

Project No. 99-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. Study the effects of the genome and the colony environment on the foraging behavior of honey bees in order to manipulate both and achieve greater pollination activity in colonies.
4. Conduct DNA surveys of feral honey bee populations to determine the extent of the spread of Africanized honey bees in California.

Objective 1: 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.

Last year I reported that we had initiated a breeding program with the USDA Honey Bee Laboratory in Tucson, Arizona to test the efficacy of selecting for resistance to Varroa. We are now in our second generation of selection for susceptible and resistant strains and are currently testing for differences between them.

Objective 1 and 3: Synthetic Brood Pheromone

We have been developing a synthetic pheromone for the stimulation of pollen foraging. Our investigations began by demonstrating that hexane extracted substances from the cuticle of larvae stimulate pollen foraging. In 1999 we demonstrated that one synthetic blend increased the number of pollen foragers more than another. However, this blend did not significantly increase pollen foraging in a large-scale experiment conducted with colonies pollinating almonds.

We recognized that the amount of pheromone the colonies were receiving might not have been sufficient to stimulate pollen foraging. Therefore, in February-March 2000 we tested the effect of increasing doses of synthetic brood pheromone on the ratio of pollen to non-pollen foragers on honey bee colonies in an almond orchard. A significant increase in the ratio indicates that the number of pollen foragers has been increased. Preliminary small trials performed in flight cages suggested that a dose of 3:1 (pheromone : adult bee) significantly increased the ratio of pollen to non-pollen foragers.

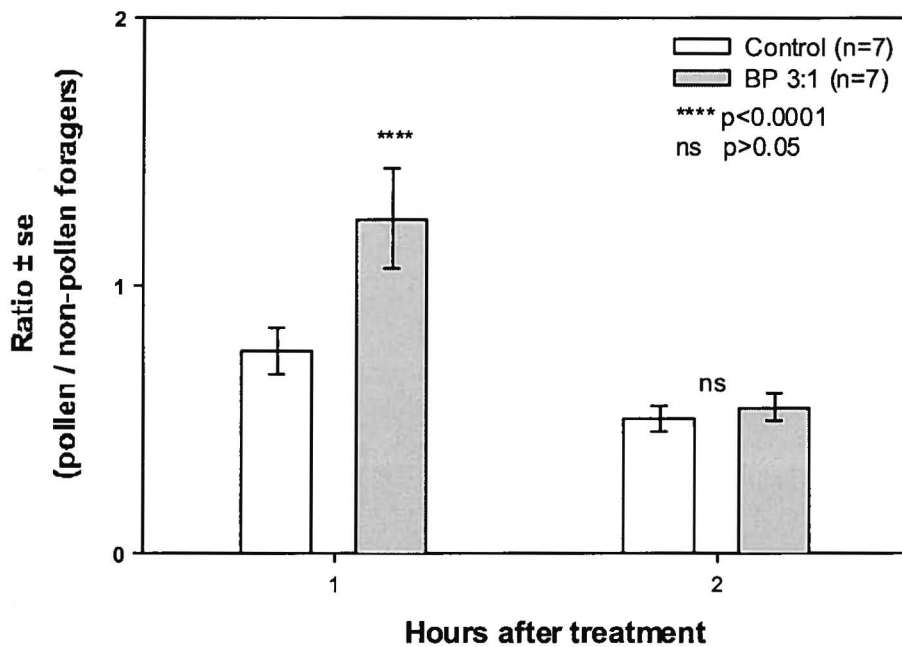
We treated seven colonies with 3:1 brood pheromone larval equivalents to adult honey bees presented on glass plates placed in the brood nest area of the colonies. Another seven colonies were controls, given blank solvent treated glass plates. One and two hours after treatment the number of pollen and non-pollen foragers entering each colony was counted for a 5-minute interval. The pollen to non-pollen forager ratio was significantly greater in the pheromone treated colonies one hour after the treatments were applied (Table 1; Fig.1). Two hours after application there was no treatment difference in the ratios of foragers (Table 1; Fig. 1). When the glass plates were removed from the colonies approximately 3 hours after application there was no visible residue of pheromone remaining.

Table 1. Contingency table analysis results of foraging responses to increasing doses of BP.

Experiment	Hour after treatment	G value	Prob.
3:1 BP vs Control	1	47.8	****
	2	0.7	ns

ns $p > 0.05$, **** $p < 0.0001$

In a separate experiment, 12 colonies were selected to alternately receive a pulse treatment of a 10:1 ratio of synthetic pheromone to adult bees and a control treatment. At 0930 h (Pulse I) six colonies received a glass plate carrying the synthetic pheromone treatment and its nearest neighbor received a control plate. The application of the treatments and inter-colony interval were timed so that by the time the last colony received its treatment 1 hour elapsed. One hour



after a colony received its treatment, a 5-minute entrance count was performed and the treatment was removed. A second entrance count was performed 1 hour after the treatment was removed. Then those colonies that previously received pheromone were treated with a control plate (solvent only) and those that previously received a control plate now received pheromone (Pulse II at about 1300 h). The protocol for timing and counting were the same as described above.

Figure 1.

There were significant treatment differences in the ratio of pollen to non-pollen foragers for colonies receiving the pulse treatments one hour after

application (Table 2, Fig. 2). One hour after the treatments were removed the pheromone treated colonies had entrance counts that were not significantly different from the controls for both pulses periods (Table 2; Fig. 2). These results are direct evidence that the synthetic pheromone acts as a releaser of pollen foraging that is amenable to a high degree of user control.

Table 2. Contingency table analysis results to foraging responses to pulse treatments of brood pheromone.

Pulse	Time	G value	Prob.
I	1 hour after treatment	186.4	****
	1 hour after BP removed	0.5	ns
II	1 hour after treatment	525.6	****
	1 hour after BP removed	3.8	ns

ns $p > 0.05$, **** $p < 0.0001$

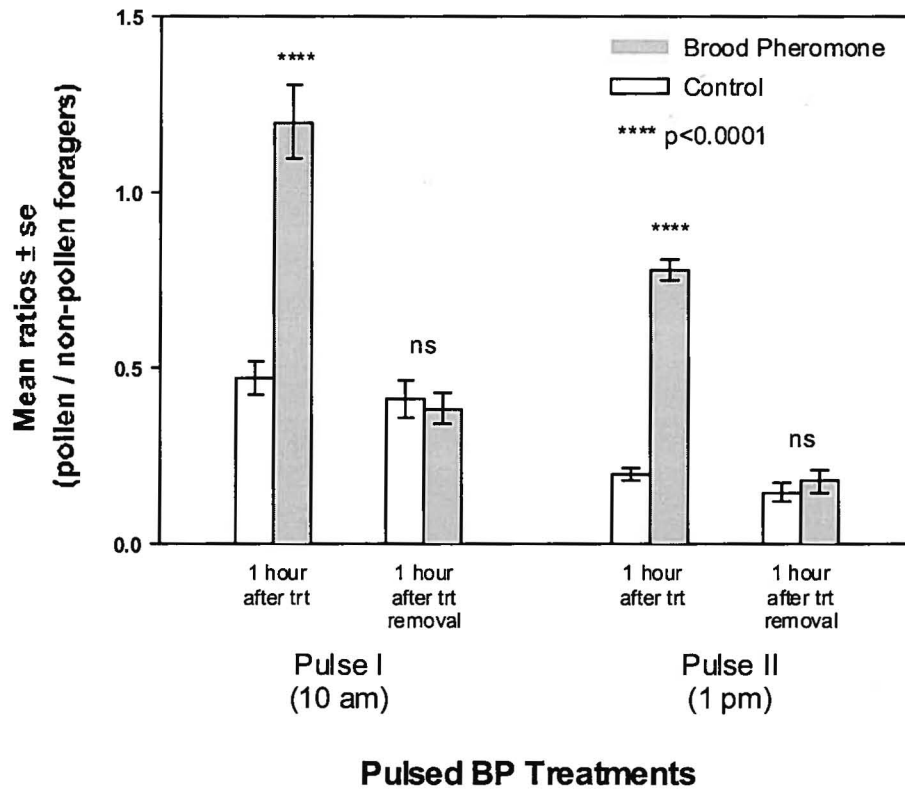


Figure 2.

Objective 2: Select and Maintain High and Low Pollen Foraging Strains

We continue to select and maintain our strains. We are now in our 19th generation of selection. Our lines are used primarily for research into the mechanisms of foraging behavior and pollination. This past year, results from a study of blueberry pollination in Maine demonstrated that our high strain bees were superior pollinators. This study was conducted by Dr. James Cane of the USDA pollination laboratory in Logan Utah. This year we plan to cooperate with him again in a larger pollination study using our bees and also in a study of almond pollination in the San Joaquin Valley.

Objective 3: What makes a pollen forager?

For the past several years, we have been studying the genetics of pollen foraging behavior. We have been getting ever closer to finding the links between genes that affect foraging behavior, the physiological effects of the genes, and the behavior. Last year I reported that we had found differences in how bees perceive the taste of sugar. I showed that our high pollen hoarding strain bees will accept, and respond to, sugar solutions of lower concentration than bees from our low strain. I also reported that we find the same phenomenon in unselected commercial pollen and nectar foragers. This suggested a direct relationship between the perception of sugar and foraging behavior. This year, we have determined that one of the genes that we mapped for pollen hoarding (storing) behavior is directly affecting the perception and response to sucrose. This demonstrates the direct mechanism from gene to sensory physiology to behavior. The better we understand what makes a pollen forager, the better able we will be to manipulate the genetic composition and environment of colonies to improve pollination.

Objective 4: The Distribution of Africanized Honey Bees in California

Africanized honey bees were first detected in California in October, 1994. Since then, we, along with the California Department of Food and Agriculture, have been monitoring their spread and increase in population using a DNA diagnostic technique that we developed. The range was mostly limited to the Imperial Valley until the spring of 1998 when the range and population underwent a tremendous increase extending throughout most of the south-eastern desert regions of California and into Los Angeles County. This past year has seen it spread throughout the Los Angeles basin and into San Diego. More

important for agriculture, AHB have now been found on the southern edge of the Tehachapi mountains in Kern County. This puts them very close to entering the San Joaquin Valley.

This year we conducted a fall survey of Bakersfield, Arvin, Lamont, and the northern side of the Tehachapi mountains. Africanized honey bees were found everywhere we looked, therefore, we cannot determine their northern limit. We can say that they are established in the southern San Joaquin Valley.