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HONEY BEE BREEDING FOR *VARROA* RESISTANCE

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Abstract

Honey bees are exposed to many damaging pathogens and parasites. The most devastating is *Varroa destructor*, which mainly affects the brood. Breeding for *Varroa*-resistant honey bees became the primary goal for many researchers around the world. In this review we tried to describe breeding for *Varroa* resistance.

Keywords: Honey bee, Varroa, Breeding

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1. Introduction

Selective honey bee breeding is a phenomenon that fascinates beekeepers around the world. They often regard it as one of the most enigmatic and complex aspects of beekeeping. Indeed, according scientists experiences participating in many international projects, both beekeepers and bee experts without a background in plant or animal breeding often have trouble correctly interpreting and conceptually visualizing the breeding process.

These difficulties arise partly because of the complex reproductive biology of honey bees, where queens mate with a multitude of drones. Fundamentally the greatest struggle for people to understand is how selection of animals with preferred characteristics in one generation leads to improved progeny in the next (Uzunov et al., 2017).

The first and very important step is to define the breeding objective. Thus, based on the economic importance, scientific evidence and practical experience, breeders must decide which traits they intend to improve, and what is the relative importance of improving the different traits? Generally, the preferred traits in selection for honey bees involve improving honey yield, gentleness, decreasing the swarming tendency and increasing *Varroa* resistance (Uzunov et al., 2017).

Varroa destructor is an external parasite of *Apis cerana* F. and the honey bee, *Apis mellifera* L. These mites feed on the hemolymph of immature and adult bees.

Varroa destructor has a reproductive cycle of about 19 days. Just before a brood cell is capped and as the bee larva in the cell approaches maturity, a female mite enters the cell to reproduce. This reproductive opportunity lasts for approximately 12 days while the host bee in the cell progresses through its late larval and pupal stages. All male mites and immature female mites die when the host bee removes the cell capping and exits the cell as an adult. Only adult female mites survive outside the cell, and they spend approximately 7 days on adult bees before repeating the reproductive cycle and entering another brood cell as given in Figure 1 (Harbo and Harris., 1999).

Figure 1. Life cycle of Varroa Destructor (URL1)

Generally, the preferred traits in selection for honey bees involve improving honey yield, gentleness, decreasing the swarming tendency and increasing *Varroa* resistance (Uzunov et al., 2017).

Honey bees are exposed to many damaging pathogens and parasites. The most devastating is *Varroa destructor*, which mainly affects the brood (Spötter et al., 2016). Breeding for *Varroa*-resistant honey bees became the primary goal for many researchers around the world. *Varroa* Sensitive Hygiene is a behavioral trait of honey bees (*Apis mellifera*) conferring economically useful and heritable resistance to *Varroa destructor*. Colonies with high expression of the trait reduce and therefore tend to maintain mite populations below economic injury levels (Villa et al., 2017).

2. Breeding Program

A breeding program represents a set of systematically planned and implemented activities aimed at the sustained genetic improvement of a honey bee population (Uzunov et al., 2017). Thus, by continuous implementation of this selection program it is expected that the colonies in the next generation will express improved behavior concerning targeted traits, enhanced production and vitality including resistance to diseases and pests, prolonged life expectancy and so on.

A breeding program should include clear breeding objectives, performance testing to evaluate the interested characteristics, estimation of the breeding values, selection, mating, production of the improved genetic stock, and evaluation.

3. Resistance Mechanism

The Russian (or Korean) haplotype of *Varroa destructor* is the hyper virulent variant which threatens *Apis mellifera* beekeeping worldwide (de Guzman et al., 1997; de Guzman et al., 1999; Anderson and Trueman, 2000). Honey bee colonies that survive infestations of this *Varroa* haplotype have one or more behavioral or physiological traits which underlie their resistance to *Varroa* (Rinderer et al., 2010).

3.1. Hygienic Behavior

Hygienic bees are able to detect, uncap and remove diseased brood. A general test of hygiene, the removal of freeze-killed brood by colonies, correlates relatively well with removal of *Varroa*-infested brood (Rinderer et al., 2010). Hygienic behavior is probably the most successful achievement in breeding bees because of controlled by two recessive genes. It's been very well studied and proven to be effective against chalkbrood, American foulbrood, and *Varroa*. For a recessive trait to be expressed, a worker needs to be homozygous for the gene. Homozygous means that it gets the same allele from the mother and father. Heterozygous means that the bee has one of the alleles and so is a carrier, but the trait is not expressed (URL2).

3.2. Grooming Behavior

Honey bees clean themselves (autogrooming) and nestmates (allogrooming). Grooming may injure or kill *Varroa* mites, or it may cause mites to either move to other parts of the autogroomer's body, transfer to a new host or be removed from the bee's body without causing visible injury. Grooming is rarely observed directly. However, variation among honey bee stocks in grooming has been inferred from the proportion of mites that drop to hive floors that are damaged, apparently from bees' mandibles (Rinderer et al., 2010). Resistance to tracheal mites has recently been found to be a grooming behavior. The bees use their middle legs to groom the mites away from their tracheal opening. It's also been found that the trait is controlled by dominant genes. It hasn't been determined if there are more than one gene involved. With assuming there's just one gene controlling it. Here if starting with a single drone that carries the resistant gene shown in Figure 2 (URL2).

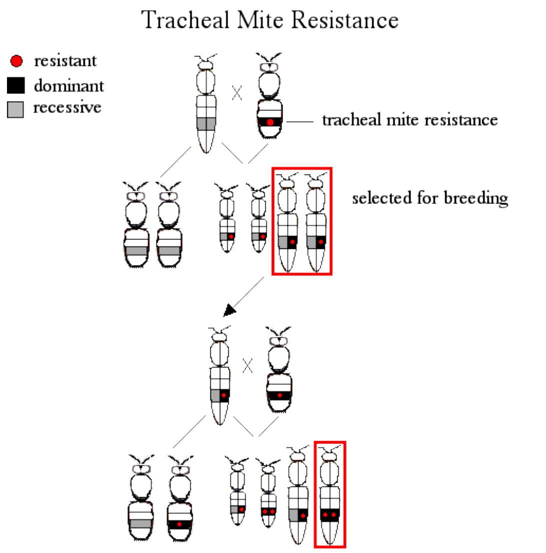

Figure 2. Breeding scheme for Varroa resistance (URL2)

Dominant traits are easier to get established into population because the first generation will express the trait. The trait will be expressed equally by bees that carry the gene for the trait on one or both of their chromosomes. It can be preferred to breed only from queens homozygous for such trait (URL2).

3.3. Removal of Mites from the Nest

The bees may carry and discard *Varroa* mites outside the nest. Likewise, living *Varroa* mites can be lost during foraging flights. The higher proportion of the infested bee did not return to the hive as compared to infested A. m. carnica and interpreted the behavior to be an adaptive contribution to resistance (Rinderer et al., 2010).

4. Calculating Heritability

It is important to calculate heritability (h^2) of a desirable characteristic before beginning a program of selective breeding. Heritability (h^2) is the proportion of the observed variance (among a group of bee colonies in this case) for which differences in heredity are responsible. (Harbo and Harris, 1999).

Some researchers used sibling analysis to calculate heritability (Harbo and Harris, 1999). Spötter at al. (2016) declared that the heritability of hygienic behavior was estimated as ~0.2 by Boecking et al. (2000) and as ~0.6 by Harbo and Harris (1999) and Lapidge et al. (2002). According to Spötter at al. (2016) 6 SNP markers had highly significant associations with the Varroa-specific defense behavior. Locke (2016) argued that a dominant genetic component to the trait's inheritance, as opposed to maternal effects or epigenetic mechanisms, and that the trait can be easily produced through selective breeding using the mite-resistant bee stock. Villa et al. (2016) argued that adaptation of mites to host cues, loss of resistance alleles in a small breeding population, or environmental effects present challenges to breeding for this trait.

5. Conclusion

Breeding for *Varroa*-resistant honey bees is a very important aim to increase honey bee products and vitality of the stock. Heritability value of this trait is about 0.25; in this situation it is possible to improve that character by selection.

Conflict of Interest

The authors declare that there is no conflict of interest.

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