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NOTES AND COMMENTS

Varroa destructor resistance of honey bees in Hawaii, USA, with different genetic proportions of Varroa Sensitive Hygiene (VSH)

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The Big Island of Hawaii, USA, supports an important honey bee (*Apis mellifera*) queen rearing industry that supplies queens worldwide. This industry now is threatened by *Varroa destructor*, as the mite was detected on the Big Island in 2008. Mite parasitism is now high in queen production operations because of the extended brood rearing season in the tropics, the deliberate production of large numbers of drones in many colonies, and invasion of mites from dying feral colonies. Mites can currently be managed with acaricides, and beekeepers typically treat colonies at two to four month intervals (compared to at six to twelve month intervals on the USA mainland). Acaricides may be problematic for queen producers, however, because they can interfere with queen rearing and sperm production (e.g., Haarman *et al.*, 2002, Rinderer *et al.*, 1999). An alternative management strategy might employ bees bred for mite resistance. Bees with Varroa Sensitive Hygiene (VSH) offer good resistance to *V. destructor* (Harbo and Harris, 2009). This trait could be used for breeding in Hawaii through importations of semen, as queens cannot be imported into the state. We sought to determine what proportion of VSH genetics can confer useful honey bee resistance to *V. destructor* in queen production operations in Hawaii.

In July 2010, a cooperating queen breeder established 30 colonies (without sealed brood) that were assigned to three treatment groups. Groups were created so that initial mite density was equal for the groups (0.10-0.11 ± s.d. 0.09-0.12 mites per 100 adult bees). Instrumentally inseminated queens were added to each colony. The queens were created so that their workers had either 0%, 50% or 75% of the genetics for VSH. Genetic groups were as follows: 0% VSH = commercial Hawaiian X commercial Hawaiian; 50% VSH = commercial Hawaiian X VSH; and 75% VSH = 50% VSH X VSH. Mated queens were produced from five colonies of the operation. VSH semen was from drones from Glenn Apiaries and our USDA laboratory. Previously inseminated queens (commercial Hawaiian X VSH) produced hybrid daughter queens that were inseminated to make the 75% VSH group. We initiated testing with two other queen producers, but their colonies became unusable; in one case there was inadvertent treatment with acaricide, and in the other case colonies became unviable because of small size, poor nutrition and high mite populations (which increased from July to September from 1.1 to 14.7 mites per 100 bees).

Beginning in September when experimental populations of workers were fully established, the colonies were sampled every two months to monitor the density of mites and to measure the population of brood. Mite densities were measured by sampling *ca*. 300 adult bees from the broodnest, shaking the sample in 70% ethanol to wash off phoretic mites, and counting bees and mites. Brood populations were measured by using a grid to estimate the area of sealed brood on each side of each comb to the nearest 1/6 of the side, and summing these counts to get the number of comb equivalents covered with brood. Colonies were managed initially without treatment against *V. destructor*; later, individual colonies that reached a density of 10 mites per 100 bees were treated with fluvalinate (Apistan®; Wellmark International, Schaumburg, IL, USA). Sampling of untreated colonies continued until May 2011.

Populations of mites were suppressed only in the group with the highest level of VSH. Analysis of variance showed that average mite densities in untreated colonies differed ($P < 0.05$) between the groups during November (0% > 50% > 75% VSH) and January (0%, 50% > 75% VSH). In the 0% and 50% VSH groups, mite densities increased from 0.10 mites per 100 bees when queens were established in July, to 22-24 mites per 100 bees in January (four months after the experimental colony populations were in place) (Fig. 1). By January all

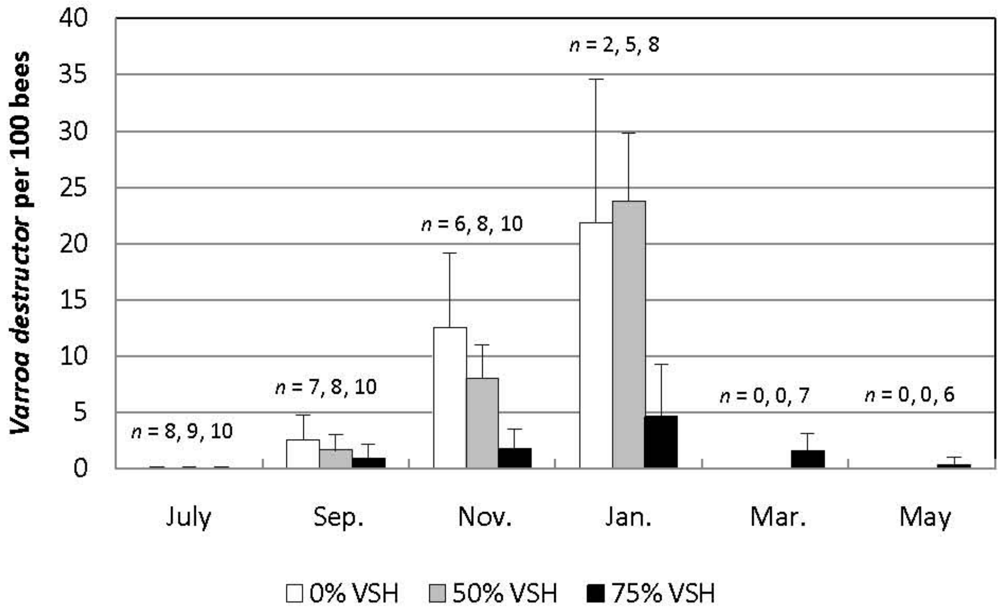

Fig. 1. Densities of *V. destructor* on adult bees (mean + 1 s.d.) in colonies having one of three proportions of the genetics for Varroa Sensitive Hygiene. The number of untreated colonies used to generate data is shown above bars for each month. No densities are shown in March and May for 0% and 50% VSH colonies because all colonies in these groups had been treated with an acaricide by March.

0% and 50% VSH colonies required treatment. In the 75% VSH colonies, average mite densities increased to 5 mites per 100 bees at 4 months and then decreased to 0.5 mites per 100 bees at 8 months. Only one of the 75% VSH colonies needed treatment (at four months) during the 8-month test.

After establishing 10 queens per treatment group in July 2010, queen survival in the 0% VSH group was 7 at 0 months (September), 6 at 2 months, 4 at 4 months, 2 at 6 months and 0 at 8 months. Queen survival in the 50% VSH group was 9 at 0 months, 8 at 2 months and 7 at 4, 6 and 8 months. Queen survival in the 75% VSH group was 10 at 0 months, 8 at 2, 4 and 6 months and 7 at 8 months.

Brood populations were smaller in the 75% VSH colonies (2.5 ± 0.4 equivalent of combs completely covered with brood) than in the other groups (0% VSH, 3.5 ± 0.1; 50% VSH, 2.9 ± 0.0). The 75% VSH colonies averaged 2.7 combs of brood until 6 months but 1.7 combs of brood at 8 months; this decrease may reflect instrumentally inseminated queens beginning to fail.

These data provide initial guidance for using genetically resistant bees to mitigate population growth of *V. destructor* in the tropical conditions of Hawaii. More than half of the genetics for VSH were necessary to significantly restrain the rapid mite population growth evident in control (0% VSH) bees in this test. Only one of the 75% VSH colonies reached the treatment threshold and mite levels fell in most 75% VSH colonies after January, perhaps when brood rearing increased. Unlike experiences involving relatively moderate mite population growth on the mainland, where outcrossing VSH queens by natural matings to presumed non-resistant drones yielded usefully resistant colonies (Harbo and Harris, 2001; Danka *et al.*, 2012), at least some mating to resistant drones would be needed to yield useful resistance in Hawaii. There now are breeder queens in Hawaii with *ca.* 94% of VSH genetics created by further backcrossing with VSH semen, and these would be useful drone sources.

These instrumentally inseminated colonies were observed during a limited period from late summer to spring, so longer term observations are necessary to understand mite population dynamics beyond eight months. In general it would be useful to evaluate our preliminary findings by testing VSH resistance using a larger number of colonies. Lastly, the high-expression VSH colonies had smaller brood areas. Whether breeding would restore full fitness in highly resistant colonies should be explored. Variation in response to *V. destructor* among existing commercial and feral bees on the Big Island (Danka *et al.*, 2009) might be exploited in such breeding.

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