Taming the Mighty Mite:

Some Thoughts on Living with *Varroa*

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I was one of those weird kids who was always turning stones or poking about in the undergrowth looking for bugs. The hidden and poorly known world of bugs fascinated me then and it still does today. I am a Professor of Biology at Western Carolina University where I teach, among other things, about the evolutionary biology of spiders and other arthropods. I am also a beekeeper who approaches *Varroa* from a different perspective; one I would like to share with you in this article.

As a kid growing up in Wales, I clearly remember gleaning everything I could about honeybees (library books on the topic being quite scarce) and I can still vividly recall the thrill of meeting a real beekeeper for the first time. I spent time in his apiary (full of WBC hives I remember); I was intrigued by his "power over the bees" and seduced by all his beekeeping paraphernalia. To encourage me, he gave me an old rusty smoker that I treasured. Alas, the thought of keeping bees ("stinging everyone to death") on a council housing estate (housing project) was not something my parents would entertain. It was many years later, in the 1980s in Wales, that I got my first bees. Since then, I have not been in any one place long enough to contemplate keeping them again until I moved back to the mountains of Western North Carolina in 2007.

Of course for anyone getting back into bees these days, it's not long before *Varroa destuctor (*Anderson & Trueman, 2000), a name not yet in my lexicon in the 1980s or indeed that was even known to science until 2000, raises its head. During my re-introduction to bees in the Buncombe County Beekeepers' bee school four years ago, a great emphasis was put on the beekeepers' public enemy #1 and how to combat it. But I was also relieved to hear a growing number of voices, especially here in the mountains, that saw the value of practicing, for want of a better term, "natural beekeeping". This philosophy is broad enough to encompass a wide range of management techniques, from those that totally eschew "hard" chemical treatments but feel comfortable with softer or "natural" treatment regimes based on volatile oils, powered sugar, etc. to those folks who "let nature work" and avoid all forms of treatment. I fall into the latter category and the purpose of this article is to provide you with enough of the science that underpins my rationale to let you make an informed choice about your own management decisions.

"Will I lose my bees if I don't treat?" Yes, some of them; sometimes losing large numbers are an inevitable consequence of selecting for a better mite as well as selecting for a better bee. Losses must be figured into a management plan. While the focus over the past ten years has rightly been on breeding mite resistant bees (we are all familiar with New Minnesota Hygienics, Russians, Suppression of Mite Reproduction (SMR Trait), Varroa Sensitive Hygiene trait (VSH)), virtually no one is considering the option of selecting for a better *mite*. Better here means a less virulent strain of *Varroa.* There are two pieces of compelling evidence that suggest non-treatment will result in less virulent mites *and* better adapted bees: Tom Seeley's 2006 Arnot Forest (NY) study, that did not get all the attention it deserved, and the real life trial conducted unwittingly in East Africa from 1997-2009 reported on in Frazier et al. (2009). I will return to both these examples later.

What of the science behind this approach? Mites, *Varroa* or another mite taxon, will always be ectoparasites of bees. They are exquisitely adapted for the task. And given the habits and especially the eusociality of honeybees, some taxon will always "take advantage" of the almost perfect conditions to protect, feed and reproduce themselves. In the process, viruses will take advantage of the mites' mode of feeding and add themselves to the mix of transmission. Viruses are another increasingly important issue and are of major concern to beekeepers. But they too, even though not alive, still operate under the same constraints of natural selection.

Firstly, as beekeepers, we need to understand the nature and scope of mites in general. When I teach my biology classes I pose this question to my students: "Are mites the ultimate arachnid—or even the ultimate animal?" They are certainly one of the most highly evolved and were among the first land animals. The oldest known mites are from the Late Devonian, 365 million years ago. Honeybees by comparison are maybe ten million years old. With 40,000 described species and perhaps more than a million in total, mites are the largest of the twelve arachnid orders (the others include spiders, scorpions, daddy long-legs, etc.). They are also the most important, both medically and economically.

There are few habitats mites have not utilized (I can't think of one right now!): terrestrial, freshwater, marine, deserts, Antarctica (the only one of two animal groups able to survive there), hot springs, your mattress—they even live in your eyelashes! Mites may be phytophagous (plant feeding), zoophagous (predators and parasites), or saprophagous (detritivorous). Those which feed on vertebrate hair or blood often carry disease organisms, such as spirochete bacteria, responsible for relapsing fever and Lyme disease. Others, ticks, chiggers, and skin mites cause mange and scabies. *Yet, the vast majority of mites are free-living,* and are found in great abundance in soils, plant litter, and even in water. Without free-living soil mites, vital to maintaining fertility, there would be no plants for our bees to feed on! To put some perspective on this, Howard Ensign Evans in his book *Life on a Little Known Planet* estimates an acre of English pasture supports 666,300,000 mites (mostly oribatid mites). The take-home message concerning mites is that they are part of the vast army of arthropods that run the planet. They are not going anywhere, no matter how many thousands of tons of pesticides we dump on them, so we had better get used to mites and figure out ways to live with them.

As beekeepers, the only long-term sustainable way to "live with them" is to create the optimal conditions for natural selection to operate. *Varroa* is an ectoparasite, feeding on the hemolymph or blood of bees, and not a parasitoid, such as a parasitic wasp whose larvae feed on caterpillars and always kill their host. *Varroa* have evolved not to kill their hosts. Given time and the right conditions, *Varroa* will become as relatively benign as tracheal mites, as has been shown in South and East Africa. Any type of "treatment" impacts the system and slows down or completely eliminates the processes leading to equilibrium. It's a short-term, non-sustainable fix that produces a pesticide-resistant mite and (at best) severely compromised bees. Of course the pesticide producers go to inordinate lengths to convince us of the value of pesticides, but science and past experience tell us otherwise.

Another important piece of the puzzle is to understand that *Apis mellifera*, the Western honeybee, is not *Varroa destructor's* natural host. *Varroa destructor* is native to Asia where it parasitizes *Apis cerana* (the Eastern or Asian honeybee). Because *A. cerana* and *Varroa destructor* have co-evolved over a long period of time, their host/parasite relationship is stable, and the bee is rarely negatively impacted by the mite. Only when colonies of *A. mellifera* were established in Asia and a host shift occurred was it demonstrated how devastating the mites could be. This shift was not instantaneous but may have taken 50-100 years (Webster & Delaplane, 2001). Typically when any pathogen/parasite makes a host shift it becomes super-virulent because the new host has no naturally evolved defenses or strategies. What we should be striving for is a situation where *Varroa destructor* becomes a relatively benign ectoparasite of the Western honeybee, *A. mellifera.*

We also need to understand the basics of the process that will lead to a sustainable bee-mite relationship. Natural selection is a suite of processes by which certain heritable traits that make it more likely for an organism to survive and successfully reproduce, become more common in a population over successive generations. It is a key mechanism of evolution. It requires three conditions: a) adequate genetic variation among individuals in a population, b) pressures for selection, caused by some environmental factor, and c) sufficient time—and in cases of co-adaption, sufficient interactions between the two taxa involved, as is the case with *Varroa destructor* and *Apis mellifera.* As beekeepers we are able to impact all three conditions, albeit both positively and negatively. A critical piece is maintaining a high degree of genetic diversity in our stock: a) through selection, which can only occur where there is a large pool of genetic material to select from; this is generally not achieved by purchasing queens from a handful of queen producers who are themselves reducing genetic diversity (a whole other issue that cannot be covered here); b) through pressures for selection to occur, which means letting the bees and mites live together for adequate amounts of time—and not producing resistant mites and compromised bees by chemical treatments; and c) by minimizing horizontal transmission and maintaining a particular strain of mite with their original host stock as much as possible.

So what does the science tell us about this approach? It is significant that there is almost nothing in the literature and just one empirical paper that I could find. In 2006, Tom Seeley reported that feral colonies of European honeybees that were well established in the Arnot Forest since at least 1978 were infested with *V. destructor*. Interestingly, their mite populations did not surge to high levels in late summer. To test if the Arnot Forest bees were able to suppress reproduction rates of mites, therefore displaying a degree of mite resistance, colonies of these bees and New World Carniolans were inoculated with mites from an apiary. The growth patterns of their mite populations were compared and no difference was found between the two colony types. This strongly suggests that the stable bee-mite relationship seen in the Arnot Forest bees reflects mite adaptation for less virulence and not bee adaptation for resistance to mites. Whereas the data supporting the avirulence of the Arnot Forest mites and a stable bee-mite relationship are convincing, when bees are managed in a typical bee yard, opportunities for unintentional horizontal transfer (as a result of infected bees drifting to other hives) as well as intentional horizontal transfer (when making splits) is high. To my knowledge, only Tom Seeley is working on this with a series of experiments with these same bee-mite populations in a controlled bee yard environment with specific management protocols (personal communication).

In a recent paper, Frazier et al. (2010) surveyed a large number of colonies of *Apis mellifera capensis* and *Apis mellifera scutellata* in widespread locations in East Africa. Almost all were infected with *Varroa destructor*. Since its introduction to South Africa in 1997, there was an initial rapid decline in native honeybee populations over seven years. However, East African beekeepers when surveyed were not even aware of the mite's presence nor had they observed any negative impact on the survival and/or productivity of their bees. The authors report (p. 463): "Yet 12 years after the mite's introduction, honeybees of both *A. m. capensis* and *A. m. scutellata*, feral and managed populations alike appear to exhibit levels of tolerance that have reduced the pest status of this mite to 'incidental' according to Allsopp (2006). He further speculates that increased hygienic behavior and a lack of chemical control used by beekeepers, is in part, responsible for this tolerance." While it was not shown that these mites had been selected for avirulence *per se*, the data do support a hypothesis that a stable bee-mite relationship had evolved in only twelve years and was probably a combination of an increase in bees' resistance to mites and a decrease in mite virulence. But critically, it was the lack of chemical control measures that was responsible.

So what does all this mean for how you manage your bees and your mites? The underpinning concept is virulence theory, which has been shown to hold up for a number of pathogens and parasites and is really very simple. If we strive to keep the same strain of mites with their host bees over time, the theory predicts the mites will become less virulent irrespective of any mite resistance the bees might acquire in the process. The process is called vertical transmission. Tom Seeley (p. 20) describes it like this: "Virulence theory suggests that vertical transmission, in which parasites are passed from host parent to offspring, promotes the evolution of avirulent parasites because the reproduction of the parasites is linked to that of their hosts." In other words, if the host reproductive success is heavily impacted by the mites, then the mites also do poorly. This is unsustainable and over time, the individual mites that reproduce and make less of an impact on their host will be favored. Their genes will accrue into the next and subsequent generations such that over a period of time, the whole population moves towards an avirulent, stable bee-mite relationship. Seeley (p. 20) states, "There are strong indications that a balanced host-parasite relationship, in which both bees and mites survive, has evolved in isolated populations living under feral or feral-like conditions in several locations." This of course assumes that very little drift is occurring between hives that would lead to the other type of transmission—horizontal. On this mode of transmission Seeley (p. 19) says, "Virulence theory suggests that horizontal transmission, defined as infectious transfer among unrelated hosts, promotes the evolution of virulent parasites by favoring those that strongly (and thus harmfully) reproduce in current hosts before moving on to new hosts" (Ewald, 1983; Bull, 1994). As beekeepers we engage in management protocols that include: chemical control of mite populations, keeping hives in too close a proximity (which encourages drifting and robbing), transferring brood combs (and their mites) between hives, and preventing swarming, all of which promote horizontal transmission and therefore more virulent mites.

Alternative management techniques that we should consider include: starting with mite tolerant bees, maximizing genetic diversity in our queens, making summer splits, and minimizing horizontal transmission. Summer splits are a good management tool, but when transferring frames, keep host and mites together and avoid mixing brood frames from different hives, even if it means making a smaller split. On the issue of using drone comb baits, the jury is still out. Common sense and the theory of natural selection predict that over time this practice would select for those mites that reproduce in worker cells, but there are no hard data out there.

Finally, on the issue of chemical control of *Varroa*, recent work by Frazier (2008) on the extent to which our bees are impacted by the acaricides we put in the hive (particularly Coumaphos, an organophosphate, and Fluvalinate, a synthetic pyrethroid) makes sobering reading. Further, when we understand the plethora of pesticides, herbicides and fungicides that bees bring back to the hive from the environment and the largely unknown sub-lethal and synergistic effects of their combinations, it is little short of miraculous that honeybees are able to exist at all. These man-made environmental stressors, in conjunction with the honeybee genome finding that bees have about 66% fewer genes involved in immune responses when compared, for example, to flies such as *Drosophila* (fruit fly) and *Anopheles* (mosquito), is further cause for alarm. We need to be aware that on top of everything bees are dealing with, they have a naturally low resistance to pathogens in general. Maintaining a highly sensitive immune system is very expensive metabolically. Selection for low numbers of immune genes suggests a higher investment in colony level protection against pathogens, i.e. propolis. Understanding the functioning of propolis as a whole colony immune defense is a new and exciting area of research being conducted mainly at Marla Spivak's lab at the University of Minnesota.

This article has been written from the perspective of the hobby or sideliner beekeeper but arguably the real issue is how commercial producers can circumvent the pesticide treadmill and still make a viable living. While many commercial beekeepers are sympathetic, there is no easy answer—only a change to a management system that expects and manages for losses (which incidentally, data show are no more on average than the consistent trend over the last few years of approximately 30% across beekeepers of all stripes).

To conclude, my intention is not to turn you into an arachnophile, but to ask you to consider a mind shift that accommodates mites and manages them in ways that promote stable relationships with their hosts. The bottom line is that it is futile in the long term to try to eradicate *Varroa*. So what alternatives do we have? Anecdotal evidence from my own bee yard and chemical-free beekeeping friends suggests that after three years with losses (sometimes heavy after years two and three), hives settle down and seem to do well. Adopting the vertical transmission protocols advocated here might well even shorten that period. Do the math. Can you deal with the inevitable losses in the beginning? With poor weather and unpredictable nectar flows, beekeeping is not an exact science, but there are things we can do to level the playing field towards establishing stable bee-mite relationships or at the very least adopt management techniques that do not work against making that long term goal a reality.

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Excellent source of information on Varroa: University of Florida; Florida Department of Agriculture and Consumer Services, entnemdept.ufl.edu/creatures/misc/bees/varroa_mite.htm

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