Status of Bees With the Trait of Varroa-Sensitive Hygiene (VSH) for Varroa Resistance

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One of the ongoing research projects at the USDA Honey Bee Breeding, Genetics and Physiology Laboratory in Baton Rouge is focused on the trait "varroa sensitive hygiene" (VSH), which helps honey bees resist infestation by varroa mites. The overall goal of the work is to provide bee breeders, queen producers and beekeepers with bees to help manage varroa effectively and economically. Genetically based resistance to varroa is regarded as the most valuable tool available for sustained management of mites. This article explains recent research and technology transfer of the VSH trait.

In 1996, when varroa resistance in honey bees was not much more than a dream, John Harbo of the USDA and Roger Hoopingarner of Michigan State University discovered a few colonies among a large test group that showed lower than average mite population growth. The apparent cause of this low growth rate was that a large proportion of mites in these colonies was not reproducing. They therefore named the trait "suppressed mite reproduction" (SMR). Subsequent research showed that the apparent suppression of mite reproduction likely was an illusion. We now know that many of the reproductive mites are being removed (or are being rendered non reproductive) by hygienic activity of adult worker bees. This more specific description of the trait resulted in a name change from SMR to VSH. A program of testing, selection and breeding for the trait has occurred at Baton Rouge for the past decade.

A variety of observations have verified that VSH bees have strong resistance to varroa. Many of these observations come from rigorous experiments. A list and pdfs of publications about this research can be found at the website of the USDA Honey Bee Breeding, Genetics and Physiology Laboratory (**http://www.ars.usda.gov/Services/Services.htm?modecode=64-13-30-00**). Some observations come simply from our experience during the routine management of colonies we keep for research and breeding; VSH colonies very rarely need to be treated with miticides.

Based on these observations, VSH breeding material was transferred to the industry beginning in 2001 through a cooperative agreement with Glenn Apiaries. Other material was distributed soon thereafter for research purposes to a few queen breeders and researchers, and some of this has been used in breeding programs and distributed more widely to beekeepers.

The early data used for selection came from short-term tests, typically lasting no longer than 3 months. Independent research by Marla Spivak and Keith Delaplane also showed improved varroa resistance in bees having some VSH genetics. We now have new data about the longer-term performance of VSH bees following a 3-year field test run largely by beekeepers in Alabama. The test was conducted through a cooperative agreement between USDA and Alabama A & M University. The primary objective was to measure the need for mite treatments by VSH bees based on mite treatment thresholds established for the southeastern United States. We compared the treatment need of VSH bees to two other stocks: Russian bees, with known varroa resistance, and commercial Italian bees that had no known varroa resistance. We also monitored other basic beekeeping characteristics, and polled the cooperating beekeepers about their experiences while managing the bee stocks.

The beekeepers (Fig. 1) are from north, central and south Alabama and primarily are hobbyists who keep bees for honey production. Each year from 2004 to 2006, about 10 beekeepers were each given equal numbers of queens of the three stocks. In 2004, VSH stock was produced by free-mating VSH queens from our research lines to drones of Italian colonies by a commercial queen breeder. In 2005 and 2006, pure VSH stock was obtained by mating VSH queens and VSH drones at an isolated site. Pure Russian stock from a commercial source was used throughout. The control stock was a widely used commercial Italian stock from Alabama. Queens were introduced into colony splits in spring 2004. In 2005 and 2006, new queens were distributed to replace superseded queens and to re-establish colonies that had died. Queen status was checked about every six months and only colonies with original marked and clipped queens were used for data collection.

Good opportunities for treating varroa come twice each year in Alabama: in late winter before springtime honey production, and in mid- to late-summer after the major honey production from either Chinese tallow in southern Alabama or cotton in central and northern Alabama. At these times the beekeepers collected a sample from the broodnest of each colony. Researchers measured varroa infestations in the samples (Fig. 2). Mite treatments were made to colonies that had varroa infestations of ≥1% (1 mite per 100 bees) in late winter, or ≥10% (2004) or ≥5% (2005, 2006) in late summer. The summer threshold was reduced after 2004 because the beekeepers wanted a more conservative threshold in order to reduce colony losses.

We also monitored tracheal mite infestations in colonies of some cooperators during each autumn. Adult worker bees were dissected to determine the percentage of bees that were infested. Colonies

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that had 20% or more of bees infested were considered to have reached a treatment threshold; however, the beekeepers chose not to make treatments against tracheal mites. Beekeepers measured honey production in 2005 and 2006 after colonies were well established. Finally, the beekeeper cooperators were asked to rate the stocks on a scale of 1 (very dissatisfied) to 5 (very satisfied) for varroa resistance, tracheal mite resistance, honey production, gentleness, food use, overwintering ability and overall utility.

Three years of observations indicated good long-term varroa resistance of VSH bees in field colonies. Varroa infestations were low when we began the test, showing that the beekeepers had been controlling mites successfully with miticides. However, by autumn 2004, soon after routine treatments ceased, varroa infestations increased and differed between bee stocks. VSH colonies had lower varroa infestations than control Italian colonies throughout the remainder of the test (Figs. 3-5). Russian colonies had varroa counts that were low and similar to those in VSH colonies during autumn 2004 and autumn 2005, but that were somewhat higher in autumn 2006. The percentages of colonies that reached treatment thresholds for varroa reflected these infestation trends. Few colonies had infestations above the 10% treatment threshold in autumn 2004. At later samplings, all of which had lower treatment thresholds, greater percentages of colonies of all three groups required treatment, but the resistant stocks needed fewer treatments than control colonies (Figs. 3-5). Note that autumn infestations are shown in the figures. Treatment trends were similar in the spring, although more colonies of all stocks reached the lower treatment threshold of 1%. Over the entire 3-year study, the average percentage of colonies that reached the varroa treatment threshold at any sampling time was 12% of VSH, 24% of Russian and 40% of Italian. In the autumn these percentages were 5% of VSH, 17% of Russian and 34% of Italian; in the spring they were 28% of VSH, 40% of Russian and 57% of Italian.

Infestations by tracheal mites generally were low throughout the test, especially in Russian colonies. Over the entire 3-year study, the average percentage of colonies that reached the treatment threshold was 1% for Russian (only 1 of 73 samples), 8% for VSH and 12% for Italian. VSH bees have not been selected strongly for resistance to tracheal mites as Russian bees have.

Honey yields did not differ between the three stocks either in 2005 or 2006 (Fig. 6). This suggests adequate productivity by the resistant stocks based on the Italian stock. The average honey yields for all stocks each year (62 lbs in 2005; 60 lbs in 2006) were 12% lower than the averages reported for Alabama by the National Agricultural Statistics Service (66 lbs in 2005; 72 lbs. in 2006).

The average longevity of queens (9.6 months) did not differ between the three stocks, but showed a trend of Russian queens living longest (Fig. 7). Some beekeepers were surprised at the rate of queen changes during this test. However, the rate of supersedure we documented here is typical of what we commonly see in field studies where queens are monitored closely.

The beekeepers' opinions about stock performance were similar for most traits. The only characteristic perceived to differ among the stocks was varroa resistance, for which VSH and Russian stocks were rated higher than for the Italian stock. The overall rating of VSH bees by the beekeepers (3.7 out of 5) was comparable to the

Fig. 1. Some of the Alabama beekeepers who managed colonies of the test stocks and contributed perceptions of the bees. Hugh Feagle (top left), Bill Mullins (bottom left), Andy Webb (top right) and Elizabeth Whitaker (lower right, with husband Jerry, after flying in to pick up test queens at Bay Minette, AL) are shown. Also participating were Jimmy Carmack, David Ellis, John Horton, Bobby Howard, Wil Montgomery, James Sitz and Mike Stoops.

Fig. 2. Rachel Watts processes varroa samples at the USDA lab in Baton Rouge. Samples of about 300 bees from the broodnest are shaken in cups of detergent water on a mechanical shaker table (rear) for 30 minutes. Mites separate from bees and fall through a screen within the cup. Bees and mites are counted to determine the infestation level.

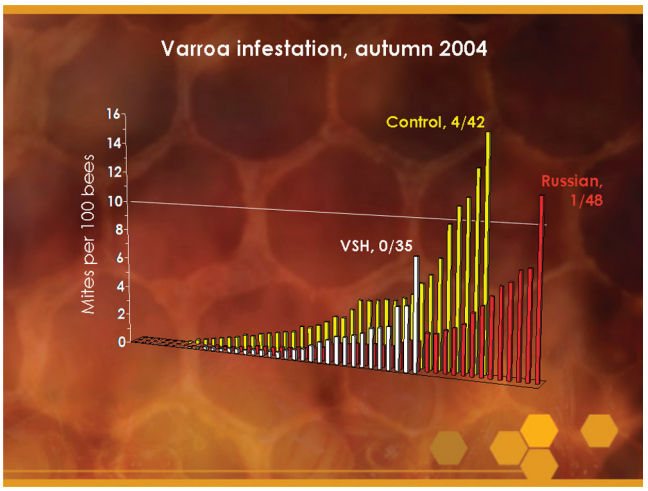

Fig. 3. Varroa infestations in autumn 2004. Each bar indicates the infestation of a single colony, and colonies are arranged in ascending order of infestation. The horizontal line shows the treatment threshold (10%) used in autumn 2004. The numbers with each stock type give the number of colonies above the treatment threshold and the total number of colonies sampled.

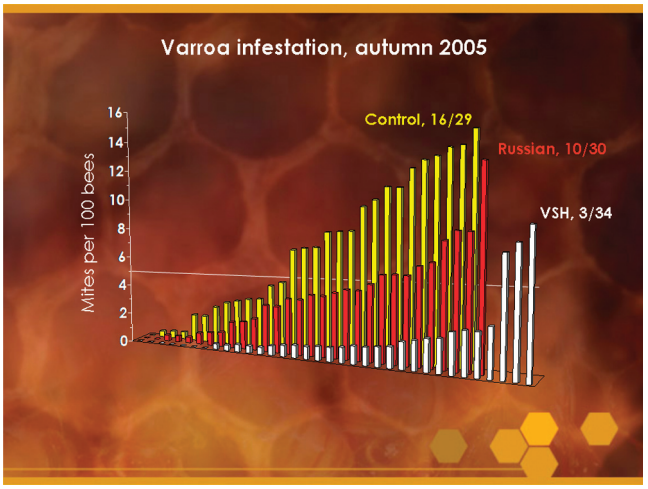

Fig. 4. Varroa infestations in autumn 2005. Information as in Figure 4 except that the treatment threshold was 5%.

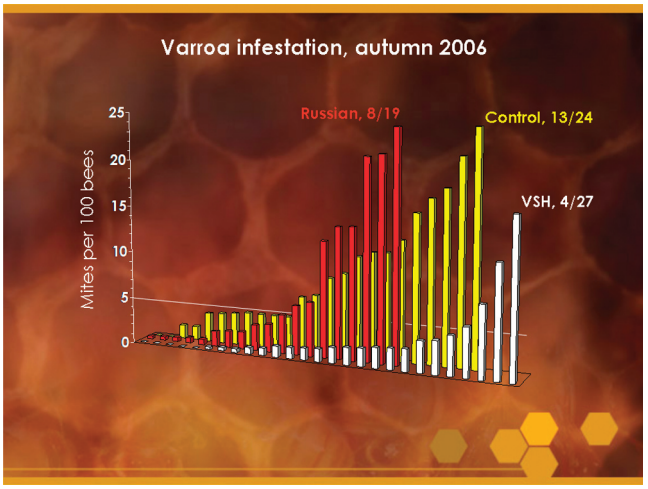

Fig. 5. Varroa infestations in autumn 2006. Information as in Figure 4 except that the treatment threshold was 5%.

ratings for Russian bees (3.8) and Italian bees (3.5).

The data from Alabama highlight the varroa resistance of bees with the VSH trait. For the first 12 months of the test, hybrid VSH colonies from the free-mated VSH queens performed as well as pure Russian colonies and better than unselected Italian colonies. Later, pure VSH colonies had lower varroa infestations and lower percentages of colonies that needed treatment than both Russian and Italian colonies. Overall, the need for treatment of VSH colonies was half that of Russian colonies and 30% that of Italian colonies. This excellent resistance to varroa came in conjunction with good general performance in the Alabama beekeeping operations.

There are lingering concerns with VSH bees. First, the trait is not easy to monitor for the typical beekeeper because evaluation currently requires microscopic examination of mite-infested brood. We are striving to find simple, practical methods that queen breeders and others can use to select for the trait and improve varroa resistance in their own breeding populations. Second, there is an infrequent problem of poor brood production in highly selected, pure VSH bees. Selection for VSH has been away from lines which tended to show this problem early in the program, and we did not see a problem in Alabama. Honey production by VSH equaled that of the other two stocks in Alabama, suggesting that broader beekeeping utility was not hampered in these bees selected for strong varroa resistance.

We continue to investigate the basic biology of the trait. The broodnest of any honey bee colony is a complex environment where brood cells sometimes are inspected, and then brood is either removed (especially if diseased of varroa infested) or recapped (especially if healthy). We know that VSH bees uncap and remove significantly more varroa-infested pupae than non-hygienic bees do. They also recap significantly more uncapped pupae than non-hygienic bees do. Although some of these recapped pupae are mite-infested, recapped pupae in VSH colonies are significantly less mite-infested than those in non-hygienic colonies.

While the fate of brood is clear, we do not understand the fate of all mites. For instance, we do not know whether just inspecting and then recapping a brood cell interferes with the reproductive capacity of any mites that are in the cell. In addition, the entire process of detecting and removing a varroa-infested pupa probably involves the actions of several worker bees, and it is difficult to directly observe these activities in the dark environment of a closed hive. A

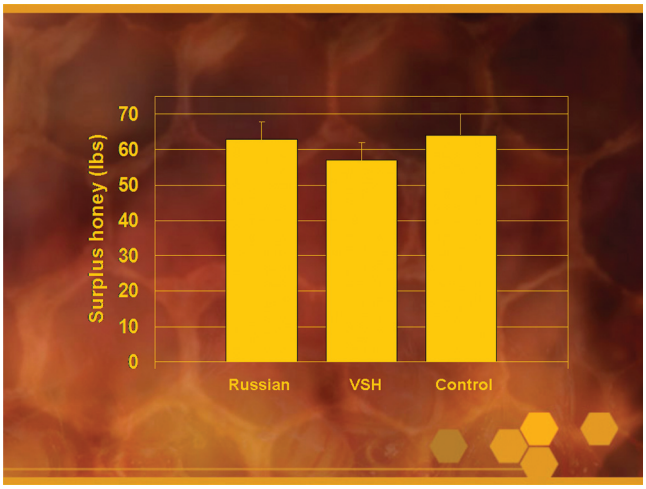

Fig 6. Average surplus honey collected from test colonies of three stocks during 2005 and 2006. Upper bars show one standard deviation from the average.

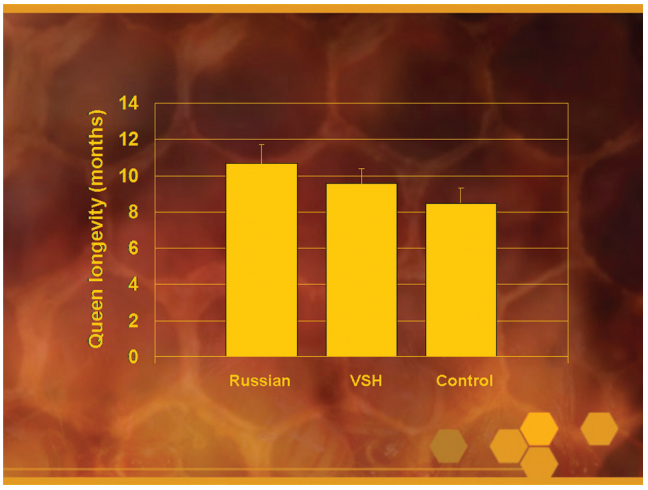

Fig. 7. Average longevity of queens of the three test stocks during the 3-year test. Upper bars show one standard deviation from the average.

better understanding of the multiple facets of bee behavior that create VSH may enable us to better target testing and selection.

Adoption of VSH bees by queen producers and beekeepers has been moderate. At Glenn Apiaries (see **http://members.aol.com/queenb95/**), Tom and Suki Glenn receive germplasm from the USDA laboratory, maintain the material, do some selection, and distribute breeder queens containing VSH to queen producers. Queen producers graft from the breeder queens and outcross VSH daughters to unselected drones. One clear attribute of the VSH trait is that VSH queens mated to other types of bees produce colonies that maintain significant levels of varroa resistance, while retaining good brood production. Ideally, the use of hybrid VSH queens should be part of an integrated approach to varroa management that incorporates sampling mite populations to make decisions about whether to apply miticides. The data from the Alabama study show the reduced need for using chemicals to control varroa in VSH colonies. We encourage beekeepers who monitor varroa infestations to conduct their own side-by-side comparisons of VSH bees with other commercially available honey bees to gauge the utility of VSH hybrids in their own beekeeping situations.

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