



Insect sleuths

Some honey bees recognize when *Varroa* mites are threatening the offspring in a closed brood cell.

Researchers do not yet know just how they do that. The worker bees might smell the damaged larva or the mite itself.

GETTING RID OF MITES

The Varroa mite is public enemy number one for bees. However, some Western honey bee colonies are starting to fight the parasites themselves. A European-American network of researchers and volunteers intends to reinforce this behavior via breeding, thereby creating Varroa-resistant bee colonies.

Sometimes, honey bees become cannibals: A worker bee will bite off the cover of a brood comb, pull out a pupa, and, together with her fellow workers, devour it. By means of this seemingly gruesome act, the bees have protected their colony, since the pupa was infested by a breeding *Varroa* mite. The parasite can now no longer reproduce, meaning it will have no offspring that can attack the colony.

Bee experts describe this behavior, which was originally only known to occur among Asian honey bees, as Varroa Sensitive Hygiene (VSH) behavior. For centuries, Asian honey bees have adapted their behavior to the parasite and now live with it. However, the *Varroa* mite has now spread across most of the world, infesting hives and infecting Western honey bees who are not ready to cope with it. If beekeepers do not intervene, these mites can destroy a colony within two years. As BartJan Fernhout, former Head of R&D Boxmeer at MSD Animal Health, explains, “Some honey bees in Europe and America are removing infested offspring. This shows that VSH already exists in our colonies. And we can help to get that behavior more broadly established.” To this end, Fernhout founded the non-profit Arista Bee Research Foundation in 2013.

The goal is to breed *Varroa*-resistant honey bees.



The midget danger: If beekeepers do not intervene, the *Varroa* mite can destroy a colony within two years.

AT A GLANCE

- // The *Varroa* mite is the key threat to the Western honey bee.
- // However, some bee colonies developed the capability to remove the parasite from their hive.
- // The Arista Bee Research Foundation hopes to strengthen and establish this behavior through breeding.



Together with many volunteer beekeepers, BartJan Fernhout aims to breed *Varroa*-resistant honey bees in Europe. For this, they open the capped brood cells and count the mites inside in painstaking manual work.

This is also a personal matter for Fernhout, a Dutch medical biologist. “With a few interruptions, I have kept bees since I was a boy. But I had my share of problems fighting the *Varroa* mite. When I lost my two best queens using a well-intended treatment, I made my decision: stop beekeeping or come up with a better solution.” In his search for a solution, Fernhout came across VSH. American researchers from the US Department of Agriculture, USDA for short, have already bred honey bees with this trait and have established a research population. So Fernhout wanted to try it with the European breeding stock as well.

Starting a year ago, the newly created project team of beekeepers selected the most promising parent bees in advance from beehives with a relatively low level of mite infestation. In addition, the general hygienic behavior was studied by freezing a small portion of the brood in the beehive using liquid nitrogen and observing how quickly the worker bees removed the dead offspring. If they do this quickly and the same colony also has a lower *Varroa* count after treatment, then the more likely they are to carry the genes involved in the desired VSH trait. A queen and a drone from promising colonies are crossed. The project team,

composed of experienced beekeepers from Belgium, Germany, France, The Netherlands and Luxembourg, have already done this more than 100 times. They then subjected the resulting colonies to a real endurance test: They ensured the bee colonies had a lot of *Varroa* mites and left them to their own devices. After three months, the researchers and volunteer workers patiently counted the adult and juvenile mites in the brood of the colony. The effort was worth it: “More than 20 colonies with the European background clearly showed a VSH behavior,” explains Fernhout. “That’s a very good result.”

The trick is to cross a queen with only one drone.

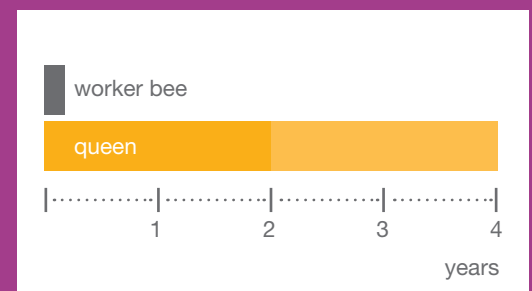
Normally, up to 15 drones mate with a queen on her nuptial flight. “However, if only two of her mates pass on VSH, not enough worker bees will engage in the clean-up behavior. This means that it is very difficult to find and select for VSH,” explains Fernhout. “However, if we select a promising drone as the sole father, we get a homogeneous bee colony.” All the worker bees are then siblings and behave in a similar fashion.

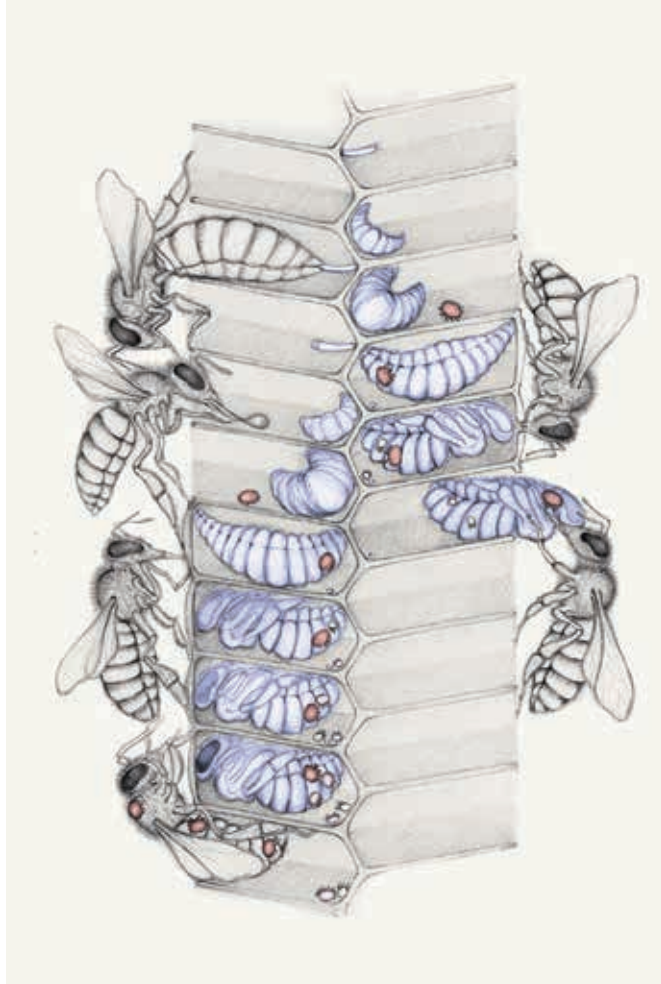
Royal wedding

A queen bee takes up her royal duties early on. She begins her nuptial flight at the age of one week. Ten meters up in the air, she mates with up to 15 drones from different colonies. Having multiple fathers means that the resulting bee colony is genetically more diverse and thus more robust. However, natural mating cannot be controlled well enough to allow for targeted bee breeding. Therefore, the queen is generally artificially inseminated or mated on isolated places.

Royal Age

The lifespan of a typical worker bee is 3 to 6 weeks, whereas the queen can live for 2 to 4 years.

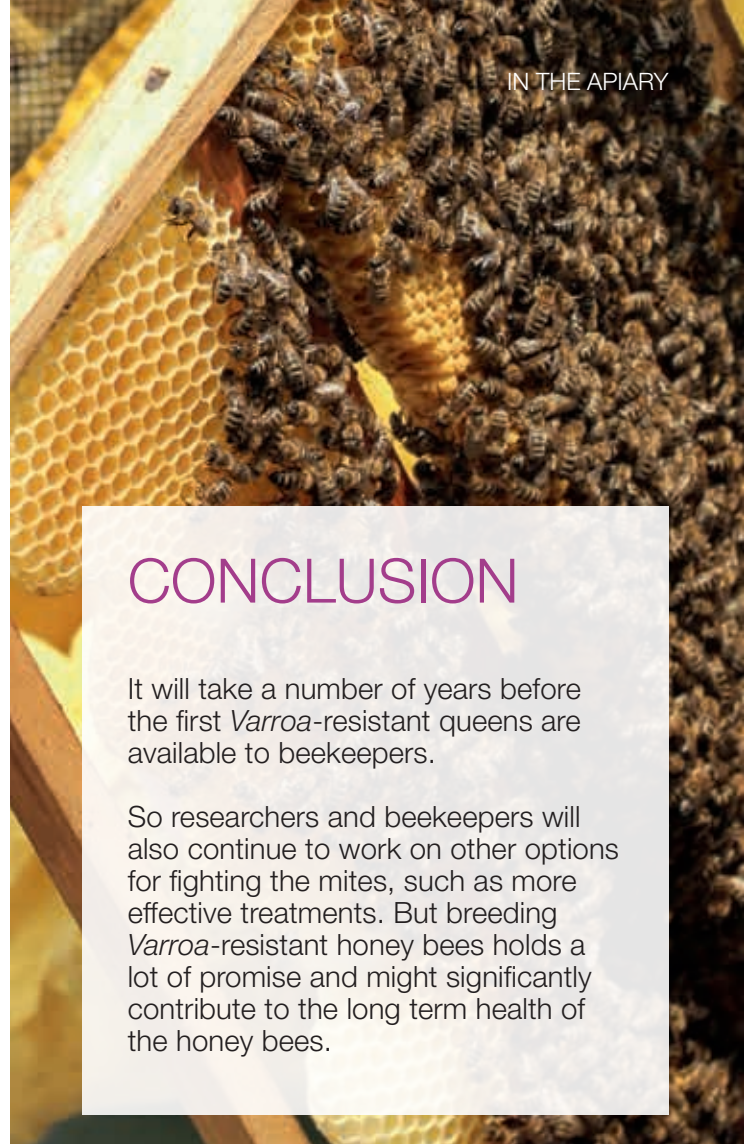




On the left side the illustration shows the normal development of honey bee brood infested with *Varroa*. The right side shows what happens if the bees have inherited the VSH trait: Worker bees detect the *Varroa* in the closed cell, open it and remove the pupae, hence preventing the mite from reproducing.

But the bees can do even better: Five American colonies were able to remove almost all the mites from their hive, bringing the *Varroa* infestation level from 20 - 40 to only 1 - 2 percent. The colonies were created with imported USDA-VSH sperm from the research population. In addition, the bee researchers and volunteers want to continue the breeding with subsequent European queens and bring this high-quality breeding stock also to 100 percent VSH – and a complete removal of the mites.

However, one problem had to be resolved: Queens that are paired with just one drone only lay eggs for up to six months instead of the normal three to four years. But the beekeepers cannot continue breeding the offspring until the following spring. The winters are too cold in northern Europe for the bees to mate and lay eggs. In order to speed up the project and to safeguard the high level of VSH, Fernhout and his colleagues therefore traveled to warmer, southern regions. “We transported the twelve most promising colonies to Spain. There we can breed a new generation up to the end of November. In addition, the warmer winter will support the survival of the newly-created queens and colonies,” explains Fernhout.



CONCLUSION

It will take a number of years before the first *Varroa*-resistant queens are available to beekeepers.

So researchers and beekeepers will also continue to work on other options for fighting the mites, such as more effective treatments. But breeding *Varroa*-resistant honey bees holds a lot of promise and might significantly contribute to the long term health of the honey bees.

He is optimistic that the project will be successful. The ultimate goal is now significantly closer. “We want to establish the VSH trait in as many honey bee lines as possible,” says Fernhout. Until then, however, many queens still need to be bred. For this purpose, the young foundation is building up a solid collaborative network among universities, institutions and beekeeping groups.

More resources are needed to build out the technologies and create a breeding program of sufficient size.

For that the non-profit Arista Bee Research Foundation is also dependent on funding. The support of governments, private sponsors and corporations is needed to fund the breeding program. As well as financial support, Bayer will also help to make the breeding more efficient. The scientists hope to develop a genetic marker test that could locate the VSH genes in the bees’ DNA. “Then we could significantly speed up the selection of the queens,” says Fernhout. For the researchers and volunteers, that would be another big step on the way to *Varroa*-resistant honey bees.