A Successful Application of the Page/Laidlaw Breeding Program

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The concept of working with a large population to improve honey bee stock is a new and innovative approach to bee breeding. Recently this approach has been applied by Drs. Page and Laidlaw who developed the Closed Population Breeding Program, (CPBP). This program is designed to establish a large population in which stock is progressively improved. It eliminates the frustration and problems of breeding systems used in the past. There are several advantages in working with the gene pool of an entire population. The problem of inbreeding, which has been the major limiting factor of inbred-hybrid breeding systems, is essentially eliminated. The CPBP is flexible in that you are not dependent on a few select queens. Selection is a continuous process and new traits can be added to your gene pool. This program finally gives the beekeeper a practical and feasible breeding program for commercial use. Vaca Valley Apiaries has been using this program for five years and we are impressed with the results, practicality and flexibility of the system.

We were fortunate to be at the University of California, Davis when Drs. Page and Laidlaw were developing their theoretical model of the CPBP and became excited about the possibilities of bee breeding using this system. Since then we have taken this program into the bee yard, given it practical application, and developed the New World Carniolan line. This was not an easy process and required some modifications. We are grateful to Dr. Rob Page and Dr. Harry Laidlaw for their encouragement, advice and patience in answering our questions to make the program workable.

Development and Maintenance of The New World Carniolan

Initially a large gene pool was established to develop the basis of our test population. Carniolan stock was collected from a variety of sources within the U.S. and Canada. Through field testing of colonies and backcrossing, stock was selected which met our expectations for performance and traditional Carniolan characteristics (temperament, overwintering and production strategies).

The base population in a CPBP consists of 35 to 50 breeders. Each spring, 5 to 10 daughter queens are reared from each breeder to establish a test population of 175 to 250 colonies. From this test population the top performing 35 to 50 colonies are selected as breeders for the next generation. Daughter queens are reared to establish a new test population and the cycle is repeated.

Test queens are instrumentally inseminated with homogenized semen, collected from an equal number of drones from each of the selected breeder colonies. Using this technique, the sperm within each queen's spermatheca is an equal genetic representation of the *entire* selected population. In this way we are able to select for maternal differentiation. This process is repeated annually providing a wholistic approach and a progressive increase in the gene frequency and consistency of desirable traits within the population.

Performance of Instrumentally Inseminated Queens

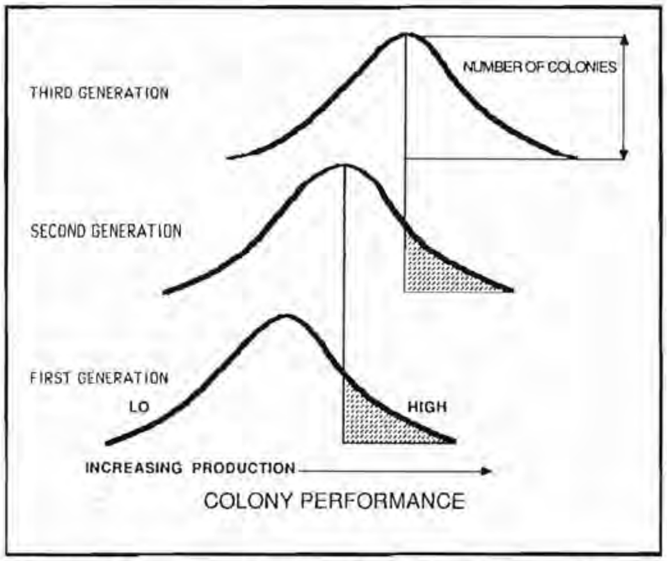
Instrumental insemination is used to control and maintain this program. Proficiency in the technique is essential and requires proper equipment and a clean laboratory. A large number of inseminations can be accomplished efficiently with the use of a large capacity syringe. Each queen is given a full semen load to assure a productive life. Keep in mind that these queens more than earn their keep by heading productive, income producing colonies as well as serve to improve the stock. Their colonies are used in pollination and honey production. This has not been possible with programs of the past.

Instrumentally inseminated, (I.I.), queens require a bit more care initially, though once established in full size colonies there appears to be little or no difference in performance compared to naturally mated queens. In the past I.I. queens acquired a reputation for supersedure. We have not found this to be a problem if queens are given proper pre- and post-insemination care. The secret appears to be establishing I.I. queens in small units and allowing them to build up their own populations. The first cycle of brood is the most critical time for these queens, which sometimes start egg production at a slower rate than naturally mated queens, and cannot meet the demands of a full size colony. For this reason, breeder queens are carefully watched and evaluated for at least 6 months before release. Given this care, we feel confident in guaranteeing their performance.

Selection

The selection of breeders is an annual process. Test queens are reared and instrumentally inseminated in late spring and early summer. These are allowed to build up into full size colonies and overwintered. Preselection data is taken in the fall and again the following spring. The honey production test and final evaluation are completed by the second spring and the cycle repeated.

Selection is based on colony performance. To properly evaluate the capability of potential breeders, queens must head full size colonies. They cannot be accurately evaluated in small units. Test queens are started in five frame nucleus colonies and allowed to build up and establish their own populations.



Selection of the top performing colonies of each generation will result in a progressive increase in consistency and the average production of the population over time.

The program is designed to enhance desirable, naturally occurring characteristics in the population. We are selecting for behavioral traits which are the result of an unknown combination of many genes. By selecting the top performing colonies of each generation we are including the combination of genes responsible for these. There are several factors and their interactions to consider in the selection process; the genetic makeup of the colony, environmental influences and beekeeper management practices. Our goal is selection based on genetic variability, therefore we want to minimize the environmental effects as much as possible. Uniform management is essential. Test colonies are treated equally. For example; if a colony is slow to build up, it is not equalized through management and will eventually be eliminated from the program for poor production.

In the process of selection we are interested in results rather than specifics. The intricate social structure of a colony is made up of many subfamilies possessing a variety of characteristics. The specific traits and/or combination of traits responsible for high productivity are our goal. Precise measurements of specific traits are costly, labor intensive, will force a reduction in number of colonies tested and limit the number of traits evaluated. By selection of the top performing colonies, we are selecting the combination of characteristics responsible for high productivity. Each selected generation shows a progressive improvement in colony performance. The distribution graph in Figure. 1 illustrates this; by choosing the top performing colonies of each generation the average production of the population is increased over time.

Selection Index

A selection index is used in our "**pre-selection**" process. This provides an objective means to evaluate colonies. A point value of 1 to 5 is given to rank the occurrence of each desired characteristic. The higher the number the greater the demonstration of the particular trait. The preselection process consists of looking at several traits and giving each a point value. The point values for each trait are added and the sum for each colony compared to the rest of the test colonies.

Several characteristics are evaluated quickly and simultaneously requiring only several minutes per colony. With a little practice, assigning point values to various traits becomes second nature. It is helpful to have a second person to record data. Instead of the tedious job of counting the number of brood cells to evaluate brood viability, or counting the number of stings in a leather patch to determine temperament, or timing how fast dead brood is removed to determine hygienic behavior, etc., a beekeeper's evaluation and a point value system eliminates unnecessary work and allows a much broader base for selection.

Characteristics include:

1. **BROOD VIABILITY;** Selection for high brood viability enables us to maintain the type and number of sex alleles essential to the integrity of our population. An estimate of

PRESELECTION DATA	Colony 1	Colony 2	Colony 3	Colony 4	Colony 5	Colony 6	Colony 7	Colony 8
Brood Viability	85-90%	90-95%	75-80%	85-90%	85-90%	95+%	85-90%	90-95%
Temperament	5	4	5	4	5	5	4	2
Spring Buildup	5	5	4	3	3	5	5	4
Cleaning	4	4	3	4	4	4	2	3
Disease	0	0	0	0	0	0	CHB	0
Swarming	4	3	4	4	4	4	4	4
Color	5	5	5	5	4	5	4	3
Total Score	23	21	Out	20	20	23	OUT	16

A selection index is used in the preselection process. A point value of 1 to 5 is given to rank the desired traits. In this example; Colonies 1, 2, 4, 5, and 6 have been included in the honey production test, while Colonies 3, 7 and 8 have been eliminated from the program. Colony 3 has been eliminated for low brood viability, Colony 7 has been eliminated for chalkbrood and Colony 8 has been eliminated because of a low total score. Based on the preselection results, the high scoring colonies are given the weight gain test. The top producing colonies are selected as breeders.

> *"A successful breeding program takes time, planning and hard work."*

PAGE . . . Cont. from page 275

the percent brood viability is determined with a quick look at the brood pattern. Queens with a brood viability of *less than 85%* are eliminated from the program. For example, Colony 3 in Figure 2 has been eliminated for this reason.

2. **SPRING BUILDUP;** Colony buildup in response to early spring pollen and nectar sources is observed. This is ranked by comparison *between* colonies.
3. **TEMPERAMENT;** Using a minimum amount of smoke, colony behavior is noted. We select for calm bees and queens which go about their business when being worked. Selection *against* runny, flighty or aggressive bees is made.
4. **CLEANING BEHAVIOR;** The *presence and/or removal of debris* from the broodnest, storage combs, and bottom board is observed.
5. **INCIDENCE OF DISEASE;** The *occurrence of disease* is determined. Negative points are given for any indication of a minor disease. Colonies showing any sign of American Foulbrood or Chalkbrood are eliminated from the program. For example in Figure 2 colony 7 has been eliminated from the program because of chalkbrood.
6. **SWARMING;** No swarm control is practiced. Observations are made of *swarm cells* during peak production. The test queen is clipped and marked with a numbered tag for easy identification.
7. **COLOR;** *Consistency in color* is an important marketing tool and an easy trait to control. Color selection of virgins and drones is made during the insemination process.

Based on the preselection results, the highest scoring 100 to 150 test colonies are moved to a reliable honey producing yard for final evaluation of industry. For example in Figure 2; Colonies 1,2,4,5, and 6 were included in the honey production test while Colonies 3,7 and 8 have been eliminate during preselection.

Evaluation of Colony Industry-Honey Production

In our selection program honey production is paramount. To be practical a simple field test is used. Whatever characteristics are responsible for high honey production — these are desired. Instead of taking tedious measurements of tongue length, nectar loads, number of foraging trips, longevity, oviposition rate of the queen, or whatever traits you feel contribute to high performance, a simple weight gain test is used. Dr. Tibor Szabo has shown that short term colony weight gain during the honey flow correlates to colony performance over the entire season.

During our nectar flow in early April, colonies are supered and weighed. Ten days later the colonies are weighed again and the total weight gain and the percent weight gain tallied. The top producing 35 to 50 colonies are selected as breeders. For example in Figure 2, Colonies 1, 2 and 6 have been selected. This test is accomplished quickly with minimal colony disturbance. During the honey harvest we do not have the burden of weighing supers or trying to figure out which super came from which colony, the data has already been collected.

After the honey harvest, the selected colonies are inspected to confirm the identity of the queen, checked for swarming and for any evidence of disease. A graft is made from each breeder queen, the daughter queens are instrumentally inseminated and the new test population established. The selection cycle is repeated.

Introduction of New Stock

The CPBP is exclusive in that it is free from the uncontrolled introduction of genetic material. New material can be added to include new traits and/or new sex alleles to the population. The new stock is carefully observed and tested before introduction into our gene pool. This can dilute some of your selection efforts, though it can also add a needed element to your population.

Discussion

The main objective of this program is to provide consistent, high quality stock. We hope this review will encourage other beekeepers to use this system to develop and improve their own stock. The use of scientifically based breeding programs will enable us to improve the economically important characteristics of the honey bee and should enable us to exclude the African honey bee from our populations. The important point to be made is bees respond favorably to selection. Some breeding systems work better than others. We need to increase and improve the selection of honey bees.

A quote from a friend, Mel Greenleaf who runs the stock selection program at Hybri-Bees, Inc., sums it up this way; "Stock improvement is not quick and it is not easy". A breeding program takes time, careful planning and a lot of work. Stock development does not happen overnight. Bees have evolved over thousands of years and the goal of any breeding program should be to find and enhance desirable characteristics.Δ

LITERATURE CITED

Greenleaf, M. (1988) Stock Selection At Hybri-Bee, Inc. Amer. Bee Jour. 128(2)136-137.

Kaftanoglu, O. and Peng, U.S. (1980). A washing technique for collecting honey bee semen. J. Apic Res. 19(3):205-211.

Laidlaw, H.H., (1982). Contemporary Queen Rearing. Dadant & Sons, Inc.

Moritz, R.F.A. (1983), Homogeneous mixing of honey bee semen by centrifugation. J. Api. Res. 22:249-255.

Page, R.E., Laidlaw, H.H. (1982). Closed Population Honey Bee Breeding. 1. Population genetics of sex determination. 2. Comparative Methods of Stock Maintenance and Selection J. Apic. Res. 21(1):30-37, 38-44.

Page, R.E., Laidlaw, H.H. and Erickson, E.H. (1983). Closed Population Honey Bee Breeding. 3., The Distribution of Sex Alleles With Gyne Supersedure.

Page, R.E., Laidlaw, H.H. (1985). Closed Population Honey Bee Breeding. Bee World 66(2): 63-72.

Page, R.E. Laidlaw, H.H. and Erickson, E.H. (1985). Closed Population Honey Bee Breeding. 4. The Distribution of Sex Alleles With Top Crossing. J. Apic. Res. 24(1):38-42.

Szabo, T.I. (1982). Phenotypic Correlations Between Colonies; Traits In The Honey Bee. Amer. Bee Jour. 122(10):711-716.