to five female eggs. Depending on the post-capping period, one or two mature daughter mites will leave the brood cell together with the mother mite and the hatching bee.

Graphic showing *Varroa* mite development stages

The first development stage of the *Varroa* mite is a six-legged larva that develops inside its closed egg. The eight-legged ***protonymph*** emerges in the post-hatching second stage. In the third phase this protonymph develops into a ***deutonymph***, which then becomes the adult mite. In the final nymph phase, the growing mite undergoes two immobile transitional chrysalis stages (***proto-*** and ***deutochrysalis***). Young female nymphs are white in color and, after molting several times during the development process, turn dark reddish-brown during the last immobile stage – the deutochrysalis – and maintain this color as adult *Varroa* mites.

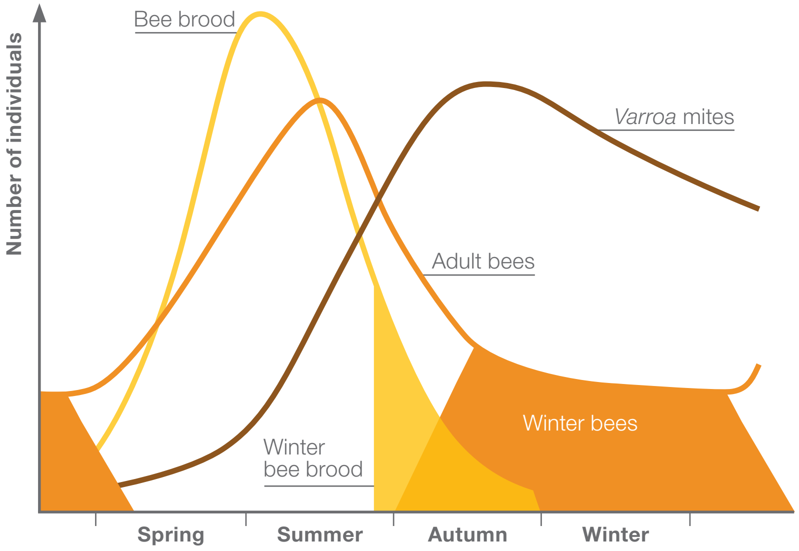
DEVELOPMENTAL STAGES



Infestation
by the Varroa Mite

Life span and population growth

Under temperate climatic conditions, a mite's life span is two to three months in summer and six to eight months in winter. The parasite is strongly dependent on its host, as it can only survive up to seven days without bees and their brood. Dead mites fall to the bottom board of the hive.



Development of the *Varroa* population in an infested honey bee colony under temperate climatic conditions

The Varroa population in a beehive can
double every four weeks
during the honey bee breeding season.

Assuming a starting population of 50 mites, it can grow to around 3,200 mites from spring to the end of summer – enough to kill even a strong honey bee colony of around 30 - 40,000 bees over the winter.

Scientists see **robbing** as the primary factor for the transmission of *Varroa* between beehives. From late summer to fall, as food sources become scarce, honey bees start to steal winter food stocks of weaker colonies. Beehives infested with *Varroa* mites and containing weakened honey bees are particularly susceptible to such attacks. As the *Varroa* mites may latch on to the invading bees, the robber bees not only return home with food but also bring back new parasites.

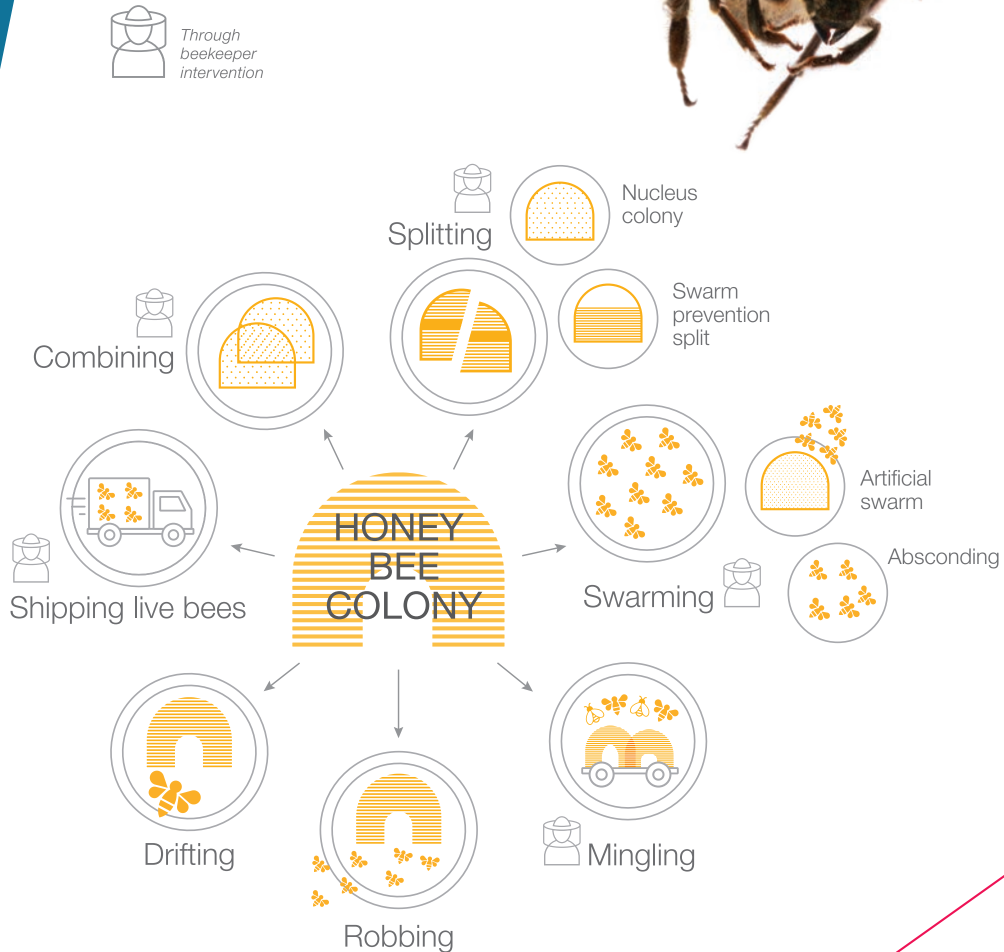
Worker bees returning from a foraging trip also regularly fly into beehives other than the one they originally came from (**drifting**).

This is how different colonies and even different apiaries come into contact with one another. Beekeepers cannot stop this happening – even between hives located several kilometers apart. Moreover, a high density of honey bee colonies in a locality further facilitates the spread of the parasite through drifting and robbery. As a result, even hives that have been successfully treated against *Varroa* mites are at risk of being reinfested by bees from untreated or unsuccessfully treated colonies. This phenomenon of reinfestation was long underestimated but is now considered to significantly contribute to beehives having critical levels of *Varroa* mite infestation, particularly in late summer and fall.

Human activities can also lead to the spread of *Varroa*. For instance, via the transport of queens or nursery bees (**shipping live bees**). The annual movement of beehives from one crop area to another, for instance, during the pollination season in the USA, has resulted in the **mingling** of billions of honey bees from tens of thousands of hives. This has aided and accelerated the spread of mites.

Swarming is a colony's natural method of reproduction. When the brood nest becomes too crowded, roughly half the worker bees will leave to establish a new colony with the old queen – and they take some of the *Varroa* mites with them to their new home. The colony renewal phase is accompanied by a short break in brood production which consequently slows down *Varroa* mite reproduction. But after this, the parasites mate inside the new brood cells and the *Varroa* mite's reproduction cycle starts all over again.

Ways the *Varroa* Mite *can spread*



The remaining bees in a colony with reduced strength, e.g. due to robbery or swarming, face an even greater danger, as around two thirds of the *Varroa* mites in a beehive reside in sealed brood cells during the breeding season. This significantly increases the proportion of bees which are likely to be infected by viruses or weakened in the overall hive population. In the worst case the colony dies, or the honey bees leave the hive in fall, the peak months for *Varroa* mite infestation. When swarming occurs under emergency conditions in fall (**absconding**), the bees depart with the queen to search for a new home, leaving behind the beehive with its infested brood cells in order to try and ensure their colony's survival.

The mites may also spread when beekeepers create new honey bee colonies, e.g. when combining two weak colonies into a new, strong colony (**combining**) or through a process known as **splitting**. The latter involves removing brood combs and worker bees from established honey bee colonies to start a new queen-less honey bee colony (**nucleus colony**). This method allows the nurse bees which stay with the brood to raise a new queen from young larvae and build up a new colony. A split can also be carried out with adult honey bees only. Beekeepers initiate an **artificial swarm** to form a new broodless colony from worker bees and an established queen. After installing on brood-free honey combs, the queen starts egg-laying and a new honey bee colony begins to develop.

In a **swarm prevention** split the beekeeper takes the existing hive, including the old queen, to a new location. A new hive with some brood, pollen and nectar from the relocated hive takes the place of the old one. Foraging bees from the old hive return to the former location of the hive and immediately start to raise a new queen from young larvae for a new honey bee colony.

Although splitting contributes to the spread of the *Varroa* mites, it can also be an efficient way to reduce the *Varroa* population in a beehive. In all the splitting methods described above, the mites can hitch a ride on bees from the old hive to the new one, but the reduction or interruption in the amount of honey bee brood means the degree of mite infestation is lower in the beehives containing the split colonies than the parent colony.

An additional *Varroa* treatment when splitting colonies, building artificial swarms or removing the queen to break the brood cycle helps to further reduce the parasite infestation in the new colony's hive.

The Varroa mite spreads from hive to hive through contact between bees from different colonies, even those several kilometers apart.

Natural and assisted reproduction of colonies are also ways by which the *Varroa* mite can spread.

Transmission *of Honey Bee Viruses*

Most honey bee viral diseases are found in latent form in bee colonies. A virus will spread among bees during their social interaction in the hive. In some cases a virus can be transmitted by *Varroa* mites. Depending on the infestation level, the vectored diseases can become visible immediately or only after several years.

Unlike the Asian species, the Western Honey Bee lacks adequate defense mechanisms to fend off the parasitic mites. Honey bees in infested hives are weakened and their immune system is affected as a result of the mites' feeding activity. This adversely impacts their vitality and shortens their life span. When the parasite feeds on a bee larva, it also transmits dangerous viruses directly into the bees' hemolymph and/or fat body, which can spread and harm bees, especially during their vulnerable development stages. *Varroa* increases the severity of the infection as some viruses, which are otherwise unproblematic for bees, become deadly when injected directly into the bees' hemolymph. Since there are no effective medicines to treat honey bee viruses, control of the *Varroa* mite is essential to reduce the spread of viruses.

One very widespread virus is the **Deformed Wing Virus (DWV)**, which occurs in both the brood and adult bees. In many cases, an infection of an adult bee does not produce any visible signs, but if the parasite transmits the virus to bee pupae, the young bees develop deformed wings. These bees are unable to fly and have a shortened life span.

The *Varroa* mite also transmits other viruses such as the **Acute Bee Paralysis Virus (ABPV)**, which infects adult bees and brood alike. It is primarily found in the bees' fat body cells and salivary glands but does not produce any visible signs of disease. The mite transmits ABPV directly into the bees' hemolymph where it spreads to the vital organs. Once in the brain, the virus induces behavioral disturbances and impairs orientation and development, all of which can have lethal effects.

An infection with DWV and/or ABPV is particularly critical for winter bees, as it severely affects their ability to survive the winter.

Bee larva with parasitizing *Varroa* mites

The Varroa mite harms honey bees in various ways:

- *Weakening the bee's immune system, causing more acute disease progression.*
- *Transmitting viruses that spread quickly within and between bee colonies.*
- *Directly transmitting viruses into the bees' hemolymph so previously harmless viruses may become lethal.*

Most Important Honey Bee **Viruses**

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Virus	Abbreviation	Symptoms and characteristics
Acute Bee Paralysis Virus	**ABPV**	The virus is present in the bees' fat body and salivary glands but in most cases the infection does not cause visible signs. However, ABPV can reach the bee's brain through the hemolymph and then cause behavioral anomalies. Bees become disoriented (e.g. flying to the wrong hive), disturbed in their development and die within a short time. The virus also affects winter bees' ability to survive until spring.
Chronic Bee Paralysis Virus	**CBPV**	Overt signs include black colored, hairless, trembling bees which are unable to fly. Affected bees are often seen around the hive entrance. Infestation may sometimes cause dysentery. Excrement spreads CBPV throughout the hive.
Israeli Acute Paralysis Virus	**IAPV**	This virus was first described in Israel in 2004, where infected bees were seen with shivering wings, a symptom that progressed to paralysis and bees dying outside the hive. IAPV is spread in the hive via bee excrement. The *Varroa* mite can also carry the virus and, once transmitted into the bees' hemolymph, it very quickly kills both pupae and adult bees.
Slow Bee Paralysis Virus	**SBPV**	This infection typically produces no visible symptoms in bees. However, the *Varroa* mite transfers the virus directly into the bee's hemolymph, where the infection can be deadly.

Virus	Abbreviation	Symptoms and characteristics
Deformed Wing Virus	**DWV**	This widespread virus impacts bees in all development stages. Initially, the infection does not cause any obvious symptoms but if the *Varroa* mite transfers the virus to a pupa, the emerging bee will develop deformed wings. The adult bee is unable to fly and has a shortened life span.
Sacbrood Virus	**SBV**	This virus typically infects brood fed with infected worker jelly. Diseased larvae fill with liquid and their bodies lose their structure within the tough, sac-like outer layer (exoskeleton). Eventually, the larva dies and dries out. A dark scab forms on the head of the dead larvae. Although adult bees typically do not show visible symptoms of SBV, they develop faster, collect less food, and die sooner.
Kashmir Bee Virus	**KBV**	This infection proves fatal to adult bees within a very short time. The *Varroa* mite increases the spread of this virus within the hive. Symptoms include black hairless bees and dead and dying bees inside and outside the hive.
Cloudy Wing Virus	**CWV**	This virus spreads through the air in the entire beehive. *Varroa* mites enhance the infection of the brood. Severely infected adult bees may have opaque wings.

Combating *the Varroa Mite*

To protect the health of their honey bees, especially in regions like Europe and North America, it is essential that beekeepers control the *Varroa* mite. In fact, the beekeepers' most important task, particularly in late summer, is to minimize the level of colony infestation to protect winter bees from the *Varroa* mite and the deadly viruses the mites spread. This is crucial to ensure sufficient numbers of healthy winter bees that hatch in fall and survive the four to six months in temperate climates, thus enabling a strong bee colony to build up again in the spring. In warmer climates where there is no, or only a very short, broodless period, it is essential to monitor *Varroa* counts closely during the year and minimize the level of colony infestation, if necessary.

Varroa treatment is crucial to ensure sufficient numbers of healthy winter bees will survive the five to six cold months.

Diagnostics

Before taking specific control measures, beekeepers should periodically check whether their hives are infested with the *Varroa* mite and, if so, determine mite infestation levels. On the basis of these findings, beekeepers can decide on an appropriate control measure. Infestation levels should also be checked during and after anti-mite treatment in order to monitor its efficacy.

Powdered sugar method

Download left image from **www.beecare.bayer.com/varroa**

Sticky board method

One detection option is to use a **sticky board**, which involves placing a flat insert underneath the brood box of the beehive for a 24 to 72 hour period. Dead mites and other debris will naturally fall from the combs onto the board. This enables beekeepers to count the daily mite drop, which they can use to estimate the severity of infestation and determine an appropriate control method.

Sticky boards are used for diagnostic purposes, to monitor the debris originating from the activities of a bee colony, including wax material, cell caps, food particles and mite drop, before and after treatments, as an indicator of mite abundance and treatment efficacy.

The sticky board is a very simple (diagnostic) method to roughly estimate the mite infestation in the hive and regularly monitor for the presence of *Varroa*. The natural death rate of the mites depends on colony strength and breeding activity, which must be taken into consideration in the survey.

Another technique is the **powdered sugar** method. Beekeepers gather approximately 500 bees from brood frames into a jar. The bees are dusted with five tablespoons of powdered sugar and the jar is shaken several times. This prevents the suckers (*apoteles*) on the legs of the *Varroa* mites from functioning properly and the mites cannot cling to their host. Beekeepers then separate the mites from the sugar using a sieve and count them on a light-colored surface. The unharmed bees are returned to the hive. This treatment should only be carried out in dry weather, to keep the powdered sugar from getting sticky and clumpy.

The **washing** method, in contrast, can be performed under any weather conditions to monitor the level of *Varroa* mite infestation. This technique requires approximately 300 bees to be removed from the hive. After washing the mites off the bees with water and detergent in a jar, the parasites are sieved out and the bees and mites counted to calculate the mites ratio per 100 bees. This indicates the level of parasite infestation in the beehive. The bees are sacrificed using this method; this does not impact colony development or performance and provides valuable information to protect the colony.

Both the powdered sugar and washing method help estimate the number of phoretic mites in the hive, i.e. those riding on adult workers or drones and feeding on the hemolymph or fat body of adult honey bees.

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ADVANTAGES AND DISADVANTAGES
OF DIFFERENT SURVEY METHODS

ADVANTAGES	DISADVANTAGES
STICKY BOARD	

// Simple monitoring of the level of *Varroa* infestation
// Additional information on the colony's state obtained from hive debris (e.g. robbing activities, Small Hives Beetles)
// Frequent monitoring possible
	// Results influenced by colony strength and breeding activity in a colony
	// Results may be influenced by wind and ants removing dead mites
	// Higher operating costs due to costs of sticky boards

POWDERED SUGAR	
// Results not influenced by colony strength // Level of phoretic mite infestation in the hive is easy to determine	// Dry weather needed to ensure optimal treatment // Assessment of mite infestation levels dependent on breeding activity in the colony, which can vary during the season
WASHING	

// Results not influenced by colony strength
// Survey possible under any weather conditions
// Level of phoretic mites in the colony easy to determine
	// Some disturbance of the colony as a result of sampling
	// Assessment of mite infestation levels dependent on brood activity in the colony, which can vary during the season

Control *Measures*

Various biological, physical, chemical and biotechnical options are available to combat the *Varroa* mite in the hive. To effectively protect honey bee colonies, beekeepers need to remember that a rapid increase in the number of mites in late summer to fall necessitates very effective treatments to protect the brood of winter bees. Otherwise, even as mite numbers fall towards the end of the year, the bees which have already matured during the period of high mite activity are considerably weakened and have a shorter lifespan. As a result, the colony may not survive until spring.

Beekeepers need to combine appropriate control measures and practice integrated apiculture to provide for the needs of the bees. *Varroa* treatment products that require specific temperature and environmental conditions are only suitable for certain regions of the world. Synthetic products to control the *Varroa* mite are not registered for use in all countries due to differing regulatory situations and market dynamics.

Acaricides are a group of pesticides used to control mites and ticks.

Products specially developed to combat the Varroa *mite are known as varroacides.*

Varroacides
Chemical Methods for Use during the Breeding Season

Organic-based varroacides

Formic acid
A chemical varroacide that can effectively protect bees from the *Varroa* mite is formic acid. This **liquid compound** vaporizes and disperses throughout the hive in gaseous form. The vapor even penetrates into the sealed cells and kills the mites feeding there, thus protecting not only the adult bees but also the developing brood. Formic acid rapidly decreases the level of mite infestation. However, temperature plays a decisive role in this treatment. If the dose of formic acid is too high because of high vaporization in high ambient temperatures, the brood is harmed; if the dose is too low due to reduced vaporization in colder weather, it has no effect at all. Formic acid is therefore mainly used by beekeepers in countries with mild climates – specifically as the main control measure in late summer after the final honey harvest.

Thymol
Varroacides based on thymol are evaporated in the hive from **cellulose wafers** or **gel carriers**. The concentration of the substance that builds up in the air poses no risk to bees but is toxic to the *Varroa* mite. The mites drop off the bees and die. Thymol-based products are most effective at maximum temperatures of 20 - 25 °C (68 - 77 °F). Such products have only limited efficacy at temperatures below 15 °C (59 °F) and should not be used at temperatures over 30 °C (86 °F).

Synthetic varroacides

In addition to organic-based varroacides, such as formic acid and thymol, synthetic varroacides are another possible chemical control method. These products have been specially developed to control parasitic mites without harming honey bees. When used according to labels, these compounds can be very effective, unless the mites have developed resistance to them.

Amitraz
Products containing the active ingredient amitraz do not directly kill the mites but paralyze them so they fall off the bees and die of starvation. Bees pick up the active ingredient via a **plastic strip** hung between the combs in the central brood chamber. The honey bees spread the compound throughout the entire hive by their social interaction.

Coumaphos
Products based on coumaphos are also spread among the bees via **plastic strips** hung between the frames in the hive. Bees pick up the active ingredient when they rub against or crawl over the strips. The compound is then passed on to other bees in the hive through social interaction. Female *Varroa* mites living on bees outside the brood cells are thus exposed to coumaphos and killed.

Flumethrin
A **plastic strip** impregnated with the active ingredient is hung between the combs in the central brood chamber. The bees pick up the active ingredient when they crawl over the strips and then evenly distribute the compound during social interaction in the hive. When mites are attached to adult bees, they come into contact with the active ingredient and subsequently die.

Tau-fluvalinate
This active ingredient adheres to the bees' bodies when bees crawl over or rub against **plastic strips** hung between the combs in the central brood chamber. The chemical substance is transferred to other bees in the hive through social interaction, thus killing the *Varroa* mites attached to adult bees.

Hanging a *Varroa* mite control strip between the combs in a beehive

Octanoate Esters
Sucrose octanoate esters occur naturally in plants. The pesticidal properties were discovered when researchers investigated the reason tobacco leaves were not attacked by mites and certain insect pests. Sucrose octanoate esters are **sprayed** and act as contact biopesticides with rapid knock-down ability. The substances act by disrupting the waxy outer layer (cuticle) of mites, causing the mite to dry out and die.

Over time, Varroa mites can develop resistance to the active ingredients of many synthetic varroacides, thus rendering them ineffective.

Beekeepers should use a combination of control methods and rotate the use of varroacides with different modes of action to counteract the emergence of such resistance.

Varroacides
Chemical Methods for Use outside the Breeding Season

Organic-based varroacides

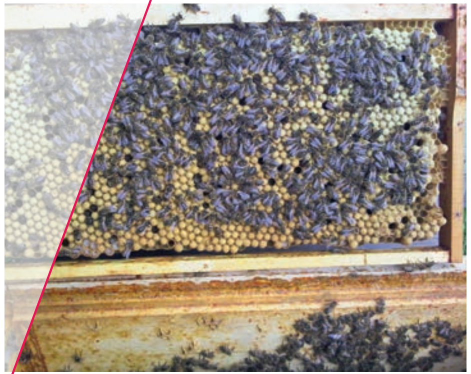
Lactic acid
Lactic acid is an effective **spray treatment**. When colonies do not have any brood, a 15 percent lactic acid solution can be sprayed lightly and evenly on both sides of the combs. Young, broodless colonies can be treated at any time. However, this method of treatment is very labor-intensive since each individual comb must be removed and sprayed on both sides.

Oxalic acid
Oxalic acid is preferably used for winter control in broodless colonies. The oxalic acid is **trickled** evenly onto the bees in the spaces between the combs. The chemical adheres to the bodies of the bees, which then pass it on to other bees in the hive through social interaction. Alternatively, **heat evaporation** of technical oxalic acid is a registered form of treatment in some countries. The treatment should be completed during the broodless period and after the final honey harvest because, after application, you have to wait until the following spring to harvest honey again.

Hop beta acid
Another possible treatment is hop beta acid. **Cardboard strips** saturated with the acid are placed into the colonies, between the brood frames. To avoid contamination, users should not take honey and wax from the brood chambers during treatment. For optimal results, hop beta acid based products should be applied when little to no brood is present in the hive.

Biotechnical
Methods

In addition to the main and follow-up control treatments with chemicals in the late summer and winter period, biotechnical methods can be used to control *Varroa.* The methods are based on one or more physical practices to reduce the mite population. They can be performed at any time, even during the foraging and breeding period of the honey bees, and do not require any veterinary products or other chemicals.



Cutting out drone brood
An empty drone comb is placed along the outermost part of the upper brood nest close to the area in the beehive where brood development takes place. Every two to three weeks the capped drone brood is removed from the brood frame.

Methods such as **drone brood removal,** which helps to minimize the level of *Varroa* mites during the entire period of drone brood rearing (spring to summer), are especially useful, as the mites infest drone brood cells as much as five to ten times more frequently than worker brood cells. This method involves hanging an empty frame on the outermost part of the upper brood nest and then cutting out the drone comb with the sealed drone brood, a measure that beekeepers should repeat every two to three weeks.

By consistently removing the drone brood, beekeepers can greatly reduce the level of infestation in a colony during the breeding season. Since additional drone brood is reared in other parts of the hive, there are still sufficient drones in the colony to mate with new virgin queens on mating flights in the vicinity of the apiary.

Generally, **colony renewal** (as described above under colony splitting and assisted colony reproduction) can also be used to control *Varroa*. After three weeks, mites present in a broodless, young colony are easier to kill by applying an effective treatment.

In the case of an **artificial swarm** of adult bees, for instance, the beekeeper takes approximately 1.5 kilograms (3.5 lbs) of bees away from the parent colony. As the *Varroa* mites mainly reside in the brood cells and have less contact with adult bees, infestation in the beehive of young colonies is automatically lower than in the parent colony. The newly established young colonies are also broodless, which means that the beekeeper can easily treat them for mites as well.

What's next
in Varroa Control Research?

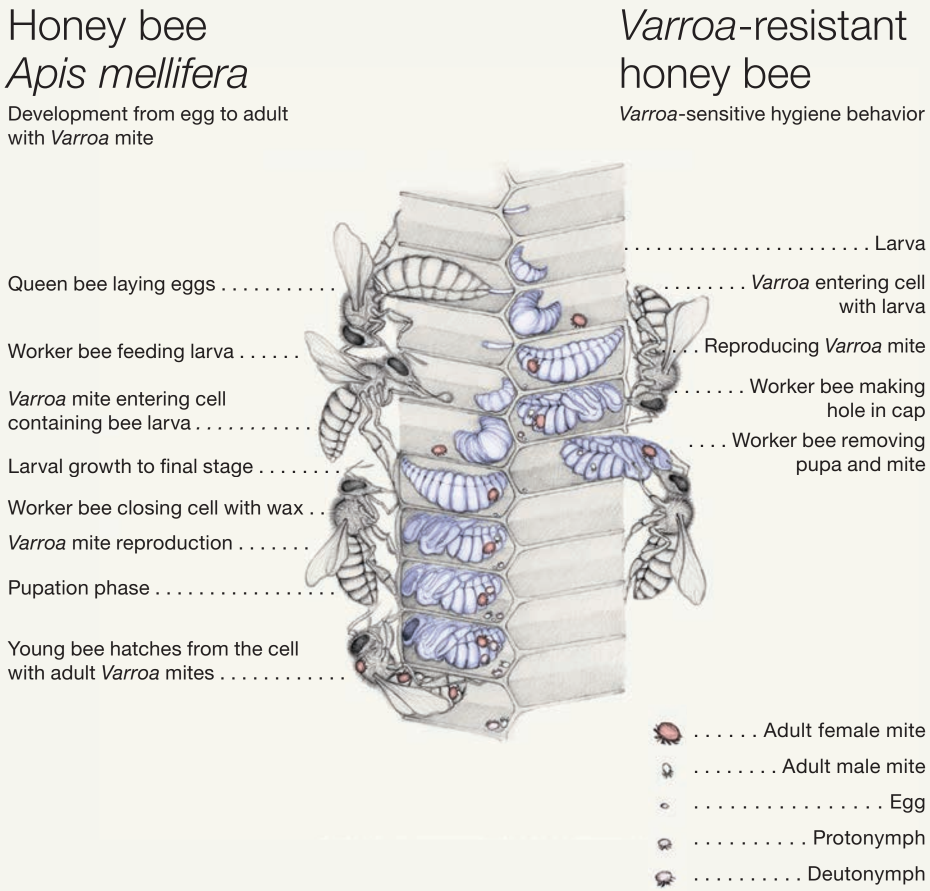
Breeding *Varroa*-resistant bee strains

In the long-term, breeding *Varroa*-resistant bee strains could contribute to solving the *Varroa* mite problem by helping honey bees to help themselves. A number of honey bee colonies are showing signs of inherent *Varroa* resistance, in that honey bees with a behavioral trait called ***Varroa*-sensitive hygiene (VSH)** can detect infested closed brood cells.

These bees remove the pupae in the infested cells and thus stop the *Varroa* mite from multiplying in the colony – a behavior pattern originally only known to occur in Asian Honey Bees. On the basis of these observations, researchers want to strengthen this defensive capability by practicing selective breeding among Western Honey Bee strains to create intrinsically *Varroa*-resistant bees.

The research being carried out by the **Arista Bee Research Foundation**, the **University of Wageningen** (Netherlands) and other universities and bee institutes is showing promising results and could significantly improve the health of honey bees in the future. However, several more years of research are still required. Consequently, researchers and beekeepers are continuing to work on developing new treatments to combat the *Varroa* mite.

Download the illustration from
http://aristabeeresearch.org/varroa-resistance/

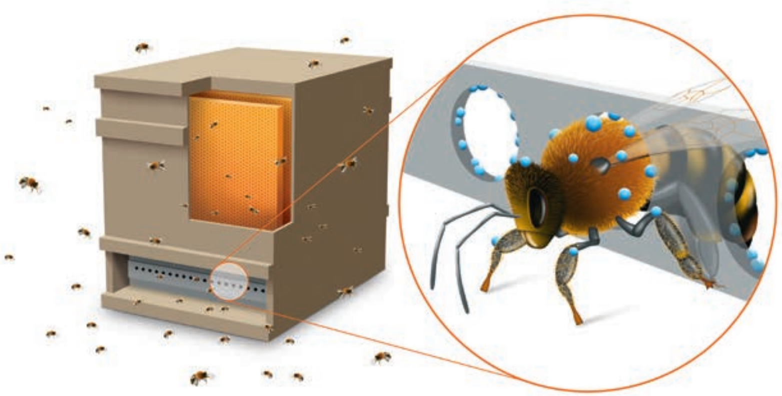


Varroa-resistant
bee strains could contribute to solving the Varroa mite problem.

Varroa Gate
Technology

Another possible approach to control *Varroa* at the beehive entrance is the **Varroa Gate** technology. Bayer's scientists have been working in collaboration with scientists from bee research institutes to develop the Varroa Gate – a strip of plastic with regular, uniform holes, containing a varroacide. Beekeepers can fit this strip over the entrance to the hive so that when the bees touch the strip or pass through its holes, the active substance will adhere to their legs or hair and be spread through the colony via social interaction. The right amount of the substance on the surface of the strip is automatically replenished to protect the honey bee colony from the *Varroa* mite.

As the strip keeps working for several weeks, beekeepers can not only protect the bees in the hive but also prevent renewed infestation from outside sources.



Varroa Gate model

Find more on the topic on our video channel:
youtube.com/BayerBeeCareCenterMonheim

Additional Research
Activities

It is vital to get to know the enemy better through intensive monitoring of the *Varroa* mite. In long term observations, researchers gain significant information about the mite and the efficacy of current countermeasures. These results help them optimize and complement *Varroa* treatments.

Other potential treatment options currently being researched include thermal treatment, ultrasonic application, RNAi technology or the development of further synthetic or organic-based varroacides.

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