On this warm spring morning my home beeyard looks very peaceful. However, as in beeyards almost everywhere, there is an ongoing struggle between the forces on our side, honey bees, and those on the other side, parasitic Varroa destructor. In most beeyards our side can’t survive without our using chemicals to control the varroa; at least some of these are chemicals believed to stress our bees, negatively affect their immune systems and possibly make them more susceptible to viruses and other microorganisms (Mullen et al., 2010; Ostiguy, 2010). This past winter was especially stressful on colonies. In my area of central Illinois losses averaged at least 50%; in other regions they have been worse. An increasing number of beekeepers realize that we are not on a sustainable path; that we cannot continue to depend on chemicals alone without suffering major losses. Many recognize that varroa resistant honey bees that are adapted to local environmental conditions are critical to reducing chemical usage and to implementing an Integrated Pest Management approach to mites and diseases.

My interest in locally adapted, mite resistant stock increased greatly over this past year after I learned about four different apiaries in Illinois where colonies had survived 5-11 years without treatment. This made me want to search for studies of survivor or mite-resistant stock from a scientific perspective. In my pursuit I came across several thought-provoking articles. Many of you may have already read one or more of them. However, perhaps like me, at the time you may have overlooked their importance. I have chosen two specific articles, as well as several related ones from an ongoing breeding/research project to summarize briefly here. It is my hope that after reading the present article, readers will have a better understanding of some of the challenges and resources available to those who wish to breed or acquire varroa resistant, locally adapted honey bees.

Local Stocks as Sources of Varroa Resistant/Tolerant Honey Bees

In 2000 Erickson et al published Producing Varroa-tolerant Honey Bees from Locally Adapted Stock: a Recipe. This is an important article that should be read – and reread — by anyone concerned about breeding varroa resistant honey bees. I didn’t appreciate its significance when I first read it because the project was conducted in Arizona and I had assumed that the bees being selected were Africanized. Because that subspecies is rightly regarded as highly defensive, as well as resistant to varroa, I dismissed the study’s relevance. However, in an earlier article the authors point out that they started the project with non-Africanized bees and that any colonies in the program that had Africanized traits were eliminated (Erickson et al 1998). They also stated that Africanized bees in another, distant apiary were no less susceptible to varroa than the study colonies of European stock. I now believe that the plan described in the 2000 article is very useful, regardless of the degree of Africanization of the stock they worked with.

The Italicized words below are taken di-
rectly from the 2000 article without altering any wording, although I did not include the authors’ additional explanations regarding each point. These are the article’s major points:

1. Identify Varroa-tolerant colonies in your apiaries.
2. Move all colonies identified as Varroa-tolerant to a single isolated test apiary. This apiary should be at least 3-4 miles from managed colonies treated for mite control.
3. Monitor Varroa levels in the selected colonies every three months.
4. Graft only from those colonies with the lowest mite loads...Never use colonies with known problems such as disease, poor productivity or unacceptable defensive behavior, no matter how Varroa-tolerant they may appear.
5. Mate all queens in the isolation test apiary.
6. Requeen colonies in your other apiaries as queens become available. Once requeued, these colonies become candidates for future selections of improved Varroa-tolerance, hence, the need for good record keeping.

Note the use of the term tolerance where most articles on the same topic use the term resistance; I will use the latter term in the rest of this article. Resistant bees, to me, are ones that manage to prevent varroa populations from increasing to the point that they cause severe economic damage or colonies to collapse, although not necessarily eliminating the mites.

This plan emphasizes starting with locally-adapted stock rather than specific hygienic, disease resistant (e.g., the Minnesota Hygienic) or varroa sensitive hygiene lines. According to the authors, varroa resistant stock may be found in 3-10% of colonies in a given apiary (Erickson et al 2000). The article also provides information on a number of methods of identifying varroa resistant colonies. The authors recommend the alcohol wash test for monitoring varroa levels; sugar roll tests would also work. They advise eliminating all colonies from the breeding program and isolation yard with more than 15 mites per 100 bees; later on lowering the cutoff to 10 or fewer mites per 100 bees. However, as mentioned later in their article, requeening with queens from colonies with the lowest mite loads is less drastic, but a less immediate alternative to physically moving undesirable colonies.

The authors also recommend making sure that survivor colonies have plenty of drones and suggest requeening entire yards rather than doing this piecemeal. The authors did not mention the use of management approaches such as screened bottom boards, dusting with powdered sugar or widely spacing hives so as to reduce movement of varroa between colonies. When Erickson et al published their “recipe” in 2000, their program colonies had gone six years without treatment. Earlier, in their 1998 article, the same authors state that overall the colonies averaged 6-7 mites per 100 bees and that four cooperating beekeepers, including one each in Georgia and New Mexico who used broadly similar approaches, had similar levels of varroa in their colonies.

Erickson and colleagues tested the “recipe” in a 600 colony commercial operation in Arizona (2000). Unlike the rather wasteful Bond “Live and let die” approach, it does not advocate stopping all treatments and letting weakened colonies die; rather it advocates continuing treatment and requeening colonies with varroa levels above 15 mites per 100 bees. Breeding progress under these conditions should be faster than with the Bond plan. The authors point out that their plan may not work equally well in all regions. In addition, their guidelines on mite loads may not apply equally to other areas of the country. Further, while the 2000 article states that one can achieve a “varroa-tolerant population” within 2 years, it’s important to note that some of the stock they began the breeding program with came from four colonies out of 36 that had survived 3...
years without varroa treatments (Erickson et al 1998). Clearly, the amount of time it will take until you have resistant colonies will depend on the stock you begin with. If you have access to bees that have gone two or more years without treatment for varroa, it will take less time to reach your goal of varroa-resistant bees. I would think that stocks within a radius of 100-200 miles from an environment similar to your own would be a good starting place, if they already possess at least some resistance to varroa. Another point regarding local stock is that while possessing resistance to varroa, it may lack other desirable characteristics. For example, in my area many of the feral colonies are quite defensive. It’s also advisable to start with stocks that are hygienic, testing your colonies with the liquid nitrogen test, as shown in Figures 1-3.

Take Home Lesson No. 1: Colonies from your area are potential sources for breeding varroa resistant/tolerant honey bees that are adapted to local environmental conditions. Eliminating colonies with undesirable traits such as defensive behavior or disease susceptibility, as well as keeping good records, are critical to success.

Feral Colonies Coexist with Varroa Mites in the Northeastern U.S.

In 2007 Tom Seeley published an article entitled Honey Bees of the Arnot Forest: a Population of Feral Colonies Persisting with Varroa Destructor in the Northeastern United States. Seeley studied feral bees isolated from managed apiaries in upstate New York. He found that this population remained quite stable; most of the colonies survived over a three-year period from 2002 to 2005. Swarms from these feral colonies that took up residence in single, deep-bait hives placed in trees later proved to be infested with varroa mites. However, their mite populations did not surge to high levels in late summer as occurs in most managed mite populations did not surge to high levels in late summer as occurs in most managed mite populations. At the end of the 4-month study, there were no differences in the growth patterns of the mite populations between the two colony types; the feral stock appeared to be no more resistant to varroa than the NWC stock. However, unlike the mites in the apiary, the Arnot Forest varroa populations were less harmful to their feral honey bee hosts because they did not increase to high levels in late summer as did the varroa in the apiary. The lower rate of reproduction means that the Arnot mites would transmit fewer viruses and would be less likely to kill their host colonies. Seeley concluded that there is a stable “mite relationship” in the Arnot Forest characterized by varroa mite avirulence, not honey bee host resistance (See SideBar A).

As Seeley (2007) noted, feral colonies distant from managed colonies are more likely to develop a “balanced host-parasite relationship,” in which the parasite is much less harmful to its host. In part this is because when beekeepers treat colonies for varroa, they help to perpetuate genes susceptible to the mites. Further, beekeeping practices such as prevention of swarming, crowding colonies and transferring combs of bees and brood between colonies may reduce the chances of development of mite resistant bees (SideBar A). It is hard to disagree with Seeley’s conclusion that the Arnot mites have evolved to be less harmful to their bee hosts. However, it’s also quite possible that the Arnot bees and their mites have coevolved in a way that the bees possess one or more means of resistance that may have “nudged” their mites toward a lower reproductive rate and avirulence. Seeley’s comparison between the Arnot and New World Carniolan colonies lasted only 4 months (July-October), which presumably would not have been sufficient time for such co-evolution to occur between the “domestic” varroa and their feral hosts (Seeley 2007).

The Arnot Forest article points out the role that varroa genetics appear to play in reduction of mite populations. There is a need to think more holistically and recognize that there is an ongoing evolutionary interaction between the bees and varroa. Breeding “better” varroa may not be practical; alternatively, it may be advantageous to acquire varroa from survivor yards along with the survivor colonies from those yards in order to achieve good survival in the face of varroa mites.

Take Home Lesson No. 2: In addition to acquiring and/or breeding varroa resistant stocks, beekeepers may make more rapid progress in achieving reduced varroa levels if we treat for populations of more harmful mites and replace them with less harmful, “good” varroa from survivor yards.

Varroa Sensitive Hygiene: A Resistance Trait Present in US Honey Bee Stocks

In 1997 John Harbo and Roger Hoopingarner reported on European honey bees in the US that had partial resistance to varroa mites. However, it wasn’t until 2006 that it was discovered that the resistance to varroa is due to the varroa sensitive hygiene trait (VSH, formerly suppressed mite reproductivity or SMR) (Ibrahim and Spivak 2006). It’s important to note that the VSH trait is targeted toward removal of varroa-infested pupae; whereas “regular” hygienic behavior (such as found in the Minnesota Hygienic line) focuses on removal of pupae infected with American foulbrood or chalkbrood (REFS). Since Harbo and Hoopingarner published their article, there have been a series of publications that provide additional information on the varroa sensitive hygiene trait and the line with the same name. The major means of resistance is that the nurse bees that have this trait detect the presence of varroa in the cells of worker pupae, uncap the affected cells and remove the pupae. As a result, any immature mites present die, although not necessarily the mother varroa. There is also evidence that the mites do not reproduce as readily in VSH brood (Ibrahim and Spivak 2006).

Interestingly, previous research had suggested that bees with the VSH trait selectively remove pupae on which varroa are reproducing. The most recent data suggest, however, that they do not target reproductive mites, but rather that their uncapping behavior probably disrupts mite reproduction and results in eventual declines in varroa numbers. This latest research also suggests that the VSH trait is not detecting the mites directly, but instead changes in the pupae due to the mites (Harris et al 2010); perhaps due to feeding on the pupae. Honey bee breeders can incorporate genetic resistance to varroa into existing commercial lines to provide significant reduction of this destructive pest. Crosses with other lines that are about 50% VSH give good control of varroa populations. In a study in Alabama, colonies with workers that were 50% VSH x 50% unselected Italian crosses had levels of mites comparable to...
to colonies of pure Russian bees; these two groups had substantially fewer varroa than the pure Italians. There were no differences in honey production.

A second study in the upper Midwest compared an Italian control line with the Minnesota Hygienic line, as well as crosses with the latter, that averaged either 37\% or 18\% VSH (Ibrahim et al 2007). Even colonies with workers averaging 18\% VSH had significantly fewer mites on adult bees than control Italian colonies or MN Hygienic colonies; a 50-75\% reduction compared to the Italians. The MN Hygienic colonies had levels of varroa intermediate between the VSH crosses and the control line. The 37\% VSH crosses had comparable honey production to the MN HYG colonies and less than the Italian control line in one operation, but not the other. Crossing the VSH line with hygienic lines of bees may well give superior results to crossing with non-resistant lines, as was done in the Alabama study mentioned above.

In my experience VSH queens crossed with local stock perform admirably. The crossbred workers are gentle. More importantly, when introduced into non-VSH colonies they start to clean mites out of capped brood rapidly. Under these circumstances the brood patterns in these colonies are often quite spotty, which initially can raise concerns (Figure 4). However, within one-three months the patterns look normal, as a result of the hygienic behavior reducing varroa levels. Last year was a terrible one for honey; and the VSH queens were introduced late in the season, so I was not able to evaluate honey production.

Take-Home Lesson No. 3: The Varroa Sensitive Hygiene line of bees has genetic resistance to varroa that can be incorporated successfully into existing commercial lines as well as locally-adapted stocks.

How Can We Use the Information in These Articles?

My intent in summarizing the above-mentioned articles is to provide those interested in breeding locally-adapted, varroa resistant, bees with information that can assist them in designing or modifying their breeding projects. The article by Erickson et al (2000) demonstrates that one can start with local stocks and select successfully for varroa resistant colonies while continuing to treat for these pests. In the process you do not have to let your colonies collapse. A key step in their approach, which is also applicable to other breeding programs, is to replace queens from colonies with high varroa populations on a reasonably frequent basis. While the authors’ recommendations of monitoring every three months may be less practical in northern climates, it’s advisable to replace poorly performing queens at least in spring and in late summer/fall as needed.

Seeley’s article (2007) appears less immediately practical than the studies by Erickson and his colleagues. However, it does help us to understand that in many cases it’s not just honey bee genetics that we must try to change. I am not aware of a workable approach to breeding “better,” or less harmful varroa. However, as discussed in Sidebar B, if we select for resistant bees, we also may be selecting for less virulent varroa.

At least two studies, previously cited, have shown that the VSH trait can be successfully introduced into commercial lines of honey bees. Given the central role that varroa mites are thought to play in Colony Collapse Disorder, in the weakening of the honey bee immune systems and the transmission of viruses, there is a clear need to increase our utilization of varroa sensitive hygiene genetics in almost all beekeeping operations. Breeder queens of the VSH line (Figure 5) can be purchased from Glenn Apiaries (http://www.glenn-apiaries.com/). There also are a growing number of queen producers who sell naturally mated VSH queens, as well as queens originating from crosses between VSH and other resistant lines. A list of these producers can be found on the same website. Glenn Apiaries also sells breeder queens of both a Carniolan and a hygienic Italian line that incorporate VSH genetics. However, it’s critically important that the pure Varroa Sensitive Hygiene line be maintained so that those beekeepers concerned about locally adapted stock can continue to introduce this valuable trait into bees acclimatized to different environments.

For those interested in breeding varroa resistant bees, there are several options that can help you reach your goals. Although I am an advocate of systematic breeding programs, less planned approaches frequently are successful. Five years ago Phil Raines,

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Sidebar B: A Link between Varroa Sensitive Hygiene and Parasite Avirulence?

By definition, avirulent parasites have lower rates of reproduction and thus are not sufficiently harmful to kill their hosts, although they may weaken them and reduce their reproductive success (Gandon et al. 2002). According to theory, avirulence will evolve under conditions of vertical transmission of parasites, for example from parent colony to swarm. However, honey bees are known to possess several means of varroa resistance that reduce reproduction in varroa and may result in mite avirulence. The most obvious candidate is varroa sensitive hygiene, which in European honey bees is best developed in the VSH line. This trait was observed previously in the Asian honey bee Apis cerana, the original host of the varroa mite, Varroa destructor (Rath and Drescher, 1990). The varroa mite appears to be in a state of avirulence or a balanced host-parasite relationship with A. cerana, in contrast to its relationship with the European honey bee, A. mellifera.

Whether or not Seeley’s Arnot Forest bees have the VSH trait is not yet clear. They may have other mechanisms that, together with vertical transmission and other environmental factors, result in varroa that are avirulent. Grooming behavior is another means by which honey bees resist varroa. Another is the lower mite reproduction observed on VSH pupae compared to Italian pupae seen even in the absence of VSH workers, in an incubator.

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Figure 4. Spotty brood on frame from colony with naturally mated VSH queen and crossbred workers in mid-March. The VSH queen was not introduced into this formerly non-VSH colony until the previous October.
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References


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