A Survey of Tracheal Mite Resistance Levels in U.S. Commercial Queen Breeder Colonies

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ABSTRACT

Eight commercial queen producers from five states submitted brood from 6 to 19 breeder colonies each so that emerging bees could be evaluated for relative resistance to tracheal mites. Young, uninfested bees from each colony of an individual queen producer, and also from colonies of two reference stocks (one known to be resistant to tracheal mites and one known to be susceptible), were simultaneously exposed to mites in infested colonies, then retrieved and dissected to determine resulting mite infestations. Results for the breeder colonies were adjusted to the average results of the resistant and susceptible reference colonies with which they were tested. The 83 breeder colonies varied widely in their responses to tracheal mites. About two-thirds were statistically similar to the resistant reference and one-fourth were similar to the susceptible reference. Three queen producers had 30 of 31 breeder colonies that were classified as resistant. The other five queen producers had breeder colonies that were very variable and of which 40% were susceptible. These susceptible colonies were eliminated from the breeding population based on the test results.

INTRODUCTION

Tracheal mites (*Acarapis woodi*) remain a vexing problem for some U.S. beekeepers 16 years after being discovered in the country. Honey bee strains having genetic resistance to tracheal mites could be used to help to solve this problem. Resistance in some strains of bees has been documented in field tests (Milne et al. 1991, Danka et al. 1995, Lin et al. 1996, Guzman et al. 1996). Colonies of resistant bees tend to withstand challenge from tracheal mites and remain productive without treatment, while susceptible colonies tend to become infested at damaging levels.

Resistance to tracheal mites is of interest to bee breeders who are trying to improve stock quality. Identifying the level of resistance in breeding colonies should be a critical part of such breeding efforts. However, little is currently known about the resistance in the commercial breeding population used to supply queens for the U.S. beekeeping industry. We sought to define what levels of resistance exist by evaluating colonies from queen production operations. In a similar manner, active testing and selection has been used by the Ontario (Canada) Bee Breeders' Association to improve tracheal mite resistance in commercial bee stock. From 1992 to 1997, average tracheal mite infestation in bees during annual tests decreased from 13 to 1.5 mites per bee (Nasr and McRory 1998). These tests were made with a standard bioassay that provides good discrimination between resistant and susceptible colonies of bees (Gary and Page 1987). Our objectives were to measure the range of resistance in a sample of U.S. commercial breeder colonies, and enable participating queen breeders to improve the quality of their stock by providing selection guidance. Further, we expected that the effort would be heuristic as a demonstration of the value of a testing program for improving bee stock.

MATERIALS AND METHODS

Eight commercial queen producers from five states participated sequentially in trials conducted during Spring 1999. To begin a trial, a participant collected a comb having sealed brood with emerging adult bees from each breeder colony to be tested. The combs were shipped via overnight carrier to our laboratory. To obtain mite-free bees, the combs were brushed free of adult bees, caged individually, and then incubated at 35EC and 50% RH. After 6-24 hours (depending on trial), each of about 40 newly emerged adult bees per test colony were marked on the abdomen with enamel paint to identify their source. Each trial also included similarly aged bees from three colonies each of resistant and susceptible reference stocks maintained by us for research. These stocks have had widely divergent responses to tracheal mites in previous studies (e.g., Danka and Villa 1998). Totals of about 500 to 1000 bees were marked within about 4 hours for each trial. All the marked bees in a trial were added to a colony having known mite infestation (45 ± 27% [$\bar{x}$ ± sd, n =12] of bees infested). One week later, the marked bees were collected from the infested colony, immobilized in the field by chilling and exposure to carbon dioxide, and stored frozen. Mite infestations were measured by dissecting each retrieved bee and counting at 30-63X magnification the adult female mites between the spiracle and the first branch in the prothoracic tracheal trunks. The mite abundance (i.e., the average number of mites per bee for all bees in a sample) usually was calculated from mite counts in 25-30 bees per test colony.

A resistance index (RI) was calculated for each breeder colony within a trial. Infestations were indexed according to the outcomes of the resistant and susceptible reference stocks within each trial because the overall mite infestations varied from trial to trial due to environmental variation. Therefore, within each trial the RI for each breeder colony was calculated as the proportion of the difference between the mean mite abundances of the two reference stocks, i.e., RI = (mite abundance in breeder colony - mean mite abundance in resistant colonies) / (mean mite abundance in susceptible colonies - mean mite abundance in resistant colonies). This scales the RIs according to standardized mite abundances of 0.0 in resistant colonies and 1.0 in susceptible colonies. Note that the mite abundance in a breeder colony can be less than that of the resistance reference; in this case the RI of the breeder colony will be less than

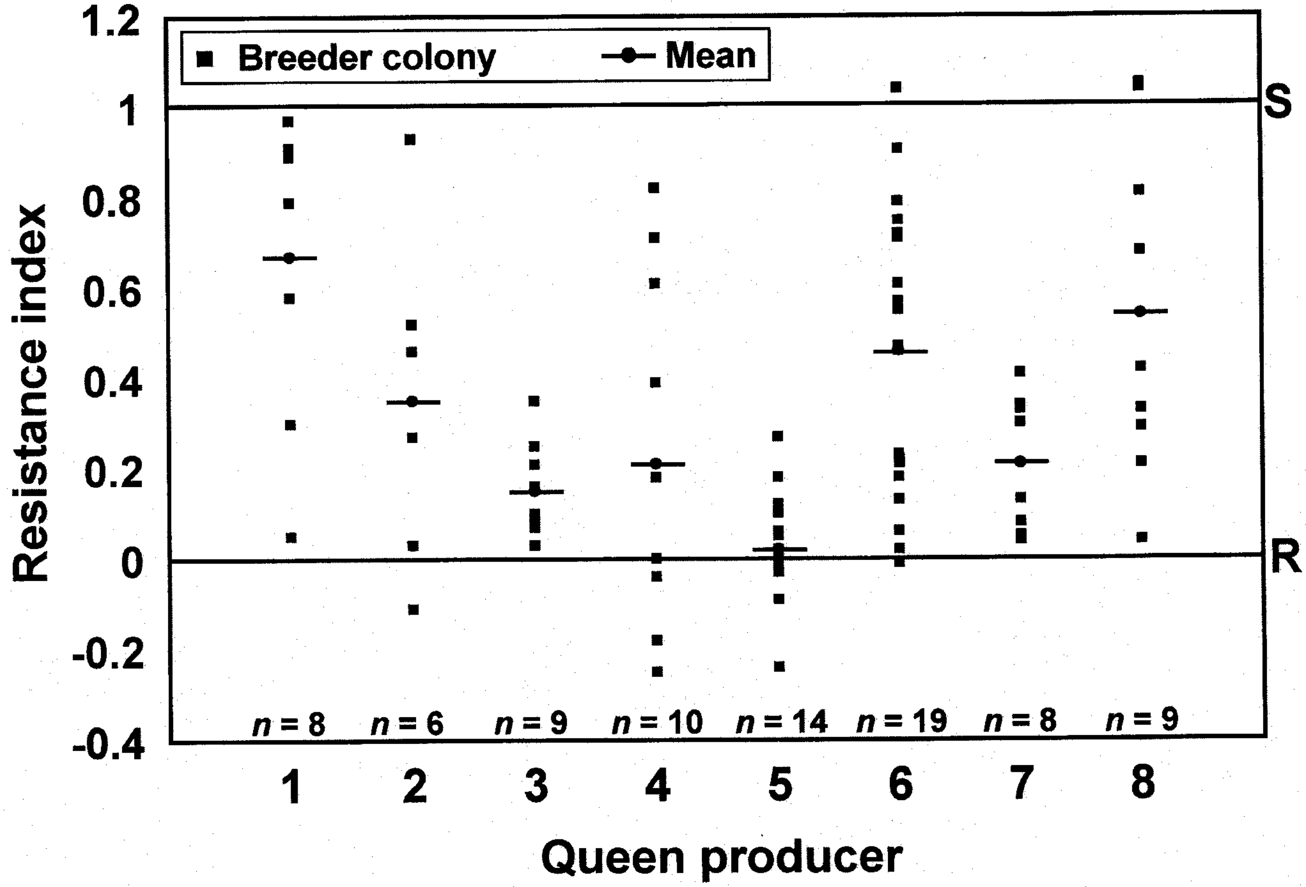

Fig. 1. Levels of resistance to tracheal mites found in breeder colonies used by eight U.S. commercial queen producers. For each colony, the resistance index (RI) shows the colony resistance relative to that of a resistant reference stock (RI set at 0.0) and a susceptible reference stock (RI set at 1.0). The number of colonies of each operation that was tested appears immediately above the x axis.

0.0. Likewise the RI of a very susceptible breeder colony can be greater than 1.0. Two RIs were calculated for each colony from six of the eight queen producers (all except numbers 4 and 8) because sufficient bee emergence from the brood combs enabled us to conduct a second trial. An average of the RIs is presented for these colonies.

RESULTS

Levels of tracheal mite resistance were markedly variable among the 83 breeder colonies we tested (Figs. 1 and 2). The overall coefficient of variation for the RIs was 108%. Seventy-two percent of the colonies were more similar to the resistant reference stock than to the susceptible reference stock, i.e., they had RIs of <0.50. A large proportion of the breeding population had useful resistance; 64% of the colonies were classified as resistant because their RIs fell below 0.347, which is the upper limit of the 95% confidence interval for the mean RI of the resistant reference colonies. Twenty-five percent of the breeder colonies were classified as susceptible because their RIs were above 0.563, the lower limit of the 95% confidence interval for the mean RI of the susceptible reference colonies.

Two general patterns were evident at the level of individual queen producers. Breeder colonies in five of eight operations (numbers 1, 2, 4, 6 and 8) spanned ranges of 0.92 to 1.07 in their RIs and encompassed the entire spectrum from full resistance (RI≈0) to full susceptibility (RI≈1). Conversely, breeder colonies in three operations (numbers 3, 5 and 7) had good average tracheal mite resistance (mean RIs of 0.15, 0.02 and 0.21, respectively) and also were relatively consistent in their performance (range of RIs of 0.31, 0.36 and 0.44, respectively).

DISCUSSION

The most striking result of this survey was the variability in levels of tracheal mite resistance among colonies of U.S. commercial breeding stock. Given the large difference in field performance of the resistant and susceptible reference stocks in a prior test (Danka et al. 1995), the variability of these breeder colonies could have profound consequences in beekeeping operations. A breeding population that comprises a wide range of tracheal mite resistance will yield propagated queens of which some would be useful in improving stock and others which would predispose their colonies to damaging mite infestations. In the absence of knowledge about the resistance levels of individual breeder colonies, the performance vis-à-vis tracheal mites of production colonies headed by commercial queens becomes largely a matter of the chance associated with a queen producer's random selection of a grafting source.

Fortunately, the majority of colonies we tested had useful resistance to tracheal mites. Average resistance in U.S. colonies likely has accrued from both natural selection and some bee breeding that has culled susceptible germplasm since 1984. Some of the queen producers involved in this survey, including those with consistently resistant breeder colonies, have screened breeders for mite infestation or sought out resistant stock to incorporate into their breeding programs.

Unfortunately, some colonies being used as breeding sources are susceptible to tracheal mites. Queens propagated from susceptible colonies and then widely distributed through commercial sales may contribute to the lingering problems associated with tracheal mites across the country. Part of the explanation for the unwitting maintenance of susceptibility in the breeding population may be that mite infestations, which apparently are common in queen breeding operations (Camazine et al. 1998), do not harm breeder colonies in warm regions of the country as much as they harm production colonies (i.e., those with propagated queens), especially those in northern honey-producing regions.

The findings from this survey emphasize the value of testing in enabling effective selection for resistance to tracheal mites. Through testing, susceptible colonies are easily identified and can be eliminated. Many of the queen breeders who participated in this survey reported that susceptible colonies were removed from their breeding programs soon after the results of the test were available. More extensive evaluation of the U.S. honey bee breeding population could rapidly enhance tracheal mite resistance in diverse bee stocks without compromising existing desirable beekeeping characteristics.

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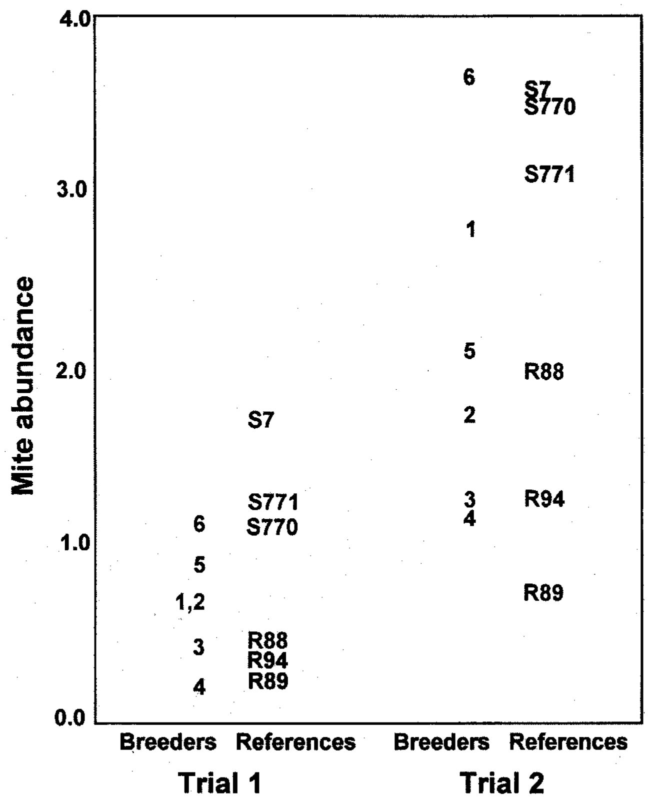

Fig. 2. An example of the data obtained from the test. The mite abundance data shown are from two trials of the six breeder colonies from queen producer #2. Within each trial, the mite abundance found in the test bees is given for each test colony, i.e., the individual breeder colonies (numbers 1-6) and reference stock colonies (three each of resistant ("R") and susceptible ("S") stocks). This example shows that 1) although absolute mite abundances varied between trials because of environmental effects, the rankings of breeder and of reference colonies were similar in the two trials, 2) resistant and susceptible reference stocks had consistently divergent responses to mites and 3) some breeder colonies were as resistant and as susceptible as the reference stocks.