Breeding of Honey Bees Resistant to Varroa jacobsoni

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There are several honey-bee mechanisms of resistance to the Varroa mite. If we can incorporate some of them into our general bee populations, we can defeat Varroa.

Introduction

VARROASIS has been the most serious problem for European beekeeping during the last years. Many efforts have been made to find efficient chemotherapy or biotechnical therapy. But the best solution would be to breed a varroasis-resistant strain of honey bees. Thus, the question arises, is it possible to breed honey bees resistant to pests or diseases? Let's look at some examples.

Examples of breeding bees resistant to pests or diseases

The acariosis disease caused by *Acarapis woodi* swept away 90% of bee colonies in Britain in the years 1913-1915. But Brother Adam (1987) noticed, that while the indigenous British black bees perished, those of the Ligurian origin survived. He was able to replace all those bee colonies which died by that Italian variety. Later, he selected a more resistant strain of bees, so that today acariosis is not a problem in Britain.

Another well known example concerns breeding of bees resistant to American foul brood (AFB). Park *et al* (1937) found, that some bee colonies were resistant to AFB even when disease killed brood was added to them, while other colonies died after being inoculated with spores of *Bacillus larvae*. The breeding program was continued, which resulted in production of a highly resistant strain of bees. After 15 selected generations from 1935-1945 resistance reached 98%. The mechanism of this resistance was also investigated. Woodrow and Holst (1942) found that resistant lines remove dead larvae while susceptible ones fail to do that. Later on, Rothenbuhler (1964) found that hygienic behavior of adult bees was responsible for the resistance. Worker bees of the resistant strain uncapped cells quickly that contained dead larvae and removed them from the cells, Two genes : u (uncap) and r (remove) were responsible for that behavior. Honey bees homozygous for both genes were resistant to AFB.

Experiences presented above show us that two questions should be answered to successfully conduct breeding for resistance to varroasis:

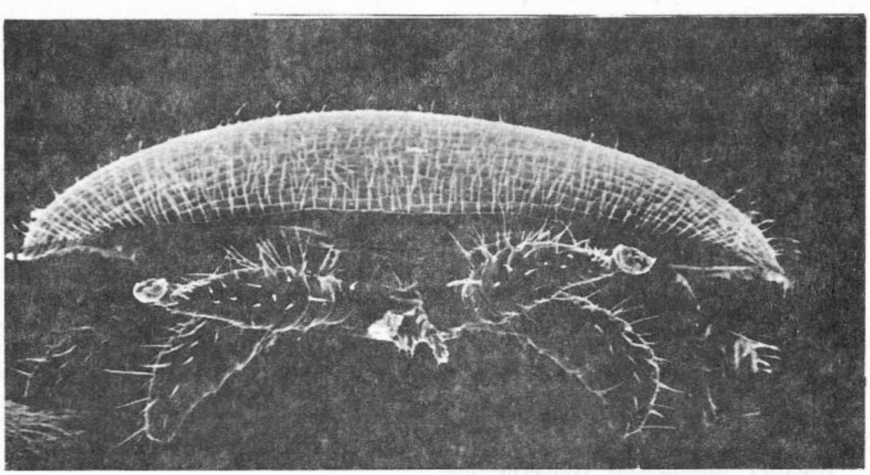
1/ Does there exist variation in resistance to varroasis between different bee colonies?

2/ Which are the mechanisms of resistance to varroasis?

Knowledge of these questions will facilitate and speed the breeding of a resistant strain.

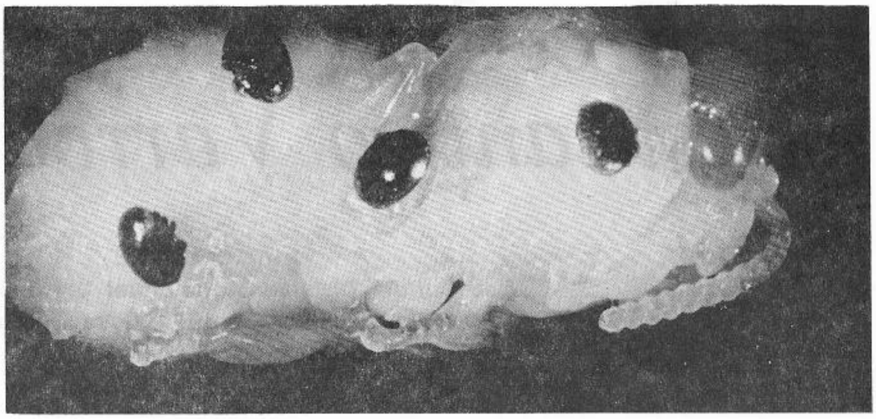
Variation in resistance to varroasis

The phenomenon of *Apis cerana* resistance to *V. jacobsoni* is well known. But differences in resistance to *V. jacobsoni* also have been found in *A. mellifera*. Differences were found to exist between different subspecies, ecotypes and even colonies of the same race of the honey bees. Infestation of hybrid European bees in Uruguay varied between 18 and 21% and dropped to 5.5% after two years (Ruttner and Marx 1984), while infested untreated bee colonies in Europe die within that time. Infestation of Africanized bees in Brazil does not increase and remains at similar low levels. As a result, Brazilian beekeepers do not treat their colonies to control the *V. jacobsoni* mite (De Jong, Seiner, Goncalves and Morse 1984). Average infestation of European bees in South Vietnam is 5% despite the fact that bee colonies have been in-



Enlarged photo of Varroa

fested for 20 years, and no chemical treatment has been applied (Woyke 1987a). Genetic differences were also found between different lines of Italian, Carniolan and Caucasian bees in Israel (Ron and Rosenthal 1987). Genetic heritability of resistance for Italian bees was 0.36-0.25. This variance of honey bee resistance to varroasis makes us hopeful about developing bees resistant to *V. jacobsoni*. Actually two-way selection for high and low resistance to *V. jacobsoni* already have been started (Kulinčevic and Rinderer 1987).



Varroa mites on honey-bee larva

Mechanisms of resistance to varroasis

Some mechanisms of the resistance are already known. *V. jacobsoni* does not increase its population in *A. cerana* colonies, because the female mites do not reproduce on worker brood. In seven examined, *A. cerana* colonies, worker brood was infested in 2.5% and drone brood in 10.3%. But not one female mite reproduced on worker brood, while 100% reproduced on drone brood. Thus the reproduction of *Varroa* in *cerana* colonies is limited to drone brood only (Koeniger, Koeniger and Wijayagunasekara, 1981).

Differences in *V. jacobsoni* reproduction were also found within *A. mellifera* bees. While 20% of female mites do not reproduce on worker brood in Europe, as many as 60-90% did not reproduce in Uruguay (Ruttner and Marks 1984). When brood of European and Africanized bees were put into the same colony, brood infestation was almost identical – 9.4 and 8.6%, respectively. But as many as 75% of mites reproduced on worker brood of European bees, while only 49% on brood of Africanized bees (Camazine 1986). Some explanations of this phenomenon are available. While in Europe 95% of female mites reproduce on drone brood, only 73% reproduce on worker brood (Schulz 1984). Honey bee hormones are probably responsible for that. The mite can synchronize its reproduction with the metamorphosis of the bee larvae with the help of the honey bee juvenile hormone (JH). There is a peak of JH in the 5th instar drone larvae. When JH was added to worker brood, then each female mite produced on the average 1.4 offspring, while on untreated brood only 0.5 offspring/female was produced (Hänel 1983). But the level of JH is probably not the only one factor responsible for the differences in *V. jacobsoni* reproduction. Woyke (1977b) suggested that *V. jacobsoni* females stay outside sealed brood for shorter period in a temperate climate than in the tropical one.

Another mechanism concerns the duration of the sealed period of the honey bee. Brood of *A. mellifera* *mellifera* remains sealed for 12.0 days, while that of the Cape bee (*A. mellifera capensis*) for only 9.6 days. Thus the sealing period of *A. capensis* brood is too short to develop an infective new mite female generation. In the Cape honey bee the mites reach this stage 0.7 days **after** emergence of the adult bee, and in the Carniolan bee the first mites become infective 2.2 days **before** the worker emerges from the cell (Mortiz and Hänel 1984). The sealed period of the Africanized bees is also shorter and lasts 11.2 days. The development period of the honey bee is highly heritable $h^2 = 0.8$. Crosses between the three races resulted in production of honey bees with intermediate periods of development (Moritz 1985).

Another resistance mechanism concerns the cleaning behavior of adult worker bees. *A. cerana* workers are able to remove the mites from their bodies in a few seconds. When the self-cleaning behavior fails, the nestmates help to remove the mites. Worker bees can also effectively remove the mites from the brood cells in a few seconds to minutes. The mites are subsequently killed and removed from the hive in a few seconds to minutes. Unfortunately, the European bees show cleaning behavior at low frequency and generally fail to remove the mite from both the adult bees and the brood (Peng, Fang, Xu, and Ge 1987a).

Interesting observations concern the behavior of a mixed population of *A. mellifera* and *A. cerana* in the same bee hive. *A. cerana* can detect the *Varroa* mite in *A. mellifera* brood (Peng et al. 1987b). A mixed population was also accomplished by introducing one *A. cerana* brood comb into an *A. mellifera* colony. After the workers emerged, both species lived together and *A. cerana* helped to clean, bite and remove mites from *A. mellifera* (Wongsiri, Tangkanasing and Sylvester 1987). Perhaps *A. mellifera* will be able to learn such behavior.

Recommendations for the future

After some resistance mechanisms are known, honey bees showing some of these characters may be selected and next the degree of that character may be increased by further selection. Honey bee lines possessing different resistance characters should be crossed, to combine in one strain different characters of the resistance mechanisms in one honey bee strain. Further selection would increase the level of resistance to the *V. jacobsoni* mite.

Another solution would be to transfer some resistance mechanism from *A. cerana* into *A. mellifera* by genetic engineering. But this is the future.

The question for today is what can we do to help to breed bees resistant to *Varroa*? At first, everybody should carefully observe his bee colonies, in order to find variations in resistance to varroasis. The most resistant colonies should be selected. Next queens should be reared from such colonies. The best thing would be to inseminate these queens instrumentally, with semen of drones from another resistant bee colony. If this is not possible, queens may be mated in the mating yard or in the apiary. In the last case, the progress will be slower, but nobody should neglect selection because he cannot inseminate queens instrumentally. Breeding of honey bees resistant to varroasis cannot be done just by one selection and rearing of queens in one season. Selection must be continued through several generations.

Even if somebody is not doing breeding work, he can still help to develop a strain of honey bee resistant to *V. jacobsoni*. He also should carefully observe his bee colonies, and after he has found one or several resistant colonies, he should report this to a scientific institution or to a bee breeding station.

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