Queen Rearing With Apis cerana

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Introduction

IN ASIA, *Apis cerana* Fabr. has been "domesticated" for 3,000 years. The earliest record of *A. cerana* beekeeping was found in China (Fang 1984). Since 1957, the modern beekeeping systems and queen rearing methods of *A. mellifera* have been introduced for use with *A. cerana* in China. The Chinese have developed techniques for their conditions to transfer *A. cerana* into modern hives to increase colony production, to select for high honey yield, to control bee diseases, to rear queens and divide colonies commercially. Fang (1988) reported that there are now more than 1,000,000 colonies of *A. cerana* in China.

Honey production by *A. cerana* in Asia has long been kept low by primitive management methods. There were few colonies and low honey yields, both of which increased when new methods of beekeeping and queen rearing were adopted. Before 1960, in Chonghue county, Guangdong (Canton) province, there were a total of 2,000 colonies of *A. cerana* with an annual yield of approximately 10,000 kg honey or an average of less than 5 kg of honey from each colony. After the adoption of modern beekeeping and queen rearing methods, the colony numbers and honey yield increased year by year. By 1963, honey bee populations had increased to about 6,000 colonies with an annual yield of 300,000 kg honey, or an average of almost 50 kg of honey per colony (Wongsiri *et al.* 1986).

General beekeeping manuals contain little information on *A. cerana* queen rearing. We hope that this compilation of information from specialized books and research articles written in Chinese and Thai on queen rearing will inform more beekeepers about this species (Lai 1982, Wongsiri 1984, Pothichot and Wongsiri 1987, Wongsiri *et al.* 1988) in comparison with *A. mellifera* (Doolittle 1915, Laidlaw 1979).

Beekeeping and queen rearing with these two species are very similar, if the generally smaller size of bees and colonies in *A. cerana* is kept in mind. However, there are some significant differences which have been found.

Queen Production Under Natural Conditions

It is possible to secure a few good queen cells from a colony which is preparing to replace an old or failing queen (supersedure). If all supersedure cells are removed, the colony will make others and the old queen does not disturb them. Occasionally we see an old queen and a young queen living together in the same colony.

Queen cells can also be taken and used from colonies preparing to swarm under natural conditions (Fig. 1). This method has been used by *A. cerana* beekeepers in Thailand. Similarly, Laidlaw (1979) recommended manipulating colonies of *A. mellifera* to stimulate the building of cells in preparation for swarming. Swarm cells are "ripe" (the queens are ready to emerge) 10-11 days after cell building began. An emerged virgin queen will destroy any remaining queen cells and inhibit queen cell production. Thus, the ripe queen cells which are desired for propagation must be removed before a virgin emerges. To requeen the colony, one queen cell (often the longest and most perfect) may be left in the colony. After removal, the ripe cells are then separated. Small or poorly formed cells are discarded. The cells are placed between layers of padded cloth to protect the queens in the cells and carried to the nucleus or prepared mating hive.

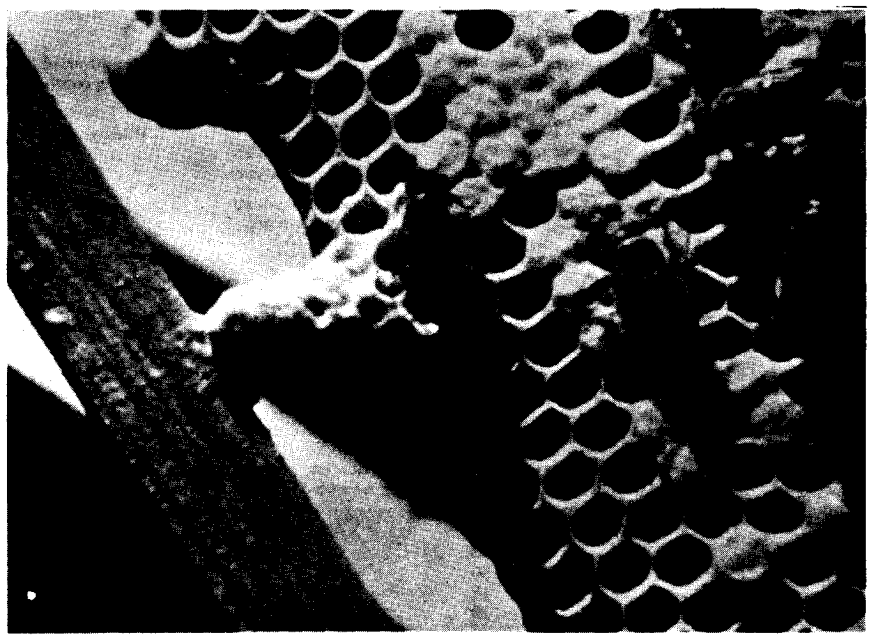

Fig. 1. Swarm queen cells.

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Queens cells may be reared under emergency conditions, as when a queen is removed from a colony. The bees will rear a few emergency cells in 1 to 2 days in young brood comb (Fig. 2). Inoue (1962, as cited by Johansson and Johansson, 1973) reported that no emergency queen cells had been found in *A. c. japonica*. If queenlessness occurs when natural conditions are unfavorable, the resulting queen larvae may be poorly fed. If one wishes to rear queens under unfavorable conditions at a more convenient time than during the swarming season, it is necessary to stimulate and feed the colony. A colony of bees can be strengthened by the addition of the required number of young bees and emerging brood from other colonies. The production of brood food can be increased by feeding a heavy sugar syrup and natural or artificial pollen (e.g., a dry soybean powder) in an external feeder. The characteristics listed in Table 1 distinguish emergency, supersedure and swarm cells.

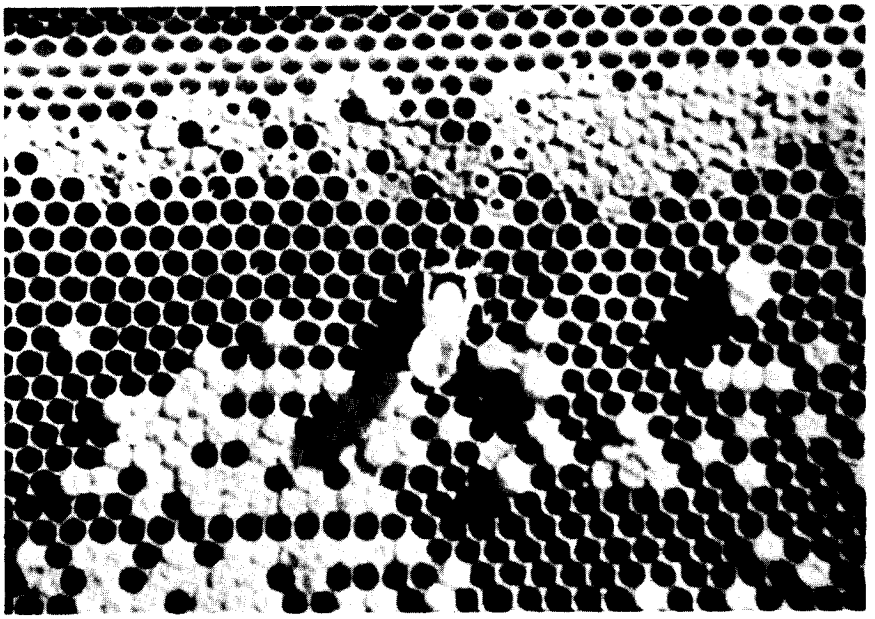

Fig. 2. An emergency queen cell.

Grafting

All methods that stimulate the colony to build queen cells from wax cell cups take advantage of the basic behavior by which the colony produces emergency cells in the absence of a queen. *A. cerana* queen rearing uses a frame with 1 to 3 bars (Fig. 3) which have 10-20 cell cups mounted at intervals (Fig. 4).

We developed a process for producing cell cups for *A. cerana* based on the process for *A. mellifera* as discussed by Laidlaw (1979). This uses wooden dipping sticks made from pieces of dowelling 6 mm in diameter, rounded and smoothed at one end. The stick is dipped and redipped into just molten wax until a cell is formed. The cell is removed and fastened to the grafting bar. In addition, we place a frame (Fig. 4) holding the wax cups into a colony for a few hours or overnight before grafting larvae so the bees can clean and prepare the cups.

We prime cells with royal jelly before placing larvae in them. *A. cerana* prefer "wet" grafts. A damp cloth or paper towelling kept over the frame from which the larvae are being taken, as well as the cell cups that will receive them, minimizes drying of the larvae. Bees are brushed (not shaken) off the grafting comb before use. Adequate illumination is needed in front of the operator, who uses a transfer tool; this may be purchased, or fashioned from a matchstick, toothpick, twisted feather, bamboo stick or grass stem. The chosen tool is inserted underneath a larva (less than 1 day old) to lift it from the worker cell. The larva is placed in one of the cell cups primed with royal jelly, which are located on the frame bars. This frame is returned to the queenless hive (cell builder) as quickly as possible. Without a honey flow, sugar syrup must be fed at least 3 days prior to grafting and throughout the cell building period. No smoke should be used during manipulation because *A. cerana* generally absconds when exposed to smoke.

The cell builder hive is a queenless, single-story colony with a minimum of 3 or 4 combs of honey and pollen and an abundance of nurse bees. If necessary, we add frames of emerging worker brood without eggs, a few days in advance. These conditions simulate the conditions in a colony preparing to swarm.

In queen rearing, the timetable for procedures must be followed strictly once it is begun, so the colonies used should be gentle as well as populous. Regardless of other conditions, certain management activities must be carried

Table 1 Queen cells under natural conditions

Type of Queen Cells	Emergency	Supersedure	Swarming
Usual number found	1-20	1-5	5-30
Position	Surface & bottom of the comb & the corners	Surface of the comb & the corners	Bottom of the comb
Age of cell at emergence of queen	10-12 days (started with 2-3 day-old larvae)	14-15 days (started with 1 day-old larvae)	Widely variable
Contents of worker cells at time queen cells started	Old eggs and young brood present	Eggs and young brood present	Eggs absent

Table 2 The production of *Apis cerana* queens by single grafting or double grafting (1988).

		Single Grafting		Double Grafting	
Colony Number	Number of Larvae Grafted	Number of Larvae Accepted	Percent Success Accepted	Number of Larvae	Percent Success
1	20	17	85	19	95
2	20	13	65	18	90
3	20	20	100	19	95
4	20	18	90	18	90
5	20	19	95	17	85
			av. 87		av. 91

There was no significant difference between the two methods by a t-test, at the 95% level.

out.

In "double grafting" a young worker larva is grafted (transferred) as usual into a queen cell, and the next day it is replaced with another young larva (less than 24 hours old). The queens of *A. cerana* produced by this technique are slightly heavier than those from single grafts. This process, theoretically at least, provides the second larvae with the abundant food fed to the first larvae and generally insures that considerably more food is put into the queen cells than the larvae can eat (Laidlaw 1979). From preliminary observations of *A. cerana*, the number of cells accepted in single grafting was not significantly less than that accepted with double grafting (Wongsiri *et al.* 1988). More than 90% of both single and double-grafted larvae were accepted and reared by the workers as queens, under optimum conditions (Table 2).

When cells are double grafted, care should be exercised in the second transfer. The body of the first larva must be discarded carefully. Unless the larvae are removed without materially changing the consistency of the jelly, the bees may remove all of the jelly and start over again, thus eliminating any beneficial effect of the double grafting.

One to three days before the queen cells are "ripe," a queenless nucleus or small colony is separated from an existing colony or the queen is removed from an existing colony. One queen is then placed in each such colony.

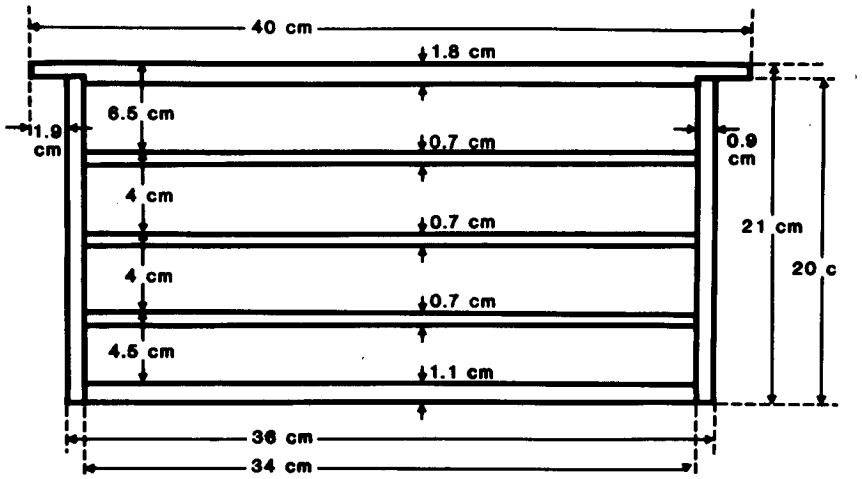

Fig. 3. Plan for a queen rearing frame with 3 bars for cups.

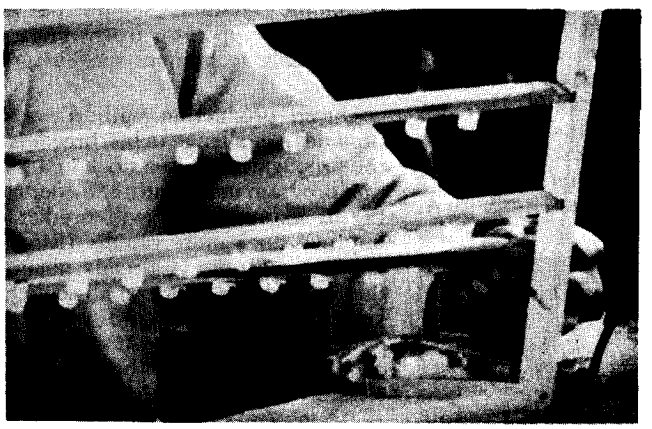

Fig. 4. Queen rearing frame.

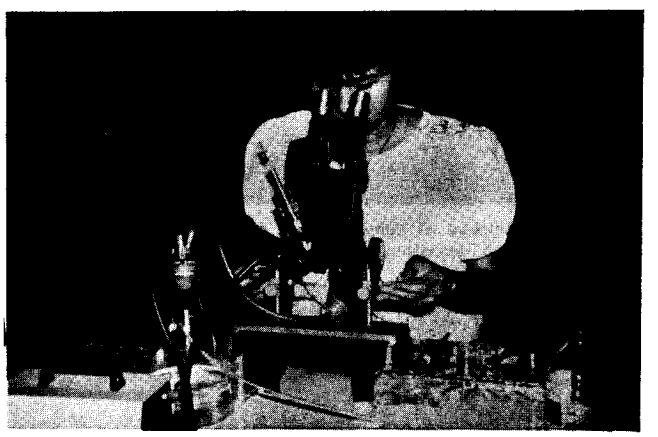

Fig. 5. Instrumental insemination of *Apis cerana*.

Controlled Mating

Instrumental insemination is important in selective breeding because it is the only way that a breeder can completely control which drones mate with a queen. Bee breeders and beekeepers are well aware of the importance of instrumental insemination for controlled mating. However, one can also improve stock in a breeding program that uses only natural mating. Instrumental insemination should not be seen as a replacement for natural mating but as an additional tool that gives a breeder absolute control of mating (Harbo 1976). To increase the productivity of *A. cerana* most efficiently, some degree of controlled mating must be assured. The optimum method of instrumental insemination of this species can be worked out only when the details of its reproduction, and especially of its mating behavior are better known.

The reproductive biology of *A. mellifera* has been studied by many authors, but such studies on *A. cerana* have only just started. Sharma (1960), Adlakha (1971) and Ruttner *et al.* (1972), investigated the mating behavior of *A. c. indica* in India. Ruttner, *et al.* (1972, 1973) studied reproduction of this species in the Federal Republic of Germany. The first successful instrumental insemination of *A. c. indica* queens was by Woyke (1973) in Germany and the egg-laying activity of these queens was investigated in Poland. Lai You-sheng in the Div. of Apiculture, Guangdong province, China carried out investigations of instrumental insemination of *A. c. cerana* in China but never published in English (Wongsiri *et al.* 1986).

The amount of *A. c. indica* semen in the oviducts was measured by Ruttner, *et al.* (1973) in Germany, in one queen returning from a mating flight. They also counted the number of spermatozoa in the spermathecae of two queens mated naturally in Germany and of one naturally mated in Pakistan. Woyke (1975) studied natural and instrumental insemination of *A. c. indica* in India.

A. c. indica inseminated instrumentally in India with 6 mm^3 semen had 1.44 million spermatozoa in the spermatheca (Woyke 1973). Queens inseminated by Woyke (1973) with 4 mm^3 in Germany had more (1.95 million) but inseminations in China with 6 mm^3 had still more (3-4 million).

A. c. indica queens inseminated with 4 mm^3 of semen (Woyke 1973), or *A. c.*

cerana queens inseminated with 4-6 mm^3 in China, as described here, produced exclusively worker brood during the first year. An instrumentally inseminated queen of an *A. cerana* F1 hybrid (Thai x Chinese) under favorable colony and environmental conditions, lays an average of 964 ± 239 (551-1491) eggs each day (Wongsiri *et al.* 1989).

As a source for semen, it is best to choose drones that have aged 7-15 days after emergence. Drones younger than 7 days are often not yet sexually mature, and those older than 15 days are more likely to cause disease or leave a residue of semen in the oviducts. Both conditions may kill a queen before she begins to lay eggs.

The mating biology of *A. c. indica* in India and Thailand and *A. c. cerana* in China differs in some respects from that of *A. mellifera*. However, although queens are smaller in *A. c. indica* in India and Thailand, they can be satisfactorily inseminated (Figs. 5, 6, 7). But the procedure with *A. cerana* and especially *A. c. indica* is much more time consuming than it is with *A. mellifera*.

Fig. 6. Release of semen to the exterior (drone endophallus with semen and mucus).

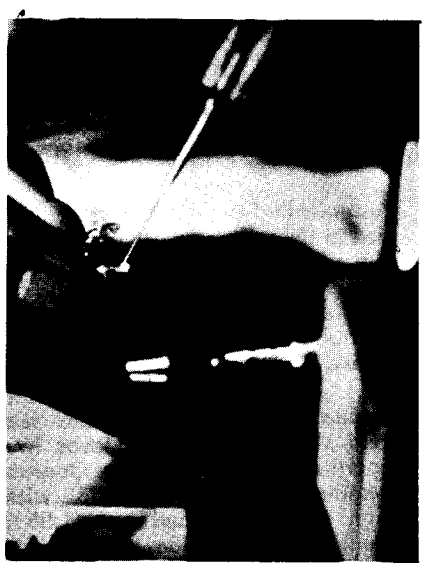

Fig. 7. Obtaining semen by taking semen into the syringe.

Conclusion

Critical factors in successful queen production with *A. mellifera* were reported by Johansson and Johansson (1973). Many of their suggestions are recommended by us for *A. cerana* and are listed below:

1. Schedules for queen rearing must coincide with the availability of mature drones for proper mating.
2. Optimal conditions for queen rearing prevail during the swarming season, or in the early part of a honey flow.
3. Colonies must have ample stores of honey and pollen.
4. Bees must be fed if there is no nectar flow.
5. Colonies should have an abundance of young bees.
6. Simple methods should be used while the operator learns more demanding techniques such as grafting.

Queen production with *A. cerana* provides a challenge to bee breeders for the propagation of bee stock in a selection program in the future. Easier rearing of many queens will predictably improve stock more rapidly (Rinderer 1986). *A. cerana* is already generally the favored species for small-scale beekeeping in tropical and subtropical Asia. In the future, *A. cerana* will probably also become the favored species for commercial beekeeping, especially if the problems of queen production and absconding can be solved.

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