The Remarkable Honey Bee

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VARROA CONTROL PAST AND FUTURE

History of Varroa in North America

The first discovery of *Varroa jacobsoni* (later renamed *Varroa destructor*) in the United States was made on Sept. 25, 1987 in Florida on colonies owned by a Wisconsin beekeeper. This beekeeper, Gary Oreskovic, was a supplier of package bees that were combined with packages from other beekeepers and sold to companies and individuals in Wisconsin. The initial infested hives were depopulated (killed). Yet by October 20 of that same year 19 of Florida's 67 counties had positive finds for the mites, and within two years the mites were found in 19 states within the United States. They are now found in every part of the Americas where bees are kept.

Cornell Prof. Roger A. Morse reported that the source of the queens that introduced the mites into North America was somewhere in South America, imported illegally by a commercial beekeeper. Between beekeeper movement of hives and packages by beekeepers and the natural interchange of bees from one colony to another, mites were efficiently distributed. It has been shown, for example, that bees foraging on flowers will join a swarm as it moves through the air. The foragers are apparently attracted to the pheromone odor of the swarm and the swarm's overall behavior. This is one method mites could be spread from colony to colony in nature. Drones, migrating from colony to colony during their reproductive flights, also provide a critical vectoring of the parasite. Also, when a colony eventually dies from the mites, remaining workers carry mites to other colonies, a notorious behavior often called the 'varroa bomb'.

Because European beekeepers had experienced the wave of varroa across that continent, there were pre-existing chemical control methods in production that were easily adapted within the United States. A compound called Apistan (fluvalinate) was impregnated into wooden strips in initial treatments in Florida and elsewhere. These were replaced by the availability of plastic Apistan strips that were widely sold to control mite numbers. There was little discussion about 'should we treat', but rather the driving insistence that we develop treatment methods that were cost effective and relatively inexpensive. This did not stop the wide-scale use of home-made delivery methods to administer fluvalinate (tau-fluvalinate is sold as Mavrik and Klartan for insecticidal and acaracidal action on aphids, trips, leafhoppers, whitefly, beetles and spider mites). Fluvalinate is a pyrethroid that acts on the insect nervous system. Because it was available for purchase by agricultural producers, many beekeepers developed their own control methods using the agricultural preparation of the compound. In doing so they both over- and under-dosed the colonies where they were attempting to achieve mite control. Over-dosing provided evidence of toxic effects to queens, drones, workers and lead to widespread comb contamination. Where lower than recommended levels were used, there were a larger number of mites that survived the treatment, ultimately leading to mite resistance to the compound. Because of the wide-spread resistance, the compound is now used only when in rotation with other mite control molecules.

Four or five? varroa mites on a drone pupa in the hand of a beekeeper. Such mite loads usually end up in colony death by the end of the season. The darkest mite is the foundress mite, the rest are daughters in different stages of development. Only fully pigmented and hardened mites survive emergence with the bee. The soft bodied mites are destroyed by the nurse bees.

Finding Tolerance Against Varroa Mites

Untreated colonies suffered horribly as the mites swept across the country. Beekeepers reported the deformity of worker bees at the time they should emerge from their cells, and the appearance of damaged wings as a result of the mites feeding on the bees. The eventual outcome was the death of the colony. Within a few years there were reports of colonies that were still alive after the mites had destroyed the rest of the colonies in the apiary. Feral bee colonies died from the mites as well, and gardeners and naturalists quickly noticed the lack of honey bees on vegetable and flower gardens, as well as a decline in the natural food bees pollinate for birds and wildlife. With the absence of completion from honey bee foragers for the same food supply, many naturalists and scientists noticed an increase in the number of bumble bees and other native pollinators. It was an interesting exercise to observe the change in the ecosystem as honey bees were somewhat suddenly removed.

The survival colonies were of interest to many beekeepers, and many small-scale producers used these few remaining colonies as the basis of their slow rebuild of bee colony numbers. The progress was slow. Researchers noticed too, and Dr. Roger Hoopingarner (Michigan State University) and Dr. John Harbo (USDA Honey-

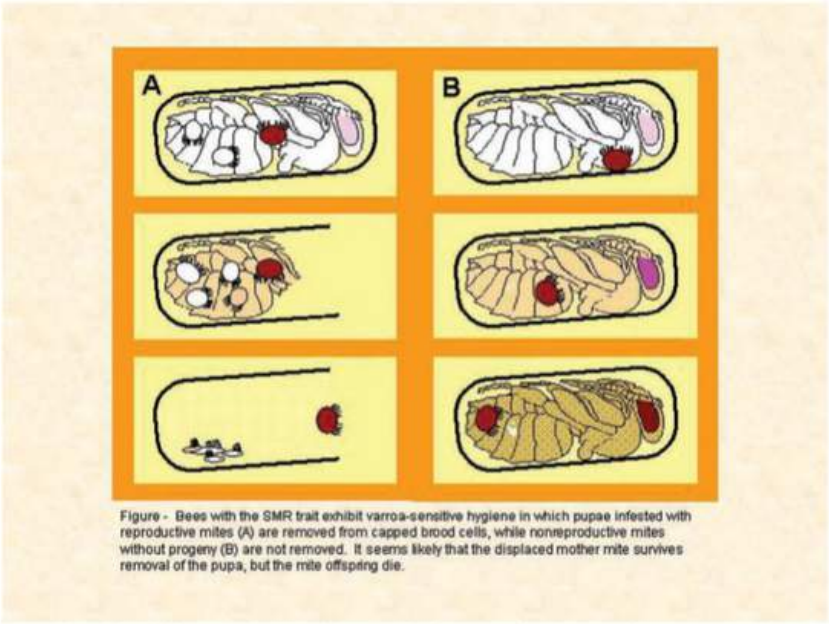

Figure - Bees with the SMR trait exhibit varroa-sensitive hygiene in which pupae infested with reproductive mites (A) are removed from capped brood cells, while nonreproductive mites without progeny (B) are not removed. It seems likely that the displaced mother mite survives removal of the pupa, but the mite offspring die.

Drawing the different fates of bees with reproductive and non-reproductive mites. Hygienic behavior removed the reproductive mites. This helps explain how the Suppressed Mite Reproduction was changed to the Varroa Sensitive Hygienic trait. USDA drawing.

Bee Breeding and Physiology Lab, Baton Rouge) sent out a call for beekeepers to ship them their queens and they started a stock of survivor queens. With Hoopingarner's retirement Harbo maintained the program, developing the Suppressed Mite Reproduction or SMR strain of honey bees.

Harbo was joined by Jeff Harris at the Baton Rouge Bee laboratory (who continued the program until his departure for Mississippi State University) and in 2003 they reported on the project and its results to date. They called this the Suppressed Mite Reproduction (SMR) trait (not a line or stock, but set of genes anyone could breed for). They established that they had identified a heritable trait of the honey bee showing that by selective breeding they could bring the mite reproduction rate to zero in worker brood. They established that the trait is additive, so that a SMR queen mated to non-SMR drones resulted in an intermediate level of mite reduction.

Russian queen, USDA photo.

They showed that once a colony was given an instrumentally inseminated SMR x SMR queen, the colony had normally reproductive mites for a period of about two months. Then, the level of mite reproduction was reduced. They also reported "Sometimes brood production is poor in colonies with artificially inseminated SMRxSMR queens, even though a queen may produce a very solid brood pattern in her first brood cycle. This does not always happen and we don't know why it happens. Consequently, a colony with an SMR breeder queen may not grow rapidly enough to become a productive field colony. Free-mated daughters of these SMR breeder queens have not had this problem, for tests have shown that colonies with free-mated SMR queens produced as much brood and bees as colonies".[1]

Later it was shown that the SMR trait is a form of hygienic behavior, and the SMR trait was renamed the VSH trait. The mechanism explaining the SMR trait has not been described, but Ibrahim and Spivak (2003, ABJ 144: 406) found that bees with the SMR trait were very hygienic and were able to remove varroa-infested pupae from capped brood cells. They also suggested that SMR bees may selectively remove pupae having reproductive mites. It was shown that the brood cells with reproductive mites were opened and removed by the bees with the hygienic trait, while the single foundress mite that is nonproductive) was not removed, and was assumed to emerge from the worker cell when the worker bee emerged. Because she had not produced offspring, she was not removed from the cell by hygienic bees. There is a group of VSH bee breeders that may be reached through VSHBreeders.org. However, beekeepers may want to place orders for VSH breeder queens through Adam Finkelstein of VP Queens (in Maryland) at **www.vpqueenbees.com**.

Hygienic Behavior in Bee Colonies

Beekeepers have been aware of genetic mechanisms for disease control since the discovery of American foulbrood (AFB) resistant colonies that developed when colonies were maintained near a wax-rendering company in Iowa that processed comb from AFB-killed colonies to render out the wax. In the late 1930's Park, Paddock and Pellett in Iowa developed an AFB-resistant stock within five years that was 95% AFB-disease free. The actual mechanisms of AFB resistance were discovered by Walter Rothenbuhler and Victor Thompson. They moved from Iowa to The Ohio State University in Columbus in the 1960s. They found that the bees with AFB-resistance possessed two recessive genes. One involved the ability to detect an Cyanogas-killed pupae in the sealed brood stage and to **uncap** the cell. A second recessive gene provided for the removal of the contents of the now opened cell to **remove** the infected bee prior to the formation of the spores of the AFB bacterium (*Paenibacillus larvae*). It required both the uncappers and the removers to eliminate the disease.

Steve Taber of the USDA Tucson Bee Laboratory continued this work, and was of the opinion that there were more than two genes involved in the resistance mechanism. He said that "A colony that cleans up a dead brood sample in 24 hours or less will never show AFB symptoms".[2]

One scientist who worked with Taber was Dr. Marla Spivak, who in 1993 started an anti-varroa breeding program at the University of Minnesota. There she inherited colonies that had been maintained by Dr. Basil Furgala using the ruminants of Starline hybrid bees. Using a frozen brood technique, she and colleague Gary Rueter selected bees for rapid removal of varroa-infested cells, attempting to seek the 24-hour removal rate of 95% or more of the killed sealed brood. This lead to the development of the Minnesota Hygienic trait of bees, which demonstrated to the beekeeping industry how simple it was to develop a mite-tolerant group of colonies by using this technique. The Minnesota Hygienic bees were widely accepted by the beekeeping industry, and the program is now maintained by commercial beekeepers.

One advantage of the hygienic behavior is the cross-species effectiveness the genetic behavior demonstrates against bacteria, fungi, viruses and a parasite.

Imported Tolerant Stock

The most popular stock imported from another country that demonstrates mite resistance is the Russian stock imported by

USDA Baton Rouge under the leadership of Dr. Thomas Rinderer. These Eastern Russian bees were the result of the side-by-side maintenance of honey bee colonies with the eastern hive bee, *Apis cerana*. This is the species of honey bee that the varroa mite developed upon, and in which it only infests the drone bees. But when *Apis mellifera* colonies were placed into the same area, the mites started their familiar population explosion and colony losses. After a long period of exposure, the eastern Russian stock developed the ability to tolerate mite populations.

Rinderer imported the queens under special permits and kept the bees in isolation until the stock was cleared of any new pathogens or parasites. Extensive testing showed the bees had a high level of adaptive tolerance for the mites. There is now a Russian bee breeders association (www.russianbreeder.org) that maintains up to 17 lines of Russian bees. That website lists nine certified breeders who produce queens for industry purchase.

The stock has been shown to produce more damaged mites (damaged appendages and exoskeletons), called Varroa Sensitive Grooming (VSG). They have a higher level of Varroa Sensitive Hygenic (VSH) behavior. Compared to other stocks, they carry a higher percentage of adult mites on adult bees, with a smaller percentage of mites in the brood nest where they reproduce. They demonstrate a higher level of hygienic behavior than other stocks. Finally, the Russian bees are very fugal with brood rearing and utilization of stores with a shorter period of brood rearing and opportunity for mite development.

Other Survivor Programs

It should be clear that there are many potential resistant stocks in North America that demonstrate improved tolerance against varroa mites. Many survivor programs are nothing more than the result of a careful beekeeper who has used no chemicals for varroa treatment and has only used locally adapted survivor stocks in new colonies and to replace queens.

More to Come

This month marks the 26th year with Varroa in the United States. While many methods of mite tolerance have been developed, the vast majority of beekeepers, from small-scale to commercial, do not use bee stocks with proven mite tolerance. Instead they use unspecified stocks and chemical controls. We will have more to say about this in a future issue.

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[1]**John R. Harbo and Jeffery Harris, 2003.** An Evaluation of Commercially Produced Queens That Have the SMR Trait. *American Bee Journal*, March, pp. 213-216.

[2]**Taber, Steve, 1987.** *Breeding Super Bees.* Northern Bee Books, UK.