INSEMINATED VS. NATURALLY MATED QUEENS: A POSSIBLE TREND IN THE INDUSTRY

S. TABER, E. COE,
and R. SWICKARD
USA

The success or perfection of artificial insemination of honey bee queens was essentially complete by 1946. At that time ROBERTS (1946) announced that honey producing colonies in Wisconsin headed by sister queens mated either naturally or artificially showed no difference in population, a reflection of eggs laid or, in honey production. LAIDLAW and ECKERT (1963) present a history of artificial insemination, however, there were certain critical or crucial areas of development that are interesting and were essential for the development of the technique. WATSON (1927) was the first to prove beyond any doubt that a queen could be inseminated. LAIDLAW (1944) showed the valvefold had to be pushed out of the way in order to place semen in the oviduct. A great amount of determined effort in many small areas were made by MACKENSEN (1947) (and many other references including the two manuals for instructions of artificial insemination, 1946 and 1970).

The technique of artificial insemination of queen bees has been utilized primarily in laboratory bee research. Now artificial insemination is beginning to be used in commercial queen production. The research set the stage over 30 years ago for an industry shift from the queen mating box to artificially inseminated queens. The 2 chief advantages of insemination over natural mating are:

1. Inseminated queens should provide a financial advantage. However, one must compare the costs of both mating procedures. In natural mating, there is the cost of the wood and of the labor required to build the mating boxes, frames, and feeders. Also, the mating box requires 1/8 to 1/4 kg of bees that are removed from potential sale or honey production. Labor involves preparation of the mating boxes in the spring, distribution of queen cells, examination for queen cell acceptance, provision of adequate food supplies, and finally, catching and packaging the mated queens for shipment. Also involved is winter storage and maintenance of the mating boxes.

In artificial insemination, the initial costs are high. The investment involves a building to house insemination operations, instruments, and microscopes. Also there is the cost of training the insemination operators while they develop proficiency. Once production has begun, costs include salaries of the employees who do the insemination and maintain the drones, queens and nursery colonies and the occasional replacement of the CO_2 supply. In addition, the care and rearing of drones is a necessary adjunct of the operation and adds to the cost of inseminated queen bees.

2. Inseminated queens should also have an advantage over natural mating during bad weather, which is here defined as weather that prevents virgin queens

from mating and worker bees from foraging. Also, adverse weather conditions can cause the bees to kill non-emerged and emerged virgins and drones if the food supply during this period is not adequate. For example, during one period of bad weather during the spring of 1975, SWICKARD had to remove 397 unmated queens from 400 mating boxes where they had been confined for over 2 weeks because of bad weather. (It has been Swickard's policy to remove old unmated virgins and replace them with new cells.) It was at that time he made the decision to transfer to artificial insemination.

There is a hypothesis which TABER and POOLE (1974), and TABER (1976) has been investigating that is as follows: Bad weather for mating is bad pollen collection weather and as a result virgin queens and drones do not grow sexually functional because of inadequate nutrition. This can be reversed by feeding an adequate supply of pollen to drones and to virgin queens.

During adverse weather, queens and drones banked in nursery colonies can be more easily fed and cared for than queens and drones in mating boxes, because the nursery colonies can be kept close by.

In our initial discussion of reasons for the shift by queen bee raisers to use artificial insemination instead of natural mating, three more were mentioned:

1. Inseminating queens with 8 μl of semen guarantees a large minimum amount of semen in the queens' spermatheca. A good effective mating is assured regardless of weather.

2. A beekeeper who has his queens artificially inseminated can guarantee the purity of the mating. Since virgin queen bees mate with 8—12 drones (TABER, 1958) and will fly 9—13 km (PEER, 1956, KONOPACKA, 1965) to mate with drones, it is easy to have mismatings. With artificial insemination, there is little likelihood of mismatings when the drone and virgin queen sources are controlled.

3. Once the skills, techniques, and equipment for artificial insemination are acquired by beekeepers, they can begin their own breeding programs. However, several unresolved difficulties exist in bee genetics ((an example is the lethal allele series (MACKENSEN, 1951)) so a great deal of research and education will be advantageous to beekeepers to act as bee breeders.

For an artificial insemination program to serve as total alternative to natural mating, several problems need to be researched and resolved; they are:

1. What new techniques of storage of virgins would reduce the death rate in banking colonies ?

2. Do queens placed in a 1 kg package of bees or a shipping cage with attendants and shipped off without laying eggs perform satisfactorily?

3. How are drones reared at the appropriate time and how can one maintain them so they are sexually effective when used for artificial insemination?

4. How can efficiency in the insemination procedure be improved? Perhaps the collection of semen could be separated from the injection of semen into the queens. TABER (1960) and HARBO (1974) have already shown the feasibility for 24-hour storage of collected semen.

When these problems outlined are solved, artificial insemination will be a definite likelihood for the majority of queens used in large scale commercial beekeeping.

Assistance in training in a new and expanding technology is not new to the bee laboratories of the Agricultural Research Service, USDA. Twenty-five years ago O. MACKENSEN at the Baton Rouge laboratory and W.C. ROBERTS then at the Madison, Wisconsin laboratory assisted in the training of G.H. CALE, Jr. who wished to develop a breeding program for Dadant and Sons. We report here on the assistance provided at the ARS Bee Research Laboratory at Tucson in training industry personnel in the artificial insemination of queen bees.

REFERENCES

HARBO, J. 1974. A technique for handling stored semen of honey bees. *Ann. Entomol. Soc. Am.* 67:191—194

KONOPACKA, Z. 1965. Studies on distance of mating flights of honey bee queens and drones, and the necessary isolation of mating stations for preventing mismatings. Final Report, *Research Institution of Pomology*, Project No. E 21—ENT—10 Pu awy, Poland

LAIDLAW, H.H. 1944. Artificial insemination of the queen bee *(Apis mellifera* L.): Morphologicall basis and results. *J. Morph.* 74:429—465

LAIDLAW, H.H. and J. E. ECKERT. 1962. Queen rearing. *Univ. Calif. Press.* Berkely

MACKENSEN, O. 1947. The effect of carbon dioxide on initial oviposition of artificially inseminated and virgin queen bees. *J. Econ. Entomol.* 40:344—349

MACKENSEN, O. 1951. Viability and sex determination in the honey bee *(Apis mellifera* L.). *Genetics* 36:500—509

MACKENSEN, O. and K. W. TUCKER. 1970. Instrumental insemination of queen bees. *Agriculture Handbook 390.* USDA, ARS

PEER, D. F. and C. L. FARRAR. 1956. The mating range of the honey bee. *J. Econ. Entomol.* 49:254—256

ROBERTS, W. C. 1946. The performance of the queen bee. *A. Bee J.* 84:185—186, 311

TABER, S., III. 1958. Concerning the number of times queen bees mate. *J. Econ. Entomol.* 51: 786—789

1960. Preservation of honey bee semen. *Science* 131:1734—1735, tables

TABER, S., III. 1976. Rearing honey bee queens throughout the year. *A. Bee J.* 116:514—517