The tiny female wasp would crawl from scale to scale stopping only long enough to insert its stingerlike ovipositor and leave a number of eggs in the host's body. The eggs soon hatched and produced small larvae which quickly killed the host. As many as 10 young wasps might issue from a single dead scale insect. The parasite produces a new generation in as little as 27 days. The rhodesgrass scale requires 60 to 70 days to complete a life cycle. At this rate, the parasite could quickly overtake and suppress its host.

During this period in the 1950's, a new variety of grass called Bell rhodesgrass was developed and released which tolerated large numbers of scale insects. When used in conjunction with the parasite *N. sangwani*, the scale population was reduced so low that no loss of yield occurred. Presence of the parasite was shown to increase yields by 30 to 40 percent.

Unfortunately, the female parasites are wingless and thus disperse very slowly. To obtain the maximum benefits in the shortest time, Michael Schuster, Texas A. & M. entomologist, seeded 900,000 acres with grass sprigs infested with parasitized scale. These sprigs were placed in frozen food cartons and dispersed from low flying aircraft at a cost of 34 cents per square mile.

Thus, more than 25 years after the rhodesgrass scale was recognized as a pest, the solution was achieved. Thanks to the persistence, perception, and ingenuity of agricultural scientists and a tiny wasp from a foreign land, cattlemen of the gulf coast can again produce more beef for the American consumer at a lower cost.

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**Tailormade Bees**

**Do Honey of a Job**

S. E. MCGREGOR and OTTO MACKENSEN

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Bill Nye watched a truck loaded with hives of bees turn off the Utah highway and into a field of flowering alfalfa. As it moved across the field, it stopped every tenth of a mile, and the driver manipulated a hoist that gently set off a dozen hives. They had been picked up with the same hoist the previous evening in California and had been hauled all night. Within minutes after their arrival in the field, the bees eagerly began visiting the alfalfa flowers. In doing so, they accidentally carried pollen from one flower to another.

This cross-pollination results in a bountiful seed crop for the farmer—a benefit that also extends to the beekeeper in pollination fees for the bees, the hay producer who plants the seed, the dairyman who feeds alfalfa hay, and ultimately the consumer of beef and dairy products.

It all started when Nye (William P. Nye of the USDA Bee Research Laboratory at Logan, Utah) wanted to

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Nectar-collecting honey bee on alfalfa blossom. Bee also picks up alfalfa pollen, which is the white mass packed on hind leg.

conduct a test that other bee scientists knew wouldn't work. He wanted to develop a bee to fit the crop. Everyone else said we should breed the crop to fit the bee. But, after he did it—with help from others, they wondered why they hadn't thought of it years ago.

The steppingstones toward development of a tailor-made bee were many, but a critical step was the need to control mating of the queen. Ordinarily, she mates with any drone she happens to meet when she goes on her mating flight. But a breeding program cannot be conducted this way. So, the present method of mechanical insemination (hand mating) was developed. It is now a standard procedure in all USDA bee research programs. It is making possible the increased knowledge of bee genetics required for intelligent bee breeding.

Off to the side was another little steppingstone. Not in the direct path, but usable nonetheless. This was the pollen trap. Basically, it is a wire grid over the hive entrance that lets the bees get in, but scrapes off the pollen they are carrying to the hive in pellets on their hind legs. These pellets fall
into a container. When they are examined, the plant source can be determined. That tells the beekeeper where his bees are working.

A trap like this will yield 25 to 75 pounds of pollen in a year. The pollen is generally used as a supplemental feed for the colony during periods of the year when no pollen is available.

Many beekeepers have observed that traps on some colonies yield more pollen than others, and that not all traps at a location yield the same kinds of pollen even on the same day. There is scientific evidence that the foraging bees from different colonies become oriented to different areas where different plants grow.

Nye had noticed that certain traps had a lot of alfalfa pollen when others alongside had little. He wanted to know if this trait was inherited, regardless of arguments that existed to the contrary. To find out, he sent some of the queens to our Bee Breeding Research Laboratory at Baton Rouge, La., and we bred some daughter queens from them. These were shipped back to him and put into colonies near alfalfa fields. The trait persisted. Colonies that yielded a lot of alfalfa pollen produced offspring that did likewise, and colonies that yielded little alfalfa pollen were succeeded by colonies that yielded little.

Of course, the alfalfa flower is a bit unusual. It is largely self-sterile. It must get its pollen from another alfalfa plant, so it is dependent on the bee for this service. Its anthers and stigma (the male and female parts) are tightly enclosed by the petals and are released, or tripped, when the bee thrusts its head into the flower. When the flower is tripped, the bee is struck on the head by the stigma and by the anthers, bearing a mass of sticky pollen. When the next flower is visited, its stigma strikes the mass of pollen accumulated on the bee’s head. Pollination results.

Some bees, only concerned with collecting alfalfa nectar, learn to get it from the side of the flower and avoid the light sock on the jaw caused by the tripping mechanism. They accidentally trip a small percentage of the flowers they visit, but their pollination efficiency is low. Pollen-collecting bees, on the other hand, trip nearly every flower they visit. They are the ones most valuable to the alfalfa grower.

After the observation was confirmed in 1963 that alfalfa pollen collection was inherited, the selection and breeding program was increased. We tested the colonies in the Utah fields of alfalfa grown for seed (some growers only produce hay and cut the plants before seed is formed). We chose the ones that collected the most pollen, removed the queens, and sent them to Baton Rouge, where the bee breeding work was done. No alfalfa seed is produced at Baton Rouge, but it does have a long season; long enough for queens to be reared, mated, and shipped to Logan in time to have worker bee progeny when alfalfa blooms. In this way, one generation a year was tested.

Nye started out by testing 356 colonies near Logan. He didn’t have that many traps, so he devised a vacuum cleaner to pick up pollen-laden bees at the hive entrance and pull them into a killing bottle. Then the percent that carried alfalfa pollen was determined. This worked well for a quick test of a large number of colonies.

As the pollen preference study continued, another problem was created. Inbreeding and selecting for one quality caused some of the other desirable qualities to gradually disappear. Our bees lost viability and vigor, and they became more restless and difficult to handle. So we had to breed out these bad qualities as we continued to select for alfalfa pollen preference. The strain is much improved now, but not as vigorous as we would like.

In 1963, the best colonies collected an average of 40 percent alfalfa pollen. Through the next three generations, this increased to 85 percent. Not only the percent, but also the amount of alfalfa pollen taken from traps was greater in our selected strain than in a commercial strain. In addition to the colonies showing a high preference for alfalfa pollen, we had also selected a
Bees, the most important pollinators of our agricultural crops, also pollinate many wild flowers, shrubs, and trees. Other agents assist the bees. Nectar-feeding bat, top, is visiting agave. These bats also feed on and pollinate saguaro or giant cactus of Southwest. Bee, below, and whitewing dove, left, are pollinating saguaro.
group showing weak, or low, preference. In this line, the percentage decreased to 18 percent during the same period. Hybrids between the two lines were intermediate.

These results, together with those from backcrosses of the hybrid to the inbred lines, in which a lot of breeding and technical study was involved, confirmed that pollen collection was inherited and showed us that it was dependent on many hereditary determiners. This meant that efforts to develop still better strains for alfalfa pollination should be fruitful.

Further proof that the alfalfa preference was real was brought out by the 1966 tests. That year, we placed the test colonies where alfalfa was the main source of pollen (other pollens were scarce). Later we moved the colonies to a location where other pollens were abundant, but alfalfa was scarce.

We learned that where alfalfa pollen was abundant, 99 percent of the pollen collectors from the "high" line and 53 percent from the "low" line collected alfalfa pollen. Where alfalfa pollen was scarce, the corresponding percentages were 54 and 2.

This showed us that when other pollen sources were scarce, the low line was forced to gather alfalfa pollen to meet its need, while the high line got along fairly well with alfalfa pollen.

Where other sources of pollen were abundant, the low line almost completely ignored alfalfa. The bees from the high line were attracted away from alfalfa to a far less extent.

This also proved that the alfalfa pollen-collecting bee is most valuable to the seed-grower where it is most needed—in areas where there is much competition from other plants for the honey bee's services.

One question that came up repeatedly was whether the high line colonies gathered more alfalfa pollen because their bees ranged a shorter distance from the hive than bees of the low line. To answer this question, colonies of both lines were placed in three locations: In a field of alfalfa, 1½ miles from it, and 4½ miles from the field. At all locations, colonies of the high line collected more alfalfa pollen than the low line colonies. This proved that the alfalfa pollen preference was real, and not just a matter of convenience for the colony.

About 90 crops grown in the United States are dependent on bees for pollination. To develop special pollinating strains for each of these is not practical now. But a few crops are important enough and have a sufficiently difficult pollination problem to make development of a practical strain worthwhile.

One of the crops is red clover. Petals of the flower of this plant are united at the base to form a tube which is so long and narrow that honey bees have difficulty reaching the nectar in its base. However, we may have been led astray by too many references to this long corolla tube and the short tongue of the honey bee.

This tube length is a factor only in nectar collection. The honey bee can reach the red clover pollen when it wants to. The flowers of red clover are also self-sterile and require cross-pollination. Whenever honey bees are thick on red clover, the seed yields are good.

The alfalfa experiment indicates that when bees are placed on red clover, some of them will probably show a preference for its pollen.

Nectar-seeking bees have formerly been considered for red clover pollination, but pollen-seeking bees would be much better. The trait is doubtless present in certain colonies. We need only to ferret it out and develop it to have a tailor-made red clover-pollinating honeybee.

Cotton is considered largely self-fertilizing, but it benefits from cross-pollination. And in the production of a hybrid cotton, large-scale insect cross-pollination is essential. As in alfalfa, the honey bee has been placed near cotton more for honey production than for pollination. A few colonies have been seen, however, that collected cotton pollen freely. A search is now underway for other colonies that demonstrate this trait.
There is no clear evidence now that bees inherit a preference for any pollen except alfalfa. Yet, when pollen traps were placed on colonies in New Jersey cranberry bogs in 1966, one colony consistently collected almost pure cranberry pollen, while others around it collected about half cranberry pollen with a mixture of other pollens. Daughters have been bred from this queen, and tests are underway to determine whether a preference for cranberry pollen is inherited.

Positive results would show that preference for pollen of a specific plant by bees may not be unusual, and that selective breeding for preference of certain pollens could be made. Or in less technical terms, we would say that we can tailor a bee to fit almost any crop.

**Everything Is Automated These Days—Even Water**

CHESTER E. EVANS

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Spiraling labor costs coupled with inexpensive water are major causes for inefficient use of irrigation water. Farmers are reluctant to use additional labor just to conserve water. Instead, the farmer may use his labor force for other more pressing jobs. Irrigating often becomes a second priority. It is frequently an around-the-clock job, and schedules for changing water are not always met at night. Besides, experienced or reliable irrigators currently are seldom available for hire.

Haise, with coworker E. G. Kruse, first invented devices to automate standard irrigation structures and turnouts and tested them at the Colorado State University Foothills Hydraulics Laboratory in Fort Collins. Basically, all systems developed consisted of four essential parts: (1) Gates or valves in irrigation structures that could be opened or closed, (2) a source of air

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