Bomb vs Bond

Non-chemical options
Part II

By M.E.A. McNeil

Part I of this article examined the segue among three of the several factors known to affect the decline of honey bees: Varroa and the pathogens it vectors, the use of acaracides, and management.

"Bond" in the title is from the live-and-let-die approach of entomologist and commercial beekeeper John Kefuss. His recent scientific paper in The Journal of Apicultural Research[1] describes breeding for resistance to Varroa by not treating, which he has successfully done in his commercial operation. "Bomb" in the title is what epidemiologist Dennis vanEngelsdorp, head of the Bee Informed Partnership (BIP), finds in nationwide data showing sudden spikes in Varroa infestation – likely caused by infected collapsing colonies.

A constellation of approaches was reviewed in Part I. This segment of the article will profile a few beekeepers developing resistant stock and offer some non-chemical management techniques.

A cadre of front line bee researchers are not buying into a doom and gloom scenario: "We disagree with the negative characterization of the status of honey bees with genetically-based mite resistance," wrote Bob Danka, Tom Rinderer, Marla Spivak, and John Kefuss.[2] These researchers come to the subject from diverse but deep experience– Danka and Rinderer developed the Russian bee at the USDA Baton Rouge lab; Spivak, with Gary Reuter, developed the Minnesota Hygienic line; Kefuss, an entomologist and commercial beekeeper, has bred untreated stock for decades in France.

They address barriers to the wider adaptation of resistant stock: One example is waiting on hold for more information such as "a call for detailed knowledge of resistance mechanisms". Yves LeConte, who heads the French national bee lab has found that those mechanisms can differ; for some, the mites are prevented from reproducing well; in others it is the physiology of the bee. Investigating this is a valuable pursuit, according to, Danka's group, but, they posit, there is enough understanding of hygienic behaviors to proceed with breeding – as LeConte himself has done.

Another barrier they cite is criticism against blind selection for resistance – simply breeding from queens with low mite infestations. They write: "This has already been documented to be a viable breeding approach that is led to honey bees that are now used by both small-scale and commercial beekeepers with no or minimal acaricide import: Russian honey bees in the USA and bees bred by John Kefuss in France."

They find a lack of general use of mite-resistant stock in the beekeeping community. This is reflected in vanEngelsdorp's BIP survey, in which fewer than 10% of beekeepers reported working with resistant stocks. In other surveys, Russians, Minnesota Hygienic and VSH bees are reported to be used by around 24%; still low numbers to tip genetic change.

The writers point out two potential problems with sustainability: The first is maintaining characteristics of mite resistance. It's possible to do, they say, noting beekeepers who have kept bees "without the use of acaricides for up to a decade, as well as numerous programs with resistant bees in an IPM approach…These show clear progress toward eliminating or reducing reliance on chemical control of Varroa."

The second potential problem they see is loss of genetic diversity; to prevent it, they recommend outcrossing. Genetic markers are an important subject for research and special breeding: However, "They clearly were not essential for the development of the current Varroa resistant stocks now being used."

The writers conclude: "The effectiveness of IPM programs, presumably including genetically resistant bees for Varroa control, depends on the dedication and proficiency of individual beekeepers." The time commitment for some hands-on manipulations is great, and not feasible on a large scale. The writers conclude: "Our experience is that small-scale beekeepers are further ahead than large-scale beekeepers in acceptance of resistant bees."

It should be acknowledged here that the work of the BIP Tech Transfer Teams has made notable progress by testing for resistant behavior in commercial operations, allowing them to make selections in that direction.

In any case, dozens of colonies are required for a breeding program – 50 to 100 according to Maryann Frazier of Penn State. Entomologist David Tarpy of North Carolina State agrees and said, "It's indisputable that it needs to be a closed population. People can raise queens from one or two colonies, but it's not breeding."

Selecting for a single trait, such as hygienic behavior, can be done in as few as five years, according to Sue Cobey of Washington State University, who has been breeding bees for over 30 years. But, she said, "Developing mite resistant bees is a much more difficult and complex task".

Kefuss agrees, describing bee genetics as "like a sack of marbles." His first approach is what he calls his Soft-Bond method. "Test to see which hives need treatment. Treat, then re-queen these hives with queens from hives that need little or no treatment. After a few generations you will find out whether or not your bees are tolerant." He later incorporated a freeze-kill brood assay to test for hygienic behavior. The BIP Tech Teams use a liquid nitrogen test.

"It is clear that mechanisms of resistance and tolerance (whatever they are) may require years to be expressed before they can be utilized for selection," wrote Kefuss. "Chemical mite control masks and destroys natural selection for these mechanisms. There are clear reasons why beekeepers should select for mite resistance... Chemicals used to treat against mites have been clearly found to impact colony health, immunity, and potentiate the effects of insecticides. Breeding projects in different parts of the world have demonstrated that it is possible to select bees with increased levels of resistance to *Varroa destructor*, and that this is a commercially viable situation. Our results demonstrate that it is possible to select bees that lower mite populations using simple methods adapted to commercial beekeeping conditions and to breed this genetic material into other honey bee gene pools even when the underlying resistance mechanism is not understood (blind selection). We believe that it is the responsibility of everyone who breeds bees to try to select for mite resistance to reduce chemicals in hives. We owe this effort to the general public and to future generations of beekeepers."

A study by Frey and Rosencranz says, "Our results point to a conflict between beekeeping practices [treating] and the selection of Varroa resistant honey bees. For many selection programs, a colony should be allowed to host a number of mites sufficient to demonstrate the capacity of a colony to control the growth of the mite population."[3]

Some beekeepers are advocating for resistance selection. "We can't depend on chemicals," said Jon Zawislak, a biologist at the University of Arkansas. "Bee breeding is the key to our future. But as soon as bees are bred, we are back to the gene pool."

Frazier said, "To my mind, the common ground is IPM. That might be selecting resistant stock or working toward that. You need a plan to deal with Varroa."

Approaches to this goal vary considerably. The following is a sampling of just a few individuals; it begs to be expanded to more of the many on this mission.

Beekeeper Kirk Webster and bee biologist Greg Hunt of Purdue both keep untreated apiaries, albeit a thousand miles apart. The reasons they, and others, can keep bees without chemical intervention are twofold: stock selected and maintained for mite resistance and their skill. Both Hunt and Webster make the point that novice beekeepers need to develop the competence to control infestation. Even so, at any level of experience, it's more than a disadvantage to begin with treated bees of unknown characteristics. It takes practiced and ongoing selection to maintain resistant stock. "Breeding is very labor intensive," said Hunt.

Webster said, "The mite bomb thing is a real phenomenon. It's from idealistic people wanting to help the bees, abandoning colonies of non-resistant bees. The beekeeper needs to build up a whole system for coexistence with stock management practices and allow time – about 4 to 5 years – with stock that has some promise to begin with.

"It's a pleasure to keep bees without worrying about treating them," said Webster. "There is a huge potential for a more holistic look at the whole system. I hope for more beekeepers to take advantage of the opportunity to move away from treatments. It is no more risky and costly than what they have done so far. I'm not the only one, and I'm not even the best example."

His mentors, pioneering organic farmers Bill and Martha Treichler, taught him to regard pests and diseases as guides rather than adversaries. That worked as he selected against trachial mite in his commercial apiary. "When Varroa arrived, I had already had that experience. But they were a worse problem. The good news is that the same process took place as it had with tracheal mites. Varroa became an ally – far superior to any kind of test." Webster has integrated Russian stock into his operation with good results. "I just keep propagating from the best bees." From selection, he reports that they are less swarmy, have more brood and bigger winter clusters. "As for the question of whether survivor stock exists only in isolated pockets, I don't believe it for a minute," he said, pointing out that his apiaries are within flight distance of others.

“You can’t go cold turkey,” said Billy Davis, EAS Master Beekeeper and a founder of the Sustainable Honey Bee Program in Northern Virginia. He was speaking of his decision not to use chemical treatments 15 years ago. “It’s not non-treatment, it’s management. The bees have to come first, then comes the honey or whatever. Ask, what are the consequences of what you are doing, not just the immediate consequences.”

Aiden Wing, of Wings of Nature apiaries in the coastal mountains of California, keeps a quarter of his operation in a treatment-free queen breeding program in a relatively isolated area. His goal is to keep the remaining production hives treatment-free as well, but they are more exposed; to that end he distributes queens to surrounding beekeepers. In the meantime, he uses IPM in the vulnerable yards, relying primarily on genetics, then manipulations such as breaking the brood cycle and, lastly, organic acids and essential oils. He and his wife Audra Roles produce 1500 queens per year and 500 nukes, which sell out locally to customers from backyard to commercial beekeepers.

Over the last eight years they have collaborated with Mark Spitz and Melanie Kirby, of Zia Queenbees in New Mexico, who have raised mite-tolerant bees for decades. “We could sell more than we produce. It requires a lot of focus time per colony to run this kind of model – quality instead of quantity,” he said.

“The people I know who are successful with non-treatment are all excellent beekeepers,” said Wing. Some large-scale queen breeders are moving in this direction. Some of the smaller ones are the most motivated and knowledgeable I’ve met. We need to look where we all want national bee health to be at 50-60 years out, look at it as a journey.”

Commercial beekeeper Craig Baldwin has kept bees for some 52 years in South Dakota and Texas. He runs over a thousand colonies, including a yearly semi-load to almonds; he quit chemical treatments on them all 13 years ago. He said, “People told me, ‘You’ll be leaving money on the table,’ and in the beginning I lost 70% of my bees. Now the bees have sustained themselves. That’s the thing people don’t understand, that the bees show the way.”

He has brought in breeder queens of different stocks, including Russians, but mostly, he said, “My ace in the hole is that I select my own queens from colonies I like: I have a grading criteria. There are mites on my bees, but the colonies function fine – the mites don’t kill them. Last year my losses were 72 out of 1088 colonies, a 7% loss.”

“Experts, they all make it way too complicated. What I am promoting is people selecting for their own bees that survive.”

A number of coalitions of non-treating or IPM breeding beekeepers are at work across the country, and they have expanded to fill an article of their own. Among them are the Russian Honey Bee Breeders Association (RHBA), a dozen professionals who are maintaining the lines first developed at the USDA; the Pennsylvania Queen Rearing Project, headed by Jeff Berta, a group of IPM/treatment-free beekeepers across the state supported by grants and the expertise of the Penn State University Center for Pollinator Research (CPR); The Heartland Honey Bee Breeders Consortium, a nine-state cooperative that meets yearly for an insemination event at the Purdue Bee Lab under Greg Hunt and Krispn Given. These, and others, deserve more detailed attention than can be given here. They are major players in the movement toward resistant breeding.

Nonchemical Management Strategies

The popular motto "Bees are the new chickens" may have led to the doom of the packages bought by well-meaning novices; keeping bees requires more than cooping them up. It takes good stock and skilled management. Given those essentials, midsize to backyard beekeepers choosing to avoid or reduce chemicals in their hives can employ techniques that are unsupportable at a large scale. For that reason, some researchers are looking to smaller apiaries as possible sources of genetics for large commercial operations.

The ideal approach is agreed on by both the Bond and the Bomb sides of the discussion: IPM (Integrated Pest Management). That strategy begins with knowing one's adversary – in this case learning behaviors of the Varroa mite. In short, it breeds in brood cells, doubles in numbers monthly over bee season as bee populations decline, and migrates on robbers and other bees, especially from collapsing colonies. Other problems follow Varroa, particularly viruses that have become more virulent because of the way the mites vector them. So the beekeeper's wisest strategy is to game this knowledge.

Resistant stock: Varying opinions in this discussion converge in the recognition that any plan to increase nonchemical management requires resistant stock. For most beekeepers, it means ordering bees from a breeder with a thoughtful selection program. VanEngelsdorp lists some stocks with that potential: VSH, Russians, Minnesota Hygienic, Carniolans, Buckfast. The BIP survey cited several examples, including Caucasians with 42% fewer losses and Buckfast bees with 84% fewer. The survey found higher losses with packages instead of nucs, a finding reported elsewhere as well.

Local stock: "Spreading locally resistant stock is the way we need to go," said Jeff Pettis. That does not mean eschewing added genetics, since diverse lineages promote hybrid vigor – greater disease resistance and parasite tolerance, he said. In the BIP survey, use of locally selected bee stock resulted in 18 to 41% fewer overwintering losses in three consecutive survey years.

"Smaller programs might be the ones that come up with good stock that could be used by large commercial beekeepers," said Elina Nino, UC Davis Extension Apiarist. It should be noted that any swarm in a tree is not necessarily survivor stock, according to Debbie Delaney of the University of Delaware.

Sharing stock: Beekeepers who wish to control the mating stock for their apiaries often do so by sharing queen cells or queens with their neighbors, widening the area in which their queens will find suitable mates. Some take their largesse beyond their immediate environs: Vincent Aloyo, a professor of biochemistry and EAS Master Beekeeper distributes queens to new beekeepers from a collaborative Chester County, PA, mating yard.

Testing: Mite testing is critical according to most, but not all. Most recommendations are for both early and late season testing either by alcohol or sugar roll.[4] Sticky boards are another method, but they have been shown to be significantly less accurate. Mite thresholds signaling disaster vary by season, but in the 80's it was 20 mites per hundred bees; now it is closer to 3 per 100. Jeff Pettis of the USDA Beltsville lab notes that the lab offers free diagnostic service for several potential problems. (He adds that comb for shipping must be wrapped only in paper, never in plastic.) BIP offers an extensive testing program.

Splitting: To reproduce, Varroa needs brood at the larval stage; the female hops into a cell before it sealed. There it multiples incestuously while it, and its offspring, dine on the pupa's hemolymph. Splitting a colony deprives the mite of its reproductive site. A new queen will take some 27 days to develop, mate and begin laying. Any remaining brood will have emerged by then. The BIP national survey found splitting to be the best technique for reducing losses.

"Remember that in walk-away splits bees can choose older eggs," said Tarpy. It makes sense for the bees to want a new queen as soon as possible. The problem that creates is that older larvae develop into poor to even drone-laying queens. "Go back in four days," he said. "Remove capped cells. The remaining ones will be younger, better. There is a need for timing to be perfect. Co-opt the bees' biology by selecting younger queen cells." He cautions that before splitting it is necessary to calculate drone availability to coincide with queen mating. "Well-mated queens have colonies that have more brood, store more food and have more comb. The colony is a reflection of how good the queen is."

Commercial beekeepers who split their colonies tend to retain the newer colonies better than non-split ones according to BIP. For example, Mary Woltz of Bees' Needs on Long Island breeds all of her queens by splitting in her stationary apiaries on organic farms, nurseries, and gardens. This technique could correlate with colony size, below.

Other means of brood interruption: A queen can be caged on the comb for 1-2 weeks to interrupt brood rearing. There is no BIP data on the effectiveness of this technique, although there are anecdotal reports that it is successful, time consuming, requires skill, and is not a stand-alone solution. It has the potential for lowering honey yield as a result of delay in brood production, but then, so does splitting. The resulting brood interruption can be an opportunity for those living in warmer climates without a natural break in brood rearing who choose to treat with a soft chemical. In any case, The University of Minnesota reports that some beekeepers have success giving their colonies a 30-day brood break.

Small colony size: Seeley observed that the feral bees he monitored maintained small colony size and speculates that could be a good strategy for beekeepers. Jeff Pettis said, "A single brood box may be ideal. Two deeps is almost too much; three mediums is good." Billy Davis of Virginia runs his untreated apiary successfully in nuc boxes.

Drone brood culling: Drone brood removal is an inexpensive and effective technique. Varroa prefer drone brood, which has the longest gestation, allowing the mites to reproduce more successfully. The beekeeper removes the drone comb before the 24th day, when it will release its lethal guests, and freezes it or gives it to grateful chickens. Management involves using either drone-size foundation or a shallow frame in a standard box to encourage concentrated drone laying. Repeating two or three times during colony population increase will compound effectiveness. By the same token, missed timing compounds the acceleration of mites: you can't forget it.

Operations in Northern States using this technique were found in the BIP survey to have 10-33% reductions in loss in three of four years surveyed; nationally, with this technique there were 11% fewer overwintering colony losses in one of four years.

It can be bothersome both to the beekeeper and the bees to disassemble a colony to pull and replace drone comb. To solve that problem, vanEngelsdorp said, "We developed a two-tower system to help alleviate excuses of not taking out the comb. They are two [wall to wall] full colonies with queen excluder and honey supers." The shared honey supers are straddled over the two hives -- allowing for half covers on each brood box stack that allow access to cull drone brood. "The great thing about this is it has exactly the same advantages of a double queen system: You actually produce 30% more honey. We've basically bought more time by using the drone brood treatment."

Spacing, marking: Adequate spacing between colonies reduces drifting, as does putting distinguishing markings on colonies such as the geometric designs used by von Frisch. It appears that the distant natural spacing of the feral colonies in the Arnot Forest, studied by Tom Seeley, has been a factor in eliminating the spread of mites there through drifting. At Jeff Pettis's open discussion on mites at the last EAS, a speaker from the audience said of closely grouped hives, "It's like a train station or an airplane, you'll get sick in high density." Tellingly, in a German study of migration of mites (Frey & Rosencranz), infestation was four times more likely to take place in crowded apiaries; a less dense apiary remained "below the damage threshold". The distant spacing of the colonies in the Arnot Forest would rarely be possible for a beekeeper, but, Seeley remarked that as much separation as possible helps.

Comb management: The recommendation from BIP is to replace brood frames every 3-5 years and remove brood frames with more than half drone-size cells. On the BIP finding that continuous use of comb was advantageous, vanEngelsdorp said, "It could be a fluke". Freezing combs for storage was found in apiaries that lost fewer colonies in the BIP survey, making it a recommended strategy.

Keep the strong ones: Pettis encourages culling weak queens: "We tend to keep bringing our problems along by nurturing poor colonies."

Be aware: "Pay attention to the signals you get – what you hear, what you see; be in tune with your bees," said Pettis. A good example is Woltz of Long Island, who maintained the same honey yield from 65 colonies that she once got from 100 by doubling down on the care she takes with management. And, said Pettis, stay informed: "Small hive beetle was on no one's radar." He points out problems offshore that we may need to face by being willing to reexamine our gamebook.

Screened bottom boards: The BIP national survey found no advantage reported nationally in four consecutive survey years; however in the Northern States there was a 12.4% loss reduction in one survey year for those using screened bottom boards. That being said, there are plenty of

adherents who claim that even a small mite fall – and they do fall – adds to the total. It is a regional and individual choice.
Maybe not so helpful: **Powdered sugar:** This method showed no reduction in overwintering losses from four consecutive BIP survey years. Icing sugar is placed between frames of brood causing bees to groom it off, together with phoretic mites. It is recommended to check mite levels before and after this treatment to determine its efficacy.
Not helpful: **Small cell size:** Several investigations have concluded that small cell size does not diminish mite reproduction, among them studies by Jennifer Berry of the University of Georgia,[5] The Florida Department of Agriculture,[6] the New Zealand Ruakura Research Centre. Tom Seeley of Cornell concluded that "Small-cell comb does not control Varroa mites in colonies of honeybees of European origin" both in managed colonies and in feral bees in the Arnot Forest. Jeff Pettis said, "Small colonies but not small cell."

To conclude, Pettis is hopeful for the future: "It will stabilize. The host-parasite relationship will stabilize."

Beekeeper Jack Grimshaw, musing on the problem in the hallway at the last EAS. said, change comes about "one beekeeper at a time".

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[2] Danka, Robert, Thomas Rinderer, Marla Spivak, John Kefuss (2013), "Varroa destructor: research avenues towards sustainable control", *Journal of Apicultural Research* 52(2): 69-71.
[3] Frey, Eva and Peter Rosenkranz (2014) Autumn Invasion Rates of *Varroa destructor* Into Honey Bee (*Hymenoptera: Apidae*) Colonies and the Resulting Increase in Mite Populations, *Journal of Economic Entomology*, 107(2):508-515. 2014.
[4] Mite testing kit from the University of Minnesota: https://www.bookstore.umn.edu/viewProduct.cgi?categoryID=6751&productID=47142#.V8B0GDWDn3A
[5] Jennifer Berry, *Bee Culture*, Nov 2009 Small Cell Foundation and Varroa Mites.
[6] The Florida Department of Agriculture and Consumer Services small cell study in *Experimental and applied Acarology 2009 47:311316.*