

What is varroa behavioural resistance?

Dr Max Watkins, Vita Bee Health

Several years ago, Paulo Mielgo and I ran varroa mite treatment trials in the USA with a variety of products containing different active ingredients. After treatments in apiaries that were relatively isolated, we recorded large mite drops, indicating that the treatments were working.

About one month later, we returned to undertake mite washes to see how many mites were present after the treatments. We were astonished to record even more mites than in the immediate post-treatment monitoring. Although it is conceivable that these isolated apiaries had been affected by mite bombs from collapsing feral colonies in the area, we had no evidence that this might be the case. So, our thoughts turned to other possibilities.

I set up the first varroa resistance monitoring programme in Europe in 1993 and now had to consider an often-overlooked phenomenon: behavioural resistance. Unlike genetic and physiological resistance, behavioural resistance focuses on patterns of movement and behaviour that avoid or minimise contact with control substances, including changes in reproductive behaviour.

Behavioural resistance is a phenomenon which has been observed in insects and other animals. There are examples of mice and rodents that have changed their previously established routes to avoid traps and baits that have been placed along them. Such behavioural adaptations can be passed on to succeeding generations, thereby inhibiting their control long term.

Paulo and I first suspected behavioural resistance in 2017/18 and, although it was undocumented in the literature, our field observations and talking to beekeepers and researchers firmed up our suspicions. We think that this phenomenon of behavioural resistance in varroa mites is quite widespread and plays an important part in the otherwise unexpected level of survival of mites in honey bee colonies.

However, it is not known what form of behavioural resistance the mites might be adopting – or even if this was the explanation of the post-treatment mite falls.

To date, research in the area has been limited, so we turned to our long-established research partners: Professor Alexandros Papachristoforou at the University of Thessaly in Greece, and Dr Benjamin Poirot of Apinov in La Rochelle, France.

Both of these organisations have impressive track records specialising in honey bee research and the application of science in beekeeping. I passionately believe that our combined research will yield results to help in the design of new techniques for dealing with varroa infestations in the future.



Apinov

In France, Dr Benjamin Poirot of Apinov, from a beekeeping family, has experienced the growing sophistication of beekeeping: "Today beekeeping is much more technical," he says. "When I was young it was super easy, but even now it's not too complicated and with scientific methods it's still quite possible to be a commercial beekeeper despite the many and developing challenges."

We formulated a PhD research plan with Apinov, who appointed Théa Missud.

Behavioural resistance types under investigation

Théa is investigating two possible types of behavioural adaptations. One form of resistance might be avoidance of treatments, but another possibility is that mites change the duration of their phoretic stage (hitchhiking on bees to move around – a time when they are potentially exposed to treatments, not hidden in cells), and thereby reduce their exposure to treatments.

Behavioural avoidance experiments

In Phase 1, an experimental design was set up in the form of a Y-maze, in which mites can choose to travel along one arm of the Y leading to an acaricide or the other arm to a non-acaricide. A variety of acaricides were included in the studies.

The mites are obtained from beekeepers who send Théa brood comb from their colonies. Colonies which have been treated for varroa are preferred and their treatment history is recorded. Carefully, using a beekeeping grafting tool, she can move the mites without damaging them. She can standardise for their ages because their colouring indicates their approximate age – increased browning of an exoskeleton indicates an older mite. All the mites are female, since males die soon after mating and are notable for being white.

Théa is currently focusing on acaricides containing one of three commonly used active ingredients plus one non-acaricide control. She runs the experiment with Y-mazes to try to establish which ingredients attract or repel the mites. Observing the mites, Théa has realised that they make binary decisions about which arm of the maze to travel along in less than one minute. The mites base their decisions on olfactory methods, she says. She returns 18 hours after putting them in their respective mazes to check where they are.

Preliminary results suggest that the mites may avoid some treatments, are attracted to others, while yet others seem neither attractive nor deterrent. However, many more experiments, which are ongoing, are needed to verify these findings.

In due course, Phase 2 of the research will investigate the duration of the phoretic stage of the mites.

University of Thessaly, Greece

A complementary and parallel study is also underway at the University of Thessaly. Under the direction of Professor Alexandros Papachristoforou, a PhD student, Lavrentia Karatosidi, will begin a twofold experiment. First, she will try to discover if there are any morphological differences, such as size, between resistant and non-resistant mites. Second, a more ambitious objective, is to establish if there are different cardiac responses and activity between mites from resistant and non-resistant colonies.

Known examples of behavioural resistance

A species of caterpillar (*Heliothis virescens*) has been observed to have reduced movement on pyrethroid-treated surfaces. This has been interpreted as behavioural resistance to decrease contact with the substance.

In contrast, a species of fly (*Haematobia irritans*) has been observed to have increased movement to shorten exposure to pyrethroids.

Cabbage moths have been observed to lay eggs in less-exposed areas to minimise contact with insecticides.

Mosquitoes and some mites have been observed to change their activity schedules, their preferences for outdoor rest, or modification of bite sites – all interpreted as behavioural resistance techniques.

Ways the varroa mite can develop behavioural resistance

Varroa mites have sensory hairs on their front legs which can detect volatiles, temperature and humidity.

The sensory hairs can also detect hydrocarbons and hence their preference for drone brood, which is richer in hydrocarbons.

Similar types of detection may encourage the varroa to detect nurse bees over foragers and select by age.

- 1 A female varroa mite on wax comb
- 2 A varroa mite on honey bee larva
- 3 A male varroa mite, identifiable by its white colouring
- 4 Collecting varroa mites
- 5 A series of Y-mazes

All photos courtesy of Théa Missud and Apinov.

REFERENCE

Missud, Théa (2025). *Ethology of Varroa destructor, major parasite of the honeybee: study of avoidance behavior in response to acaricides*. Internship thesis for Master's degree presented to University of Poitiers and Apinov.

For any queries on this research on behavioural resistance in varroa instigated, designed and funded by Vita Bee Health, please contact Dr Max Watkins or Paulo Mielgo of Vita Bee Health.



Dr Max Watkins, CEO of Vita (Europe) Limited, Vita Bee Health Ltd and of Vita Bee Health Canada Limited. Max is co-founder and CEO of Vita (Europe) Limited, a specialist company researching, developing, registering and marketing veterinary medicines for honey bee health, worldwide. He is a biologist with experience of novel control methods for pests and pathogens in forestry, public health and animal health and for the past 35 years has been particularly focused on developing products for sustaining and improving honey bee health. He has set up many research projects with different universities and institutes across the world, and has a long history in working with resistant mites. In 1993, he set up the first varroa resistance monitoring programme with government and university bodies across Europe.