A New Approach to Honey Bee Breeding at the Baton Rouge USDA Laboratory[1]

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A MAJOR long-term goal established for the Bee Breeding and Stock Center Laboratory is the development of superior stocks of bees for American agriculture (Harbo et al. 1973). To achieve this goal, personnel at the laboratory must first answer three important questions. What is superior stock? How is superiority measured? How can superior stocks be produced? We have developed a framework for answering these questions and envisioned a breeding program to bring us closer to the goal.

What is Superior Stock?

Every beekeeper can comment about what he wants in superior stock. Some want good honey producers; others want good pollinators. The beekeeper in New Jersey may want resistance to EFB; the beekeeper in Minnesota, resistance to Nosema; the beekeeper in Ohio, resistance to AFB; the beekeeper in California, resistance to chalk brood. The Canadian customer of package producers may want fast-building colonies; the mid-West U.S. customer may want colonies that build more slowly.

These examples illustrate two concepts. First, improved bee stocks should be superior for a number of characteristics. Each characteristic relates to an ultimate goal of more honey, more bees, or better pollination service, by focusing on a potential problem that might interfere with the ultimate goal. Second, the characteristics that constitute superiority in bees depend largely on the nature of a beekeeper's operation and the geographic area in which the operation is conducted.

Because of the diversity of the beekeeping industry, both in goals and geography, it is unrealistic to hope for the production of a "SUPER BEE" suitable to everyone's needs. A realistic hope is the production of a number of stocks, each having a collection of characteristics economically important to different segments of the diverse beekeeping community.

How is Superiority Measured?

Since superiority in bees relates to a collection of economically important characteristics, each characteristic must be measured. If these measurements were to be made entirely in bee yards, difficult problems would arise and a breeding program could easily have less success than hoped. Honey production assessment would depend on nectar flows; pollination activity measures would depend on floral preferences in the local environment; disease-resistant measures would depend on the occurrence of epizootics or clumsy whole-colony infectivity tests. Furthermore, climate, weather, drifting, unequal colony strengths, colony morale, and the past history of colonies all would make the measurements rather imprecise. Ideally, measurements of the various characteristics should be made in the laboratory.

Laboratory approaches to the measurements of characteristics of bees have recently been pioneered by personnel at the Ohio State University bee laboratory under the direction of Professor W. C. Rothenbuhler. They have measured hoarding behavior (Kulincevic and Rothenbuhler 1973), response to a virus disease (Kulincevic and Rothenbuhler 1975, Rinderer 1975), and honey bee defense responses (Collins 1976). Generally, such laboratory testing has decided advantages. The measurements are independent of weather, location, and climate. Also, they are relatively quick and are reasonably repeatable. Furthermore, if properly designed, they are precise enough to distinguish between the genetic values of different bees. Certain caution is required with laboratory testing, for field tests are necessary to determine the value and continued value of the laboratory tests. Laboratory testing for a number of characteristics is ideally suited to a breeding technique long used by animal geneticists, called a selection index. Such an index is a numerical method to rank and choose, on the basis of overall merit, the best of a number of possible breeder animals or lines.

A selection index takes into consideration a number of important pieces of information. The first pieces of information, essential for the selection index number, are the scores obtained from the laboratory testing for the characteristics one hopes to improve. By itself, such a combined score would prove very useful in bee breeding because it provides a way to evaluate and compare net genetic merit.

As still more information is brought into the index number, its usefulness increases. The relative economic value of the various characteristics can be used to weigh each laboratory test score. If this is done, an index score contains information about genetic value and economic value. In this way, if one characteristic is twice as valuable economically as a second characteristic, we can emphasize that first characteristic twice as much in our analysis.

However, not all characteristics are equally responsive to selection. Some characteristics can be greatly improved, and relatively easily. Other characteristics can be only moderately improved, and then only with great difficulty. The attribute of responsiveness to selection has a genetic basis and can be estimated. Geneticists call this estimate heritability. If a selection index is weighted with estimates of heritability we can place proper emphasis on the various characteristics in terms of how difficult it will be to improve them.

Characteristics are often correlated because most genes affect more than one character. Knowing what these effects are is very important to a breeding program. The nature of these correlations can be quite varied. In some cases when one characteristic is improved there is a strong tendency to improve a second characteristic. In other cases, when one characteristic is improved, there is a strong tendency to impair a second characteristic. Correlations can vary from strong through weak to nonexistent. If the correla-

tions between the characteristics in a bee breeding program are known they can be incorporated into a selection index. When they are incorporated, the assessment of genetic - economic value of potential breeders becomes still more refined and useful.

It is apparent that a selection index is complicated. That is good, because the net merit of bee stocks is complicated, and a selection index estimates net merit. However, because of the complication involved in establishing a selection index, the index itself should be tested, and improvements made on the basis of a short-term pilot selection program. Once it has been tested in this way the selection index provides a systematic, precise approach to the measurement of superiority.

How Can Superior Stocks Be Produced?

While a selection index approach makes it possible to assess superiority, a breeding scheme is still needed that will be of value in producing superior production stock. Our choices are wide, for geneticists have invested much time and creativity in the design of breeding schemes. One scheme that is especially appealing is based on the concept of specific combining ability.

Breeding schemes that use specific combining ability are aimed towards developing inbred lines which, when crossed, produce exceptional hybrids. Thus, the inbred line parents of hybrids are evaluated on the performance of the hybrid offspring. With such schemes the performance of the hybrids is the basis for the continued selection of the inbreds. In this way the best possibilities for useful hybrid vigor are encouraged. Those parents that produced the best hybrids are bred to maintain and improve the inbred lines.

Progress and Expectations

A program of stock improvement based on laboratory testing, a selection index, and specific combining ability has begun at the Baton Rouge laboratory. At present, we are working with three characteristics; resistance to Nosema, hoarding behavior, and longevity. Certain progress has been made. Laboratory testing procedures have been developed (Rinderer 1976; Rinderer and Elliott 1977) and combined with existing procedures (Kulincevic and Rothenbuhler 1973). Very recently, information about some correlations has been obtained and some experiments are underway to determine other correlations and heritabilities.

The future holds promise. While this kind of breeding program requires time, material resources, human energy, and patience, it is essential to use modern methods and proceed in an orderly manner for identifiable results. Superior bees, like well-reared children, require investments of time, material resources, and human energy. However, successful results are well worth those investments.

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FOOTNOTES

[1] In cooperation with the Louisiana Agricultural Experiment Station.

Reprinted from March, 1977, American Bee Journal
Vol. 117 (3): 146 and 147