ANNUAL REPORT

Project Title: Developing an Artificial Diet for the Honey Bee *Apis mellifera*

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Location: Carl Hayden Bee Research Center, USDA ARS, 2000 E. Allen Rd, Tucson AZ
Project Year: 2004

Relevant AES/CE Project No.: 04-GW-02

Summary:

In 2004, we successfully reformulated the liquid/protein honey bee diet based on feedback from the beekeepers who participated in the diet alpha test. The new formula is easier to mix and requires only water to rehydrate and a moderate amount of stirring to complete the formula. Once in solution, the formula does not separate or degrade. This novel product was developed in a cooperative partnership with the USDA and is currently being considered for a patent. We anticipate the diet being available for commercial sales in the fall of 2005. Bee longevity and viability trials using the new formula demonstrated that the diet was as nutritionally effective as natural pollen. In a product beta-test, two thousand pounds of the diet was sent to twelve beekeepers around the country to test in their operations. Colony development and brood strength were two criteria that we asked growers to monitor. Evaluation forms were sent out with the formula. Grower feedback and modifications based on their experiences will be the final step before taking the product to market in the fall of 2005.

Problem and its Significance:

Currently the beekeeping industry needs a good quality, highly palatable, pollen substitute diet for honey bee colonies. Supplemental diets are needed to promote brood rearing prior to moving to pollination. Researchers have demonstrated that stronger colonies are better crop pollinators because they can send more bees into the field and the presence of brood in the colony stimulates pollen foraging (Hoopingarner and Waller 1992, Erber & Page 2002). The need for a better diet product was raised by both the American Honey Producers and the American Beekeeping Federation at the 2002 national meetings. Commercial almond pollinators have expressed a specific interest in a liquid protein diet that could be administered as a component of, or along with high fructose corn syrup prior to moving the bees into the orchards.

Pollen substitutes that are currently available are typically made into patties and placed directly into the colonies. These patties generally stimulate brood production for a short period of time, then, if natural pollen is not available, brood production will cease and the bees will stop eating the substitute. Another problem is that the patties dry out and get hard before the bees can eat them. These are generally acknowledged phenomenon. If dried pollen is added to the diet, bees will consume greater

quantities of the patties than if the pollen is not present. However, while adding stored pollen to the mix makes the patties more attractive to the bees, it is costly and increases the chance of spreading disease pathogens or parasites to the honey bees.

Objectives 2004:

Project objectives are as follows:

1. Continue to collect and tabulate the data from the 2003 surveys sent out with the test diet.
2. Modify or reformulate the diet as indicated by results from the survey and feedback from the beekeepers.
3. Begin formulating and testing a patty diet based on formulas developed in liquid/protein diet.

Plans and Procedures:

1. Continue to collect and tabulate the data from the 2003 surveys sent out with the test diet.

The survey forms were collated and based on the cooperators' replies we reformulated the diet to mix more easily, stay in suspension longer and resist microbial contamination. About half of the growers said they had a favorable experience with the product in the original formulation. However, some of the cooperators had difficulty with the formulation in several critical areas. First, many had trouble getting the diet into solution, and 30% of the respondents indicated that the solids and liquid components of the diet separated before the bees could consume the product. In over 50% of the surveys, beekeepers indicated that there had been microbial contamination of the diet before the bees could consume all of the diet provided. Some growers reported exceptional brood production following the application of the diet. Based on the feedback from the growers, and the modifications made to the base formulation we believe we will have a superior honey bee diet supplement.

2. Modify or reformulate the diet as indicated by results from the survey and feedback from the beekeepers.

Based on the above feedback, we have reformulated the diet to mix more easily in cold water and have changed the sugar formulations to accommodate all dry components so fructose syrup does not have to be used in the preparation. New hydrocolloids were applied to the suspension to minimize separation and microbial stabilizers were adjusted to prevent contamination. Laboratory and field trials at the Carl Hayden Bee Research Center indicate the problems reported by the beekeepers have been overcome.

3. Begin formulating and testing a patty diet based on principles developed for the liquid/protein diet.

In the past year we have tested several emoluments for their ability to keep diet components soft and moist even in the Tucson environment. We feel that these hydrocolloids when added to a patty diet formula will be the basis for a superior diet formulation. As in past diet development experiments, preference testing is providing a quick evaluation of the patty formulation both in honey bee palatability and how well it stands up to the hive environment.

The diet is based on the embodiments of successful liquid protein diet. The challenge is to produce a patty formulation that will support bee development, is easy to prepare and is palatable to the bees. That final aspect, palatability, is the aspect we are currently addressing. While the bees will eat the present diet we want to increase consumption because increased utilization will ultimately increase hemolymph protein levels within the colony.

Diet Acceptance and Consumption

Honey bee preference testing experiments were conducted to determine how well the bees would accept or consume the newly formulated diet. The diet was compared against the old formulation and a sugar syrup control. Rate and quantity of consumption were monitored. Individual bee feeding duration was also monitored. Results indicated no significant difference between the new formula and the previous formula.

Hemolymph Protein Analysis

To be certain that the newly formulated diet supported colony brood development. Hemolymph protein analysis was conducted on newly emerged bees fed specific experimental diets. One hundred newly emerged bees were placed in 3"X 7"X 2" plexiglas cages where they were fed the respective diets. Hemolymph samples were taken at intervals of 15, 30 and 60 days, and the bees were maintained under controlled nutritional and environmental conditions. The diets fed to the bees included, liquid protein diet, corbicular pollen made into a patty with sugar and water, BeePro, a commercially available pollen supplement, and sugar syrup controls. Hemolymph protein analysis protocol set forth in 1998 by Cremonez, DE Jong and Bitondi and was followed to determine the relative benefit of the diet compared to control diets of natural pollen. A minimum of five samples from each diet were tested at the prescribed intervals. Mean protein levels were contrasted with the controls and any differences were determined by a one-way analysis of variance.

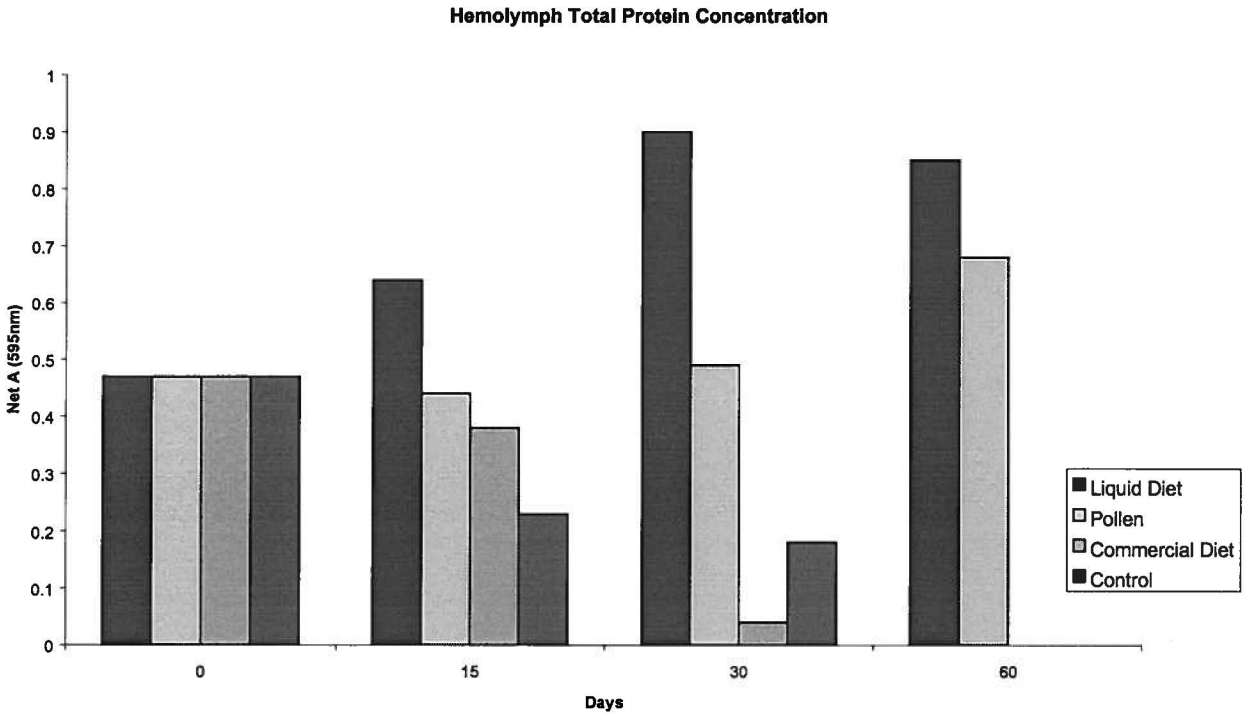
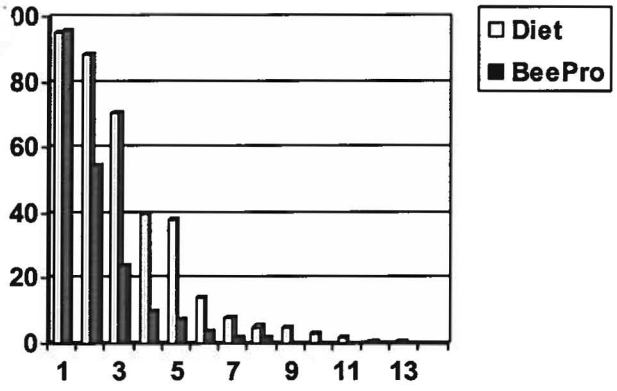


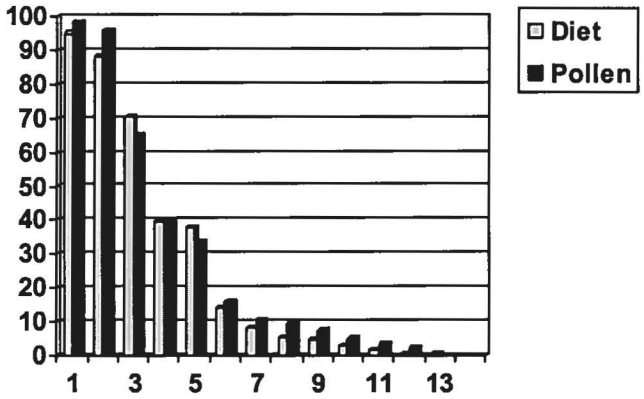
Table 1.

On day zero, the hemolymph levels in all samples were identical. After 15 days of feeding on the specific diets, our liquid protein diet (dark blue) had supported significantly higher hemolymph protein levels than did any of the other diets. Bees fed BeePro (light blue) and the sugar syrup controls experienced a significant loss of protein over the life of the experiment. Bees on sugar syrup and BeePro died before the end of the experiment (60 days). Our diet and natural pollen are the only diets that supported honey bee longevity beyond the sixty day experimental period.

Longevity

Bees fed the new liquid protein diet lived significantly longer than bee fed either sugar syrup or BeePro. There was no significant difference between bees fed our diet and natural pollen (Table 2). This indicates that the diet was readily absorbed and had nutritional quality comparable to natural pollen. These findings could be significant to the pollination industry since bees that live longer result in higher colony populations and stronger colonies are generally better pollinators.





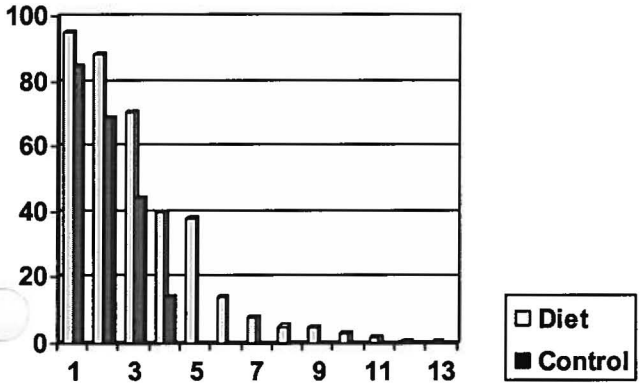


Table 2

A comparison of honey bee longevity between bees fed the reformulated liquid protein diet, BeePro (a commercially available diet) and sugar syrup control. Our diet and natural pollen provided the greatest longevity.

References

Erber, Joachim and Rob Page, The Evolutionary Dynamics of Social Organization in Insect Societies, The Bulletin of the Santa Fe Institute Summer 2002

Hoopingarner, Roger A., and Gordon D. Waller, Crop Pollination, The Hive and the Honey Bee, Dadant & Sons, Hamilton, Illinois, 1992.