Project No. 98-RP-o0 - Honey Bee Management, Genetics, and Breeding

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Objectives:

1. Develop management methods for the commercial beekeeping industry to maintain and produce commercial honey bees of good genetic stock that are resistant to diseases, free of objectionable Africanized honey bee genetic material, and are of high commercial value for pollination.

2. Selectively breed and maintain strains of bees that are more effective pollinating units.

3. Construct genetic maps and identify genetic markers that are close to genes of economic importance, such as defensive behavior, pollen collecting, and disease resistance. These maps will then be used in programs of DNA marker assisted breeding and for directly assessing the potential characteristics of colonies of commercial breeding stock.

4. Conduct DNA surveys of feral honey bee populations to determine the extent of the spread of Africanized honey bees in California.

Improving Pollination Activity of Colonies

They key to effective pollination of almonds is a large supply of bees, or bees that work very hard at pollination. The trend for past several years has been toward a short supply of bees, therefore, I have focused my research on improving the pollination activity of colonies. There are two possible approaches: modify the genetic composition of bees or modify the colony environment to stimulate foraging. For the past 9 years I have concentrated my efforts on the production of strains of bees that tend to specialize on collecting pollen. This selection program has been very successful resulting in the production of bees that have 80% more pollen collecting activity than unselected commercial colonies. However, beekeepers have been resistant to using these bees because they like their own stocks and/or fear that the high pollen foraging strains will make less honey. As a result, I have begun research designed to modify the colony environment to stimulate more pollen foraging.

Last year I first reported that the young larvae of honey bees produce chemical substances that stimulate pollen foraging behavior. We rinsed larvae in hexane, a solvent, then placed the hexane-extracted compounds into colonies and observed an increase in the numbers of pollen foragers of about 2 fold. However, the number of nectar foragers remained the same, suggesting that colonies contain large numbers of unemployed foragers. These results demonstrated that pollen foraging activity could be increased in colonies, presumably without affecting honey production.

This year we tested a synthetic blend of compounds found on the surface of larvae. These compounds are readily available from chemical suppliers and are inexpensive. We combined them together to mimic the blend found on larvae and found that they in fact mimic the effects of brood and brood pheromone (pheromones are chemicals that modify behavior) on foraging behavior. These results open the door for developing behavior modifying compounds for producing "designer" colonies for specific commercial use. In particular, it may be possible to add synthetic brood pheromone to colonies during the time they are needed for pollination, then remove the pheromone when colonies are used for honey production. We will test the efficacy of synthetic brood pheromone for stimulating pollinator activity in the almond orchards next year.

Perception of Sugar and Foraging Behavior

Honey bees respond reflexively to sugar. A bee automatically extends her tongue (proboscis) when a solution of sucrose is touched to her antenna. This reflex can be used to study foraging behavior and determine the factors that result in pollen and nectar foraging. We tested pollen and nectar foragers and found that pollen foragers respond (stick out the proboscis) to lower concentrations of sucrose solution than do nectar foragers. We then tested bees from the high and low pollen foraging strains we have selected and found similar results: bees from the high strain respond to lower concentrations of sugar, even when they are very young, before they begin foraging.

The next step was to determine if we could actually predict what bees would collect as foragers before they reached foraging age. Bees normally initiate foraging behavior when they are about 3 weeks old. So, we sampled very young bees (about 1 week old) from a colony and determined the concentration of sugar at which they extended their tongues (we called this their response threshold to sugar). We then recorded the response threshold and tagged each bee with a plastic numbered disk in order to identify them later when they began foraging. We collected returning tagged foragers and sampled the loads they collected on their foraging trips. We found that the response threshold of one week old bees was a good indicator of their foraging behavior two weeks later. Bees with the lowest response thresholds tend to collect water, next pollen, then nectar, and those with the highest response thresholds to sugar tend to return empty to the hive after a foraging trip.

If we can manipulate the response thresholds of honey bees we should be able to manipulate their foraging behavior. Therefore, we tested the effects of exposure to brood pheromone on response thresholds. We took bees that just emerged as adults and exposed them to brood pheromone extracts for one week. We then compared the sugar response thresholds of bees exposed to pheromone with those that were not exposed and found significant differences. The bees exposed to pheromone had lower response thresholds, like pollen foragers. We had altered their foraging futures by chemical manipulation. We now have a method to test many potential behavior modifying compounds and will continue this line of research with that objective.

Selection for Resistance to Varroa mites

Varroa mites feed upon adult and larval honey bees causing severe damage to workers and eventually the death of the colony. They are the number one problem in commercial beekeeping today and are the number one reason for the decline in numbers of commercial colonies. Currently, Varroa is controlled chemically by application of fluvalinate, a chemical designed to kill mites but not bees. However, it has been recently reported that Varroa are becoming resistant to fluvalinate, a potential disaster for the bee industry.

It is known that Varroa females have lower reproductive capacity when they live in colonies of a sister species of our commercial honey bee. This suggests that it may be possible to artificially select strains of our bees that reduce the reproductive capacity of Varroa and thereby become resistant. This summer we initiated a selection program for resistance to Varroa in cooperation with the USDA Honey Bee Research Laboratory in Tucson, Arizona. The objective is to select bees with larvae that are less attractive to Varroa and result in reduced numbers of offspring produced by each Varroa female. We conducted our first set of crosses this summer to establish our foundation population. We tested larvae from more than 30 foundation colonies and identified those with larvae that supported high and low populations of mites. Those colonies will be used to produce parents to initiate our two way selection for high and low resistant bees. We are now raising queens and drones for our crosses. We will artificially inseminate the queens in November and test them again in January or February to see the results of our first generation of selection.

The Spread of Africanized Honey Bees in California

In October 1994, Africanized honey bees were first detected near Blythe, California. As a consequence, we began monitoring honey bee populations in southern California using DNA techniques we developed to distinguish AHB from commercial and feral bees. Our first survey in the spring of 1995 detected no AHB throughout the south-eastern corner of the State. In 1996 we detected 3 AHB at two sites followed by 34 AHB detected at 12 sites in 1997 for an estimated 13.8% of all foraging bees sampled. The estimated area of southern California thought to have AHB, however, grew little during this period.

This year, spring of 1998, we again sampled the south-east corner of California and found that the range of AHB had greatly increased and that the AHB had greatly increased in relative abundance. Altogether, we sampled 198 AHB at 66 different sites. We estimated that 44% of all foraging bees were AHB. This represented a huge increase in their proportions relative to European honey bees in that area. In addition, the range expanded north of Palm Springs nearly to Kern County, and west to within 20 miles of Los Angeles County. At their current rate of spread, they could easily reach or extend beyond the Tehachapi mountains into the Central Valley next year. We had all hoped that the spread of AHB had been halted and confined to remote areas of Riverside County and the Imperial valley, but we were wrong. It now appears that they have regained their momentum and are spreading rapidly.