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BREEDING HONEY BEES FOR POLLINATION OF SPECIFIC CROPS

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The production of seed or fruit of some crop plants is very dependent upon bees as pollination agents. Alfalfa (lucerne) is one of these. Its flowers are largely self sterile and almost incapable of automatic self-pollination. Bees are therefore required for both self and cross pollination. The alfalfa flower presents special problems. Both the stigma and stamens are enclosed in the keel, of the flower. When the bee thrusts its head into a flower it releases the sexual column and is thereby struck on the head by a mass of sticky pollen and by the receptive area (stigma) of the female organ. Since the next flower is nearly always visited in the same manner, its stigma strikes the mass of pollen accumulated from previous visits. Bees concerned only with collecting nectar learn to obtain it by approaching the flower from the side, thus avoiding the pollination mechanism. Although the nectar collectors accidentally trip a small percentage of the flowers they visit, their pollination efficiency is low. Pollen collectors, on the other hand, trip nearly every flower they visit so long as they continue to collect pollen. It is, therefore, the pollen seekers that are the most valuable pollinators.

Since the flowers must be tripped to be pollinated, the problem is to increase the tripping rate. This has been sought through (1) methods of management of the alfalfa crop, (2) breeding alfalfa that is easier to trip or more attractive to bees, (3) better management of both wild and honey bees, and (4) honey bee breeding. It is the last of these that we are concerned with here.

Bee behavior varies a great deal from colony to colony. Some of this variability is environmental or accidental and some is hereditary. In pollen trap collections we observed differences between colonies in the varieties of pollen brought in. At first we assumed this to be caused by scout bees of different colonies getting started on different plants and the pollen collectors having a tendency to continue to gather the kind of pollen they started on. Differences in pollen collection among colonies and races of bees have been reported by a number of investigators. Distinct differences in alfalfa pollen collection were observed at our Logan, Utah Laboratory and in 1961 Dr. G. E. Bohart suggested a joint project with the Baton Rouge, Louisiana Laboratory on breeding bees for alfalfa pollination. Such a project was begun in 1962 with 3 main objectives. These were (1) to determine if alfalfa pollen preference is inherited, (2) to obtain information on how it is inherited, and (3) to select a superior bee for alfalfa pollination. Differences in total pollen collection are difficult to measure on account of the influence of colony population, amount of brood being reared, plant condition, and many other factors. Preference for a specific pollen, on the other hand, such as alfalfa pollen, is easily determined because it is measured by the ratio of the specific pollen to other pollens and is largely independent of colony conditions.

In our project several samples of bees were taken at the entrance semi-weekly and the percent of pollen collectors that were alfalfa pollen collectors determined. The breeding was done at Baton Rouge in the spring of the year and the testing and selection in fields of alfalfa grown for seed at Logan, Utah in July and August. Thus we proceeded at the rate of one generation a year.

In 1962, 356 colonies from 3 sources were tested and 3 high and 3 low alfalfa pollen collecting colonies selected for the establishment of a high and a low line. In 1963 virgin queens and drones reared from each of these selected colonies were mated together to form 6 mating groups of sister queens. The tests for that year showed that there was a greater similarity between colonies within mating groups than between less related colonies of different mating groups. This result indicated that alfalfa pollen preference was an inherited characteristic and encouraged us to continue.

In the third and fourth generations (1964—1965) inbreeding proceeded at a slower rate. In the high line the percentage alfalfa pollen collection increased from 40 in 1963 to 66 in 1965 and in the low line it decreased from 26 percent in 1963 to 8 percent in 1965. In a group of colonies whose worker bees were hybrids between the high and low lines the average percentage alfalfa pollen collection was intermediate.

The conclusions we can draw from the fifth generation (1966) depend on how we interpret the data. We had all our colonies first at a location where pollen sources other than alfalfa were scarce and later at a location where the prevalence of non-alfalfa pollen sources was more comparable with that of previous years. The percentages for the two locations combined were 85 for the high line and 18 for the low line. At the location with limited pollen sources the corresponding percentages were 99 and 53. At the one with more pollen sources the corresponding percentages were 54 and 2. Where non-alfalfa pollen sources were scarce the low line bees made an effort to hunt out other pollens, but were forced to gather some of the abundant alfalfa pollen whereas the high line was almost completely satisfied with alfalfa pollen. Where the non-alfalfa pollen sources were relatively abundant the situation was reversed. The low line bees almost completely ignored the alfalfa while the bees of the high line were attracted away from alfalfa to a much less extent. At each location the line that had an abundance of its preferred pollen available collected the most total pollen, possibly because its bees spent less time searching. These observations suggest that the alfalfa pollen collecting strain may be of greatest value in locations where other pollen sources are abundant.

It has not yet been shown that bees of our high line will set a better seed crop than presently available commercial strains, but we do have evidence that they have a greater preference for alfalfa pollen. For each of the two seasons, 1963 and 1964 we tested an unselected group of colonies along with the inbred lines and found the average percentage alfalfa pollen collectors to fall below the midpoint between the high and low lines.

Have we reached our objectives? Our first objective was to determine heritability. The fact that we have been able to select distinct low and high alfalfa pollen collection lines that do not overlap should be ample proof that preference for a specific pollen can be inherited. Our second objective was to determine the mode of inheritance. The intermediate hybrid and the variability of our backcrosses indicate that this characteristic is dependent on many genes each having a small effect. We have seen no evidence of dominance. The third objective was to develop bees for possible use in commercial alfalfa seed production. Although we now have a high preference line, its handling characteristics are not too good due to the fact that during the first few generations we selected only for alfalfa pollen collection. As a result of the necessary inbreeding, vigor and brood viability are both low. In addition the stock winters poorly. We are confident that such characteristics can be avoided and a superior bee for commercial use can be developed by the proper breeding methods.

Among other plants with a pollination problem for which it might be economically feasible to develop and supply special pollination strains are red clover, cranberries and possibly hybrid cotton. Red clover is also self sterile and requires cross pollination. In addition it has such a long corrola tube that honey bees have difficulty reaching the nectar. Efforts toward better pollination have been in the direction of providing bumble bees providing long tongued bees and breeding for shorter corrola length. What could be more logical than selecting a bee that prefers the pollen of red clover. Then pollination could be adequate regardless of nectar conditions or competition from other plants. Of course, a long tongued bee with a red clover pollen preference would be ideal. It has already been observed that the percentage of red clover pollen collecting bees is higher among North European bees than among Carniolan and Italian bees. This suggests the existence of genetic differences.

As yet we have little evidence of heritability of preference for any pollen other than alfalfa. A difference has been noted in the amount of cranberry pollen brought in by different colonies and a project is now underway to determine if the tendency is inherited. Proof of heritability would show that inheritance of a specific pollen preference is not unusual and would throw the door wide open to the development of a variety of special pollinating strains.