Bomb vs Bond

Treatment/nontreatment:
The twain do meet, and let us count the ways
Part I

By M.E.A. McNeil

The mite. Beekeepers don't need to specify which of the 48,200 known mite species, even though there are 86 different mites that live with bees, mostly scavengers. For all, *the one* is *Varroa destructor*, but beyond that there is not even agreement that something has to be done about it.

One entomologist considers the mites a strategically useful selective pressure and advertises to buy them. Conversely, an epidemiologist considers them an epidemic to quell.

The first is John Kefuss, who recently published a scientific paper in *The Journal of Apicultural Research* on successful breeding for resistance by not treating in his commercial operation.[1] He calls his approach to mites The Bond Method – "live and let die".

The second is Dennis vanEngelsdorp, a professor at the University of Maryland and project director for the nation-wide Bee Informed Project (BIP).[2] He concludes that untreated colonies can generate mites – a phenomenon he illustrates with a film clip of a hydrogen bomb blast.

What seems at first take to be a standoff is not as intractable as it seems. Kefuss sees a role for treatment and vanEngelsdorp supports non-chemical management practices. Neither is binary; both see what appears to be a dichotomy as parts of the same mission: As vanEngelsdorp puts it, "This is the long term solution: we need bees that are resistant to mites."

Evidence for gaming the mite-bee relationship is still being painstakingly gathered, and gaps hint at unknown others. Entomologist Dave Tarpy said, as a scientist "You have to feel comfortable feeling stupid." What he means is that a shedding of preconceptions can open new understanding.

An aside about definitions (already time to try on the stupid hat): The word for successful coexistence with a parasite, as Varroa does on *A. m. cerana*, is actually "tolerance". However, the word "resistance", which denotes elimination, has come to be used instead to describe the characteristics of bees that "keep *Varroa distructor* at a relatively low level" (Danka, Rinderer, Spivak, Kefuss, 2013[3]). Hey, those are the experts, so that meaning will be used here. Just the same, it is widely agreed that the mite will not be completely eliminated but is here to stay (i.e. tolerated). The original meaning of "resistance" is retained in reference to chemicals, as in fluvalinate-resistant mites. Still there?

Scroll back in time when little was known about how to combat bee disease, let alone pests. In the 1930's researcher O. W. Park saw bees uncapping cells to rid the hive of American foulbrood. In 1942, Woodrow and Holst reported observing the same behavior, with bees removing AFB spores in the latent, non-infectious state. W.C. Rothenbuhler picked up the research in the 50's, coining the term "hygienic behavior".

His idea was abandoned in favor of antibiotics, which were far less labor intensive than breeding for an elusive trait. And the Rothenbuhler stock, so carefully developed through inseminated lines to concentrate the foulbrood-resistant genes, is said to have collapsed from inbreeding – resistant to one disease but susceptible to another (a virus called hairless black syndrome). From the stupidity stance, this failure became a gift, a lesson for subsequent breeding lines to be strengthened with more diverse genetics.

It was widely believed at the time that a chemical approach could create effective controls. It made sense: Science had confronted human diseases such as smallpox. When a sufficiently large percentage of a population has been vaccinated, the result is herd immunity, a greatly diminished chance for isolated outbreaks to become epidemic. Chemical solutions were widely heralded; a UC entomologist said that when he started his studies he was advised that his work would eventually no longer be needed because all insects would be eliminated.

While efforts to develop acaricidal treatments to control Varroa were underway, it was not known that bees could be bred to combat Varroa. Kefuss was a beta tester for early chemical controls and, finding them harmful to both the bees and himself, he began exploring the uncharted possibilities of breeding. At the time, that eventuality appeared remote to impossible.

In the 1980s Steve Tabor and Martha Gilliam at the USDA lab in Tucson picked up Rothenbuhler's work and found that the hygenic trait produced resistance to chalkbrood as well as foulbrood. They suggested that Marla Spivak take the query further when she began her tenure at the University of Minnesota in 1993.

That same year, Kefuss wrote in the ABJ, "I think that now that the initial panic phase [of the introduction of Varroa] is about over, it is time for beekeepers to stop horsing around and get moving in the correct direction – genetic control." He had worked as an undergrad in Rothenbuhler's basement lab and saw first hand that AFB resistant bees could clean up frames with thousands of scales, whereas non-resistant colonies would succumb to only a couple of infected cells. "I hope that chemical control [of Varroa] will be a thing of the past," he wrote over 20 years ago.

Hygienic behavior has now been correlated with not only disease resistance but Varroa control. Spivak, with Gary Reuter, developed what is known as the Minnesota Hygienic line of bees. Another line was developed at the USDA Baton Rouge lab by by John Harbo and Jeffrey Harris -- VSH (Varroa Sensitive Hygiene) that further increased the degree of hygienic behavior. Grooming, the trait that brings Varroa's original host, *A m ceranna*, into parity with the mite, is bred into VSH bees by Greg Hunt to produce the Purdue "ankle biting" bees. "I think if we can combine these two traits, we will have bees we don't need to treat for mites," said Hunt. "But you have to keep selecting."

As Danka et al (2013) wrote, "Honey bee strains that are resistant to Varroa are a valuable resource…Although these bees have not completely solved the problem."

Which brings us to the relationship between natural defense and intervention that is so difficult to parse. Where the twain meet is in management, and dealing with mites requires a level of knowledge, skill and experience. There are choices to be made that will vary by circumstance.

"It's not black and white – not nontreatment versus treatment, it's how to manage our bees," said apiculturist Maryann Frazier recently honored by the Eastern Apiculture Society (EAS) for her career at PennState.

"It's a semantic problem," said Dave Tarpy, an entomologist at North Carolina State University. "That dichotomous choice is exactly the problem – it's not dichotomous. 'Treatment' is assumed to mean using synthetic acaricides. We need to use the words 'control' or 'mitigation'. The opposite is not doing anything."

The word "beekeeper" applies to a diversity – those with one or two backyard colonies, those with scores to hundreds, and large scale commercial beekeepers who can best be described (not perjoratively, for their consummate skill deserves respect) as bee herders. It is not speculative to say that they'd all like it a lot to have the option to bypass chemical treatment. Some migratory beekeepers, like John Miller, set aside yards to that aim but few of them can crow success.

The BIP data now show summer losses, in addition to winter losses, in an ongoing crisis. "Four factors are affecting colony health," vanEngelsdorp said, "Parasites and pathogens; pesticides that farmers use and beekeepers are applying to control varroa mite; poor nutrition because of monoculture habitat or the lack of good forage; and management. There's little question that nationally, on average, according to this national honey bee disease survey, we have mite populations that are exceeding what we think causes damage." Leaving aside the question of whether our agricultural system needs an overhaul, the segue among three of these factors is explored in this article: Varroa and the pathogens it vectors, the use of acaracides, and management. What follows is a constellation of points of view.

"We are on a year-by-year basis to ask if we have enough bees for almond pollination," said entomologist Jim Frazier. "When we don't, something will hit the fan."

"It's unsustainable" said Jeff Pettis, of the USDA in Beltsville. "Beekeepers can increase medications and feed for bees and still suffer heavy losses… I think that breeding, the movement toward resistant stock is the way to go."

What's telling in the BIP yearly survey is that fewer than 10% of all beekeepers report working with resistant stocks.

How do we get there from here?

Keeping bees alive is frustrating enough to result in differing intransigent conclusions. The goals and needs of various cohorts are in large part different, but in critical ways they segue. All the same, confrontation for some seems to have trumped respectful, substantive, practical, scientifically based exchanges. It's not a new paradigm: At the Industrial Revolution, industry was thought of as the evil twin of nature, and that opposition has survived in current attitudes. Perhaps sustainability is better understood as sustaining nature as we humans prefer it: No one is interested in sustaining the Aedes mosquito that spreads the Zika virus, and how fond are we of protecting Varroa?

Perhaps better understanding with a dash of compassion could bring detente to the Hatfield-McCoy treatment-nontreatment feud. In any case, it is high time to call a truce on the potshots from both sides ("mite farmers", "beekeeping Taliban" or "chemical treadmillers"). Our bees are intermarrying kin to our neighbor's, and we are stuck with our relatives. The bare truth is that all of us are furthered by a shared goal – one that affects not only our apiaries but our environment: the wellbeing of the bees whose example of hive mind could benefit their keepers.

To begin with, there is agreement that Varroa is one of the major causes of bee mortality where it has invaded. From where it was first observed in 1952 in the USSR on the European honey bee (*Apis mellifera L*), it took only 35 years to spread throughout Europe, Asia, South and North America -- where it was found in 1987. Few places, such as Australia, are free of the mite. It is well adapted to travel on bees and move into brood cells to breed.

The hope is to come to terms with Varroa just as we have with the tracheal mite – which, according to Pettis, is no longer found in samples sent to the Beltsville USDA lab.

But this is a different critter. Tracheal mites perish outside the bee trachea from dehydration. In contrast is "the Varroa complex": The mite has an exoskeleton hard enough to allow it to live outside the hive but thin enough that it can slip between a bee's abdominal plates to feed. Among its sensory hairs are nail-like protuberances that deter bees from grooming them off. Varroa has a wax coating that absorbs the scent of the colony, giving it a chemical camouflage. Its feet, like a gecko's, can cling and move nimbly. It can respond to bee brood pheromones to time its entry into a cell, bury itself in the pool of food at the bottom and breathe through a tube adapted for the purpose. It doubles in numbers every month, building in strength as bee colonies naturally decline toward winter. By October, when the brood shrinks in size, the vast majority of mites that have matured in the cells become phoretic and ready to spread via drifting and robbing bees.

Varroa digest their food outside of their body by injecting spit into a bee, liquefying the nutrients and sucking them up. In that way, they spread viruses, and the way they spred them has changed the pathogens. Before the mite invasion, viruses were passed from queen to progeny – vertically transmitted. Because the host had to survive, the virus could not be lethal. But mites transfer the pathogens bee to bee, horizontally, injecting viruses, some of which have increased their malignity because they can kill their hosts without penalty.

Not only has the virulence of the viruses increased, the virulence of the mites has increased: "In the 1980s 20 mites per 100 bees was the threshold for colony loss," said vanEngelsdorp. "Now it is closer to 3 per 100."

The logical explanation is that chemical treatment over 30 years has selected for more resistant mites. That can be the case for the synthetic acaracides such as fluvalinate (Apistan) and coumaphos (Checkmite), which also remain in the wax these decades later – *all* of our wax according to entomologist Jim Frazier. It may become true for Amitraz as well, according to vanEngelsdorp: “To use this product four times a year is a disaster waiting to happen. It is a sure way to breed a resistant mite. Just using one product consistently is a very shortsighted option.” He recommends a combination of treatments. The bio-based, so-called “soft” chemicals like thymol (ApiLife VAR), formic acid (Mite Away Quick), and oxalic acid are thought to both dissipate and, because of the way they act, avoid resistance.

It’s widely acknowledged that treatment is a devil’s bargain. Pettis points out that the Beltsville bees treated with Amitraz now do better. On the other hand, vanEngeldorp said,“There’s no question that the presence of coumaphos, fluvalinate, and Amitraz negatively affect the queens and negatively affect workers. It’s like chemotherapy — you don’t do it because it’s good for you, but because it’s better than the alternative. So you do these treatments and realize that there is a cost. We’ve talked about these organic acids and essential oils as if they’re somehow better for the bees than the synthetics. They may be better but nothing is free.”

“What’s going to happen next? There is no secret backyard recipe,” he said. “The fact is that most [new] products are years away. We are in a very tough place for commercial beekeepers. We’re stuck with what we have right now.”

It’s a sticky wicket. No one approach fits all, although some can affect many. Schools of thought:

Option 1, *chemical treatment.* Schedule applications as soon as the presence of mites is detected in a test at the beginning of the season, treating as many as four times – often hard chemicals in spring and “soft” chemicals in fall. This approach has many reluctant adherants, and, among them, detractors: Zac Browning, an Idaho commercial beekeeper has called it “a perpetual cycle of diminishing returns.” It can be doomed if you do, doomed if you don’t: Frey and Rosencranz (2014) wrote, “Yearly treatments are indespensible.” [4] However, they quote Yves LeConte (2010), “‘there are frequent reports from beekeepers who complain of colony damage and high numbers of Varroa mites although the recommended treatment as been performed’.” Still, treating beekeepers fared best in the BIP data.

Option 2, IPM (Integrated Pest Management). This, like Kefuss’s Soft Bond Method, is a plan for using non-chemical management techniques and reserving chemical control as a last resort. “To my mind the common ground is IPM,” said Maryann Frazier. “That might be resistant stock or working toward that. You need a plan to deal with Varroa. You can’t just buy bees and not have one.”

Beekeeping courses taught by Spivak and Reuter at the University of Minnesota stress keeping resistant stock (e.g. bees bred for hygienic behavior and grooming), monitoring for mites, using nonchemical management techniques, raising queens from resistant colonies, and, as a last recourse, using organic chemical control, not synthetic miticides.[5] Spivak thinks this Soft Bond approach is the most realistic for backyard beekeepers in areas densely populated by other beekeepers where the risk of mite reinfestation is high.

Option 3, *Non-chemical management* The theory is to allow evolution to create parity – Kefuss’s Bond Method; he uses this live-and-let-die approach in his Toulouse apiary, which is nearly mite free as reported from examination by numerous visitors. Such an approach has been demonstrated by others, notably Yves LeConte, head of the French national bee lab.

An example of untreated bees coming to parity with mites is found in the feral colonies studied by Tom Seeley of Cornell: "We show that while the honey bee population has been hard hit by the introduction of parasitic mites, it most likely did not go extinct. Rather, the bees have rapidly evolved to tolerate the mites'presence, and now exist at the same colony densities today, as they did in the past (2013)." Contributing factors for the success of those feral colonies are their isolation and small size.

South Africa's live-and-let-die approach to the Varroa infestation had the similar result, according to researcher Mike Allsopp, "that we very rapidly eliminated the susceptible stock from our population. The same strategy would probably develop varroa tolerant bees anywhere in the world… Doing nothing can be the best thing to do."

"I ask myself, why are we treating?" said Pettis. "Why do we put these things in our hives? I think if we all go cold turkey for hard chemicals, in three to five years the host-parasite relationship will stabilize. But that would leave commercial beekeepers without a livelihood and no bees to breed from" in the interim.

Pettis says that mite treatments are not needed in Brazil, but he points out that American beekeeping is not comparable to South Africa or South America: There the subspecies is *A. m. scutellata* -- Africanized bees that already have behaviors that promote reisistance. Nevertheless, the approach has advocates here.

Long before the arrival of Varroa, Virginia apiarist and EAS Master Beekeeper Billy Davis was working with cattle and saw that lice treated with Apistan became resistant. "I knew ahead of time that would not be the way." He is among those who have opted to run carefully monitored chemical-free breeding programs .

Like base jumping, it takes skill to choose this approach. Spivak says that the "Hard Bond" method can work for beekeepers in relatively isolated areas that start with a large number of colonies, are willing to take severe losses for a period of time, and know how to raise queens from surviving stock. Beekeeper Rob Keller, who keeps his bees without chemical treatment, described the concurrent responsibility of that choice to "never let a colony circle the drain". Breeding this way for resistant stock requires collaborative neighbors or a relatively remote apiary in order to control mite infestation and genetics.

What concerns VanEngelsdorp is that mite and disease laden bees from failing colonies can migrate, infecting others. His bomb analogy comes from his interpretation of data from APHIS (USDA Animal and Plant Health Inspection Service), the BIP National Survey as well as Tech Team reports on mite levels sampled from from commercial beekeepers over the course of the year. These various data sources show otherwise unexplained spikes in mite loads; his interpretation is that the collapse of infested colonies can be "landmines that blow up and spread to their neighbors."

"From many global independent sources, five [mites in a sugar or alcohol test] seems to be the point where you start seeing critical problems."

Infested bees do migrate from failing colonies, according to the study of Frey and Rosencranz -- about 100 yards in a month to 4 miles in 3 months. Interestingly, that study also showed that crowding makes colonies more susceptible to infestation, in their case four times more. A high density apiary lost nearly 60% of the bees, whereas a less dense apiary remained “below the damage threshold”. It is worth noting that the subjects were treated bees with treatment withdrawn that subsequently proliferated mites; the study was not designed to evaluate resistant stock.

“Robbing of a dying or dead colony's honey is not unusual, especially if the colony’s decline coincides with a nectar dearth,” wrote Seeley. “Varroa can climb onto robber bees, and indeed are increasingly apt to climb onto the foragers/robbers (not just the nurse bees) in a colony as the Varroa abundance increases.”

Most colonies in the US -- 95% -- are commercially kept by 5% of beekeepers, whereas 95% of beekeepers are backyarders and keep 5% of the colonies. Of backyard beekeepers, 70% report to BIP that they don’t treat for mites; the data show they have higher losses than treating beekeepers. Also, stationary beekeepers had higher losses than migratory beekeepers.

VanEngelsdop says, “This is correlative data, which is not the same as causation” and he shows graphs of nonsensical coincidences to prove his point. He adds, “This data is mono-factorial. We’re just asking one question at a time.” That information comes from a nation of individual beekeepers willing to fill out detailed annual questionaires and a skilled team to sort it all out. They have been at it for five years, long enough to come up with some telling results. VanEngelsdorp emphacizes that relationships among those data have not been established, although a multifactorial analysis is now being made.

Here’s the thing about facts. No matter how much we are told that their relationships not known, we humans have a need to join them together. Absent interstacial information, we fill the void with speculation. Supposition about how these data fit together range from informed guesses to jumped-to conclusions. What’s true is that there is more than one way to assemble the puzzle pieces.

A much-repeated explanation is that novices with good will toward saving the bees often order random stock of unknown characteristics with the belief that leaving the hive unmanaged will trigger advantageous selection. Jim Bobb, president of the Pennsylvania State Beekeepers Association, said “For some it is like having pelergoniums, [annuals] that die and are just bought again for the next year.” Spivak adds that the treated packages in this cycle “just pass the buck”.

Mites are equal opportunity parasites, and neglected backyard colonies are surely among their progenitors. “Invasion does happen, that’s not new,” said Pettis.

It happens a lot of different ways. Pettis cals it “a mixing bowl”. Seeley speculated, in a 2013 study, that a mite infestation originated from a large treated hive into his untreated hives. VanEngelsdorp said, “[Migratory] holding yards spread mites” – where large numbers of colonies are exposed to condensed pests and pathogens. Failed and missed treatments also contribute, according to Spivak. So there is, as always, more to the story (this one as well): For example, a recent NPR interview with Spivak leaves out critical components of her view that infestation is not only a backyard problem, and the longterm goal of breeding for resistance that she pioneered.

The facts are that some beekeepers report not treating, and collapsing Varroa-infested colonies do proliferate mites, but it does not follow that all untreated colonies create "mite bombs" or that all such infestations come from untreated colonies. From the numbers above, assuming most commercial apiaries are treated, it comes down to 3.5% of all colonies that are not treated, and of those, it is not known how many have resistant stock and/or are managed with non-chemical controls for mites in the hands of skilled beekeepers.

Whatever the exact number, a large share of blame is placed on under 3% of beekeepers as progenitors of mites. Among these people are some who could be contributors to solutions if their measured voices are heard and the genetics they foster are shared.

But interviews at the July EAS conference reveal a disturbing pattern of long-time beekeepers who manage mites without chemicals and prefer not to enter the discussion. One, an instructor for his regional bee club who teaches the range of treatment choices, has kept his own bees without chemical treatment for eight years. He said "I prefer not to talk about it, it's so contentious." A recent bee chat posting: "[nontreatment beekeepers are] afraid to say things on this forum because of the very negative comments they have received." Kirk Webster, who supplies untreated resistant queens to that beekeeping instructor and to others, said, "they feel marginalized and judged."

"There is enough damage done by treatments," said Pettis, "That the difference in mortality increase among those who don't treat and those who treat balances out." He is among researchers, including Spivak, who think that the time and attention small-scale beekeepers can put in to treatment-free breeding could provide genetics for commercial beekeepers.

A repeated statement, delivered as a dictum, compares untreated bees to an untreated family dog. Whether the line is drawn on insects as pets at butterfly and mantis cocoons or Uncle Milton's doomed ant farms (queenless by law but fascinating for generations), the most compassionate option could be to address the health of the entire interacting population. It could be ultimately more caring to reevaluate chemical treatment, just as we have reevaluated the use of antibiotics for our own children.

"We have come so far with chemical treatment, we can come back in the other direction," said Pettis.

How can that happen? "A stark message motivates change," said vanEngelsdorp – whether it is more mindful control of mites or greater proliferation of resistant stock.

Part II of this article will explore these possibilities.

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[2] *https://beeinformed.org/*

[3] Danka, Robert G, Thomas E Rinderer, Marla Spivak, John Kefuss (2013) Comments on: "Varroa destructor: research avenues towards sustainable control", *Journal of Apicultural Research* 52(2): 69-71.

[4] Frey, Eva and Peter Rosenkranz (2014) Autumn Invasion Rates of Varroa destructor (Mesostigmata: Varroidae) Into Honey Bee (*Hymenoptera: Apidae*) Colonies and the Resulting Increase in Mite Populations, *Journal of Economic Entomology*, 107(2):508-515. 2014.

[5] *http://www.beelab.umn.edu/sites/beelab.umn.edu/files/_2016_disease_pdf_version_s.pdf*