Chapter 28

Non-stinging Honeybees Induced by Gamma Radiation

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Honeybees are useful domestic animals that produce honey and royal jelly. They are also the major natural pollinators of many important crops. Artificial pollination of crops is time-consuming and calls for great skill. When an apple-grower in Japan was asked, 'Why don't you use honeybees for pollination?', he replied, 'Honeybees sting us. I can endure the occasional sting myself, but what if my grandchildren and the children of my area should be attacked by them? Terrible!' Honeybees are highly protective of themselves and their hives, so will sting enemies if they feel threatened. Consequently, many farmers refuse to keep and make use of them.

This study succeeded in breeding non-stinging honeybees by inducing mutations with gamma-ray irradiation (Photo 1). These bees cannot sting their keepers, whom are now confident about handling and using this new type of honeybee.

Apiculture in Japan

Two species of honeybee live in Japan. One is the native Japanese honeybee (*Apis cerana*), the other is a European honeybee (*A. mellifera*). *Apis mellifera* is the main commercial species. At present, about 7000 beekeepers care for about 24,000 colonies. Honeybees are the principal insect pollinators for 80 per cent of cultivated crops, but regrettably have not been bred in large enough numbers to meet increasing demand. This is because of the potentially massive stinging capability of honeybee colonies, each consisting of from 20,000 to 60,000 workers. Farmers consider it difficult to keep honeybees.

Stinging is an instinctive reaction of the honeybee, protecting the swarm and ensuring its survival. It is impossible to remove this instinct, but it is possible to disable the stinging mechanism. The process involved in changes in heredity and form or characteristic is known as mutation. The Laboratory of Apiculture at the National Institute of Animal Industry, and the National Institute of Radiation Breeding have worked together to breed non-stinging honeybees by causing mutation using gamma-ray irradiation.

Stingers of Honeybees

Most bees have an ovipositor for egg-laying. The stinger of honeybees evolved from the ovipositor although it no longer has that function, now being exclusively used for protective purposes. Normally the stinger is stored in a small chamber at the end of the honeybee's abdomen and, when the need arises, is turned over and extruded. The stinger is a tube composed of two types of stings: one stylet and two lancets. Each sting has barbs at its end so that it cannot be removed once it penetrates the skin of the bee's enemy. The stylet plays the role of a prop against which the two lancets move alternately, first one and then the other, forcing deeper through the skin of the enemy. The stinging action is, in other words, made by the alternate movement of the two lancets rather than the pushing power of the abdomen. The base of the stinger is thick and spherical, and contains the poison to be injected into the enemy's body. In this bulb are two valves fixed to the lancets, and as the lancets slide by turns, the valves move backwards and forwards supplying poison to the stinger simultaneously. In the case of honeybees, the insertion of the stinger by the alternate movements of the lancets and the injection of poison take place at the same time. Because of the barbs, the stinger fixed in the enemy's skin does not come out and finally tears entirely from the honeybee's body taking with it the bulb of poison. The honeybee is badly injured by this process and soon dies.

In the non-stinging honeybees that were bred, the stylet and lancets are separated from each other. Because of this, the lancets cannot make the mutual sliding action and cannot perform their stinging function. The valves for sending poison are also away from the bulb and so cannot send poison to the stinger.

Breeding Non-stinging Honeybees

To induce mutation artificially it is necessary to consider the level of gamma radiation dosage, the method of irradiation, the developmental stage of the honeybee and a number of other factors. Two effective methods of inducing mutation were discovered.

In the first, an acute irradiation of gamma ray of 20 to 50 gray (Gy) was given to queens that had already completed copulation and had sperm in their spermatheca. Non-stinging honeybee workers were produced in some colonies but the mutation rate was low: 0.5–1.0 per cent. This non-stinging characteristic also appeared in the swarm following the prime swarm and in subsequent generations, indicating heritability. However, observation of the characteristic phenotype suggests that the mutation is caused not just by the work of a single gene. A line of non-stinging honeybees can probably be established if crossing and selection are repeated using these genetic resources as a basis.

The second method was acute irradiation of 30-Gy gamma ray of honeybees at the developmental stages where they metamorphose from mature larvae into pupae (eight to ten days after oviposition). In this case, almost all (97 per cent) of the honeybees subjected to gamma rays turned into non-stinging honeybees. Using this method, artificial colonies of non-stinging honeybees were made, although they were not permanent. When nectar-producing plants were placed in the chamber (kept at a stable temperature and humidity and in a long-day condition) with the colony for studying flight activities, flower-visiting and other behavioural aspects, no difference between these bees and normal honeybees was observed. This indicates that the non-stinging honeybees will probably be of practical use.

Line Selection of Non-stinging Honeybees

It is impossible to distinguish by appearance the non-stinging honeybees generated by irradiation of queens from those created by irradiation to individuals at the developmental stage. The latter may, however, show defects that occur in the generation process. However, if there is heritability, it will bring a higher experimental efficiency to selection and breeding of non-stinging honeybees. Non-stinging queens were created by the latter technique and found to lay eggs normally.

Use of Mutant Bees

Care should be taken when releasing mutants into nature in order to take into account the possible consequences of outflows or escapes of mutation-related genes and disturbance to the ecosystem by mutants. However, in the case of the European honeybee in Japan, these problems will be of less importance for the following reasons.

- European honeybees are an exotic species and need a beekeeper's care to establish themselves in the environmental conditions of Japan. This is due to such local factors as natural enemies, parasites and climate. Because of this, there are virtually no natural colonies of these honeybees in Japan. Therefore, no problem will arise with cross-breeding of mutant European bees and wild species.
- In a honeybee colony, only the queen and her drones can pass on their genetic inheritance to the next generation. Worker bees are not involved. The escape of genetic variations can be avoided by controlling queens and drones. As queens and drones are much larger than worker bees, they can be easily controlled by adjusting the size of the entrance of the hive. The colonies made in this study consisted only of worker bees.

Fig. 1. Non-stinging honeybees on a hand

Conclusion

Honeybees either sting their keepers or induce the fear of being stung. They are useful farm animals but cannot be tamed like horses, cattle or sheep. If non-stinging honeybees (Fig. 1) can be used for practical purposes, farmers will be more likely to keep and manage honeybee colonies. It will also be possible for people other than farmers or expert beekeepers to install a beehive in their garden and enjoy honey production several times a year. It is hoped that honeybees will be as widely farmed as other livestock.