Mite Zapper—A New and Effective Method for Varroa Mite Control

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Abstract

Varroa destructor (formerly *Varroa jacobsoni*) is a mite parasite which causes tremendous damage to honey bees in the U.S. and worldwide. Varroa mites can kill honey bee colonies within 1-2 years if left untreated. Various chemicals have been used to control the mite, but unfortunately chemicals can potentially harm bees and also contaminate honey if not used carefully. The mite pest is also developing resistance to chemicals. In the U.S., the main chemical used against the mite, Apistan®, is losing its potency in treating mites in many states because of mite-resistance.

It is well known that drone brood is 10-12 times more attractive to mites compared to worker brood. Once honey bee workers seal the immature drone cells, mites suck hemolymph from the brood and reproduce in a safe environment where few chemicals can penetrate through to reach the mites. The so-called "drone trapping comb" method entails removing the sealed drone brood combs and putting them into a freezer to kill the mites, together with their hosts. This method has been used extensively by small beekeepers in Europe because it requires no chemicals. However because the method is very labor-intensive, it is not practical for beekeepers with more than a few dozen colonies, and few beekeepers in the U.S. use it.

The newly invented "mitezapper" combines mite biology and a heating element inside the comb to kill mites. Consisting of resistant elements in drone combs, the device will attract most of the mites in a colony (over 90% of mites if no worker brood is in the colony). The new invention requires no opening of the hive and beekeepers need simply to hook up two terminals outside a hive to a battery for 2-3 minutes. Resistant elements in the comb heat and kill both the mites and the drone pupae. It *is* possible to regulate the temperature to kill mites only and not to harm the drone bees. Drone bees contribute little in a regular colony, so they are disposable to beekeepers.

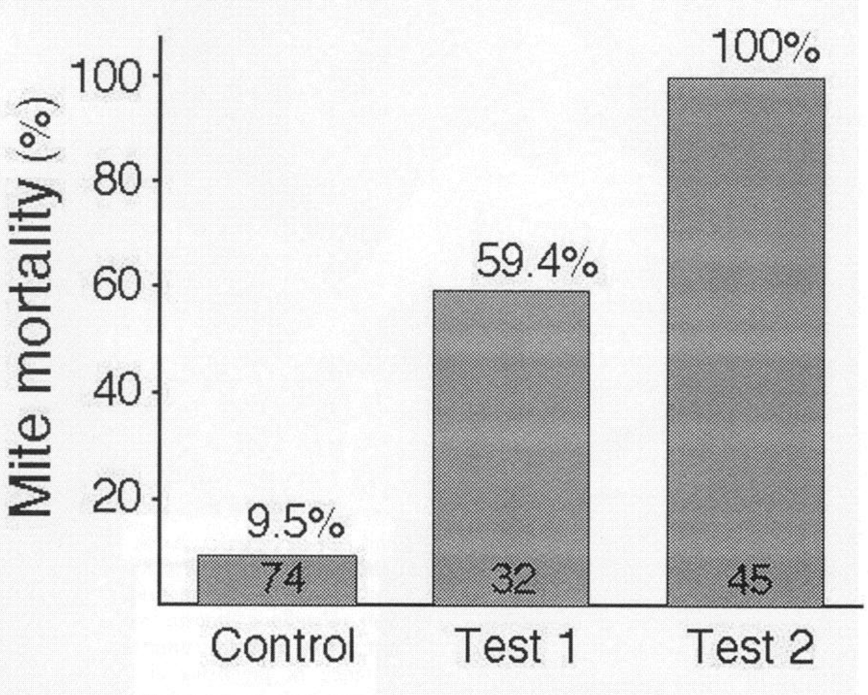

Figure 1. Natural mite mortality (control) compared to mites after the Mitezapper treatment. Numbers inside the bars are the numbers of mites tested in each treatment. Results among the three groups are highly significant (G-test for homogeneity, P<0.001).

Introduction

Since 1987, the beekeeping industry in U.S. and the pollination of many fruits and vegetables have been tremendously negatively affected by the Varroa mite, *Varroa destructor* (formerly *Varroa jacobsoni* Oudemans) (Acari: Varroidae). The varroa mite is an ecto-parasite of honey bees and is distributed worldwide (Matheson 1993, 1995). The mite used to be effectively controlled with Apistan®, but mite resistance against this chemical developed in Europe (Milani 1995) and recently also in California and Florida (Baxter et al. 1998, Elzen et al. 199X) in the U.S. Currently many states in the U.S. have emergency registration (Section 18) of coumaphos as au alternative treatment for the mite. However, coumaphos, an organo-phosphate pesticide, is highly toxic to humans and other animals, and might be removed by Environmental Protection Agency due to its high toxicity and the requirement of legislation, the Food Quality Protection Act. In addition, emergency registration only allows a limited, short-term, single use application and is granted in a state-by-state, year-by-year basis. A third chemical, formic acid, is approved in gel form for mite control, but it is only about 70% effective against the Varroa mite (Eischen 1998). There are several drawbacks associated with pest control using chemicals. One is that the pest will eventually become resistant to the pesticide, as is happening with Apistan®. A second problem is the possibility of pesticide contamination of honey bee products, such as honey, beeswax, and pollen. Chemical treatment

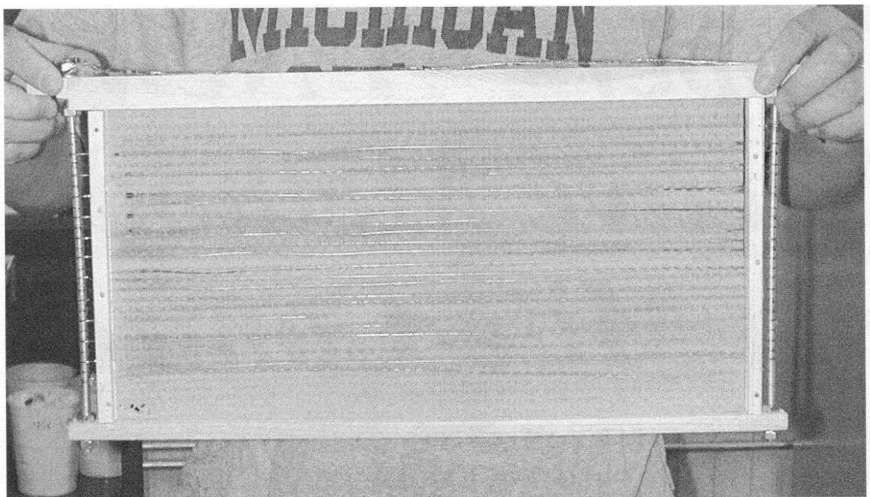

Photo 1. Closeup of Mite Zapper drone foundation unit.

can only be used during periods of no "honey flow" (before May and After September, when few flowers are blooming), thus is very inflexible in its timing. In addition, chemical control is costly for beekeepers and shrinks the profit margin, which is small to begin with, even further. For small beekeepers, Apistan® or Checkmite+ cost about $2 per strip and it takes four strips to treat a colony two times a year. Because of these reasons, it is highly urgent to find new methods for mite control, especially non-chemical methods.

Mite biology

All bees develop from eggs, to larvae, to pupae ("brood") before finally becoming an adult. The larval cells are sealed with wax capping when they are ready to pupate. This capped stage lasts 12 days in workers and 14.5 days in drones (male bees). Female Varroa mites invade "brood" cells l-2 days prior to capping. The mother mite then produces a male egg and 5-6 female eggs. During this stage, the mother mite and its offspring are protected against worker bees or chemicals, because the wax capping of the cell creates an excellent barrier. Daughter mites mature in 6-l days and emerge with the adult worker or drone to repeat the cycle (Reviewed by Sammataro et al 2000).

The immature stages of drones are 10 to 12 times more attractive to mites compared to worker brood (Boot et al 1992, 1995). It is advantageous for mites to prefer drones because they have a higher reproductive output on drones. A mother mite produces 2.6 daughter mites on drone pupae, but only 1.3 on worker pupae, (Schulz 1984), mainly because the immature stage of drones is 2 days longer than that of a worker. In addition, there might be nutritional differences between drone and worker brood. For example, Varroa mites on *Apis cerana* reproduce exclusively on drone brood, being unable to reproduce on worker brood (Rosenkranz et al., 1993; Anderson, 1994). Mainly due to this reason, the mites never cause any significant damage to the Asian honey bees because their population never gets large in a hive.

The "drone-trapping" method

The fact that mites are more attracted to drone brood has been used to develop the so-called "drone trapping" method. This method involves the following four steps: 1). Open a colony and place a drone frame into the colony. The workers will clean the cells and the queen begins to lay drone eggs in the cells (drone cells are larger than worker cells and the queen would only lay unfertilized eggs in these cells, which develop into drones). 2). Wait for about 20 days so that the drone cells are sealed and the mites are "trapped" inside these cells. 3). Open the colony again and remove the sealed drone brood frame, and 4). Store the brood frame in a freezer to kill the drone brood and the mites, or remove the drone brood capping and rinse the cells. If there is no worker brood in the colony, the method can remove over 90% of mites with a single treatment (Calis et al 1997). If there are worker brood in the colony, they will compete with drone brood in "trapping" the mites, so the efficiency will be lower. Assuming that drone brood is 20% of the total sealed brood in a colony, and that the drone brood is 10 times more attractive than the worker brood, then 71% mites will be trapped in the drone brood. Applying the method two times in a row would remove 92% mites. Because of its high efficiency and non-chemical nature, this method is popular in Europe (Jenter 1986, Fries and Hansen 1989, Schmidt-Bailey et al 1996, Schmidt-Bailey and Fuchs 1997). However because of the many steps involved, the method is time-consuming and labor-intensive and has not been widely adopted by the American beekeepers.

The "Spartan" Mitezapper

The Mitezapper combines mite biology with simple physics. A drone comb with heating elements embedded in its "foundation" (the base from which worker build their wax cells), instead of a regular drone comb, can be placed into the colony. After the drone cells are scaled, one can simply go to the hive, connect the two terminals outside the hive for l-5 minutes and the treatment is done! Electricity going through the heating element will produce heat and kill both the drone pupae and the

Photo 2. Drone comb shown attached to portable power unit.

mites. Bees will open capped brood cells and remove dead or dying brood (Boecking et al 1993, Spivak 1996). Therefore, the drone comb is ready for the **queen to lay eggs again** after **3-5** days. The main improvement of this method compared to the traditional drone trapping method is that one does not have to open the colony a second time, nor does the drone comb require further handling (being frozen, or uncapped). The "treatment" (applying heat through electricity) can be done multiple times and has a large time window (about 14 days during which the drone cells remain sealed). It is also possible to engineer the Miterapper to have the heating shut off at 44°C, at that temperature mites die, but drone bees are unharmed (BrØdsgaard and Hansen 1994).

Preliminary results

To prove that this method works, there are several questions that need to be answered. For example, will workers build normal drone wax cells when there is a metal wire embedded? Will the queen lay eggs in such a cell? Will mites invade drone cells built upon wires? How high is the mortality when heat is generated? Will the heat melt the wax when the "electricity" is applied?

To answer these questions I constructed two Prototypes. The heating element was regular wires used to strengthen wax foundation. I embedded the wires in the wax foundation with a 12 volt battery charger (6 A), which beekeepers routinely use. Each frame had wires going across 12 times. The two frames were placed into a colony that had not been chemically treated for mites. The workers built normal drone cells on the foundation, cells were sealed normally, and mites invaded these cells. In the first test, with ambient temperature at 27°C, and the average resistance at 1.8 Ohm, it took 5 min to reach 45°C (temperature sensor was put in one pupae), and the mortality was 59%. In a second test, the ambient temperature was 32°C, resistance was 2.0 Ohm, and it took 1.5 min to reach 43°C. I allowed three more minutes of "zapping" after the temperature reached 43°C. This time all 45 mites were dead, a 100% mortality. Mites not subjected to the heat treatment showed a natural mortality of only 9.5% (Fig. 1). (More recent fine-tuning of the method now shows that the entire comb can be heated to the required temperature in about IO seconds, according to the author.) The device therefore is highly effective in killing mites in a laboratory setting. However, wax near the wires melted down. Clearly, in the final product, the wires have to be embedded inside plastic, preferably plastic that is heat resistant. WC are currently conducting field trials to determine whether using this method alone is sufficient to suppress Varroa mite populations so that colonies can survive the winter.

Conclusion

We are currently searching for a manufacturer to produce the Mitezapper. There will be a few engineering problems to be solved, but the principle of using heat generated by foundation wires works. The final product is estimated to be less than $10 a piece and can easily last up to 10 years. The cost would be $1 per colony per year, compared to $8 per colony per year if using chemicals. This would save beekeepers in the U.S. millions of dollars per year with a current estimate of 2.3 million colonies and assuming 50% of the colonies receive chemicals for mite control.

I anticipate that the Mitezapper will be proven to be an effective tool for varroa mite control. The device takes the advantages of the weak point in the mite biological cycle. No chemicals are used, so that honey produced this way is truly "organic".

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