CHAPTER VII

Reliable rearing methods

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1. Introduction

After reading this and other chapters, the question may arise — what is the reason for describing quite a number of experiments and methods and comparing one with another. Why not just present a short clear recipe for the best method ? It is because one recipe will not suit all beekeepers and all conditions. If, for instance, a beekeeper no longer has good sight or a steady hand for grafting, he has to use a method of cell cutting despite certain disadvantages. Likewise conditions of management and climate will influence the rearing method. One very important factor influencing the rearing method is the number of queens wanted. Thus it is not surprising that nearly every experienced queen breeder uses his own modification of the accepted rearing methods and that each method put forward will be strongly influenced by personal experience. Therefore, it is the fundamentals of proven methods which are described in this book, including discusion of their advantages and disadvantages.

If not stated otherwise, the methods and experiences of this chapter refer to the practice used at the Austrian Apicultural Institute. The breeding station of this Institute is situated at 640 m. above sea level, in the N.E. ranges of the Eastern Alps. The climate with a high rainfall is not the best place for rearing queens in this respect. However, there is plenty of pollen during summer favouring the rearing of queens and drones until late August. Three well isolated mating places in sparsely populated valleys are at its disposal ; thus three different strains of drones may be used at the same time. Though this is not a commercial queen raising enterprise, several thousands of queens are produced each year for different purposes.

Compared to the other breeding stations described in this chapter. Lunz am See is situated at the highest geographic latitude (48°) and has the toughest climate with the shortest breeding season (15.5—15.8).

According to the international nature of this book as many experiences from other regions as possible are considered, though mainly those of large plants with commercial queen production. We succeeded in obtaining the collaboration of quite a number of well known queen producers from different continents. We wish to thank them sincerely for their readiness to communicate their valuable experiences to a wide public. Moreover we shall make every effort to utilize the experiences collected during travels and congresses, and extracted from published papers. Thus we may hope that the collection of "reliable rearing methods" will give a survey of the most popular methods used at present.

1.1. *Breeder colony and nurse colony*

During the natural reproduction, the entire development of the queen from egg to hatching takes place within one single colony. The beekeeper, however, has the rearing of queens done in different colonies (mostly two), one after the other for practical reasons.

The *breeder colony* supplies only the eggs or larvae intended to develop into queens. Breeder colonies are subject to severe selection. The characters that make them worth breeding from must already be apparent in their ancestors and they must be repeated in the sister colonies. Then the probability is high that this inheritance will be continued in the progeny. (RUTTNER F. 1973 ; RUTTNER F. & H. 1972). The breeder colony and its family is expected to have a honey yield, quantity of brood and good temperament above average ; further it should have a low swarming tendency. Colonies of this kind, however, will raise queen cells under special pressure only. Besides a breeder queen is too precious to be subjected to queen cell production. Thus the breeder colony receives good combs to fill with eggs. The method of cutting cells sometimes requires the queen to lay eggs of approximately the same age into the "breeder comb" as quickly as possible. For this purpose different kinds of partitions or excluder cages are used to confirne the queen for about one day on a comb or only on one side of it.

Nurse colonies on the other hand have only the function of nursing. The breeding material, that is young larvae, or sometimes eggs from worker cells of the breeder colony, is transferred to suitable receptacles (queen cell cups) and substituted to nurse colonies as queen cells. If a sufficient number are accepted to satisfy the beekeeper, neither the descent nor the honey yield of the nurse colony matter, because the characteristics of the nurse colony are not transferred to the young queens (see Chapter V).

Sometimes different kinds of nurse colonies are used one after the other. The *starter* colony cares for the young larvae only for the first 10—48 hours. In starter swarm boxes (3.2.3) too, the cells remain for a short time only. Afterwards the cells are transferred to a finishing colony (3.2) where they remain, mostly reduced in number, until shortly before hatching, or at least until the feeding of the larvae is finished. After capping, the cells may be put into an incubator (VIII 3.2.2) or into another colony so as to furnish a constant temperature but not necessarily have any other requirements for nursing queens (VIII 3.2.1.).

1.2. *Requirements of a nurse colony*

The nurse colony is to care for queen larvae instead of worker brood. Quite a number of factors have to interact (as discussed in detail

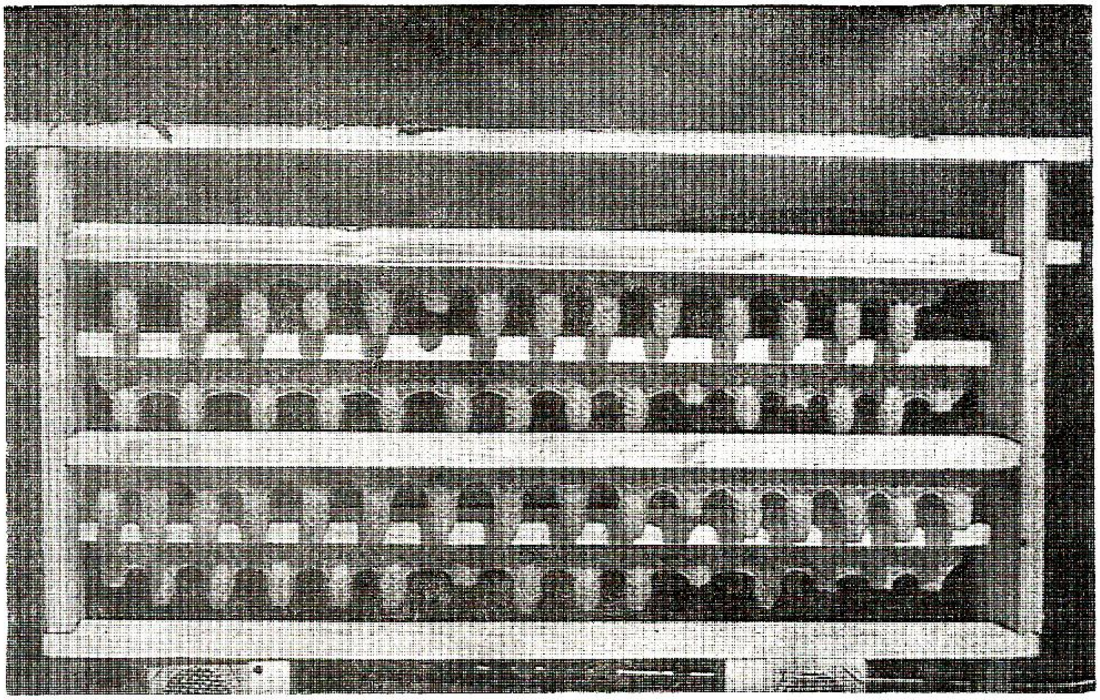


Fig. 68 — *The bee races which build many swarming cells accept very many larvae to be reared, when planned rearing is performed. To a Tellian (north African) bee colony 50 larvae are given in the morning, and with a good acceptance, other 50 fresh larvae can be given to it in the evening. In both batches, a high rate of acceptance is recorded, and larvae are very well taken care of.*

in Chapter V) to obtain the best results. The most important factors are briefly mentioned again from the stand point of the beekeeper raising queens because they are essential for the success of any rearing method

1.2.1. Descent of the nurse colony

Vital "country bees" with a high rate of reproduction are better suited for nursing than well bred colonies selected for low swarming tendency. Daughters of inbred lines too may be used provided they are outcrossed. Frequently true race hybrids are taken as nurse colonies, but mostly they are bad tempered.

1.2.2. Condition of development

Most colonies with high brood production shortly before the peak of colony development are highly suited. The bees should be densely crowded in their hive.

The appropiate nursing condition is obtained if :

(a) The number of bees of the winter colony is about doubled.

(b) Drones are present, or at least capped drone brood.

(c) The colony is constructing queen cups eventually supplied with eggs but without intense readiness to swarm.

(d) The colony is very well supplied with pollen together with good honey stores.

1.2.3. Differences in nursing capacity caused by unknown reasons

It happens here and there that out of several colonies with the same apparently good nursing capacity when viewed from outside, one or another colony nurses badly or not at all. Readiness to nurse cannot be forced — except in the swarm box (3.2.3.).

A proven method of preventing flops is to start at the beginning of the season with a greater number of nurse colonies than is really needed and immediately eliminating any colony with a cell output below average, and production is pursued only with colonies with satisfactory inate nursing tendency.

1.2.4. Health

Colonies affected by a disease are never suited for rearing queens. Even uniting several diseased colonies will not give a good nurse colony. In addition it should be considered that most interference necessary during queen rearing will favour nosematosis. This is why in some countries (Austria, Germany) the prophylactic use of Fumagillin is requested during queen rearing.

1.2.5. Age of the queen

Colonies with older queens are mostly better than those with queens from the last or even the same year, provided they are still good enough to furnish the needed amount of brood.

1.2.6. Appropriate good temper

Good temper has no immediate influence on the nursing capacity of the colony, but it may influence indirectly the motivation management

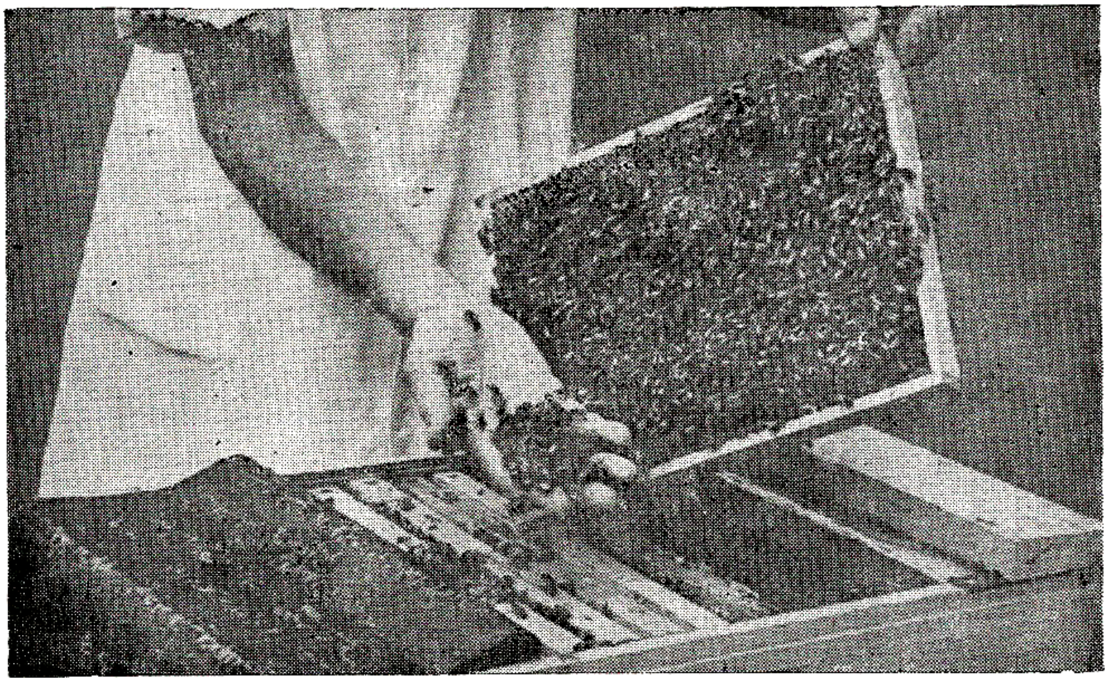


Fig. 69 — *It is nice to work with gentle bees*

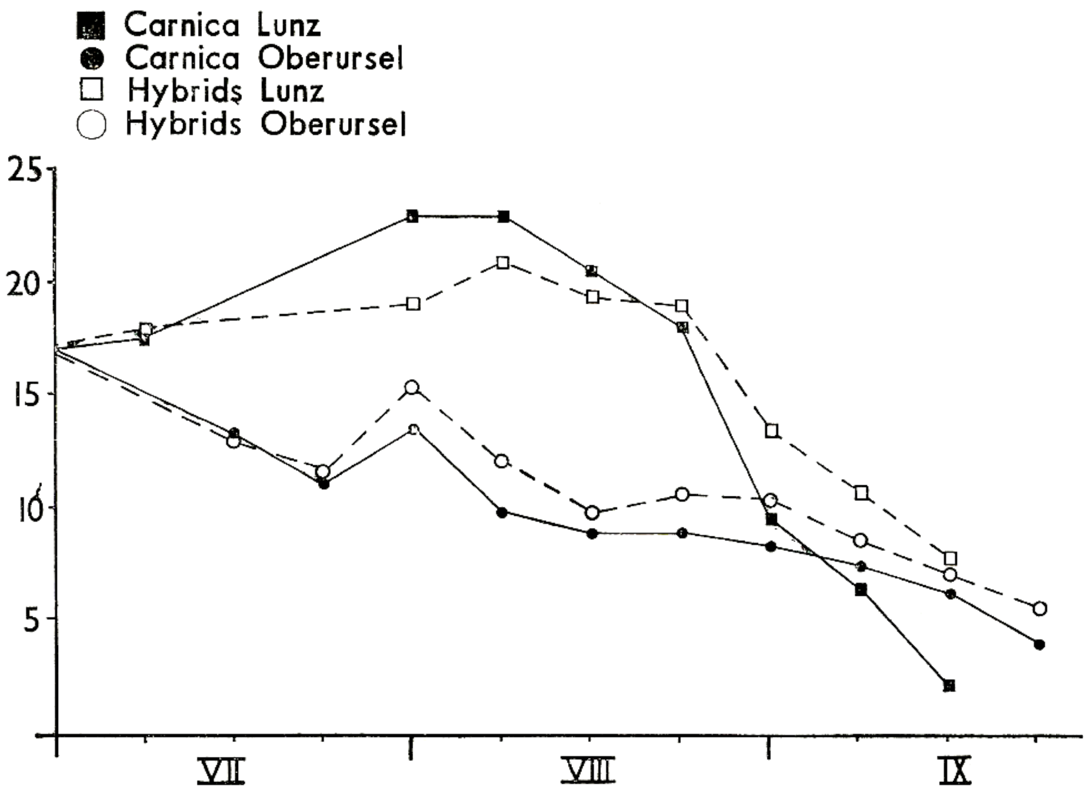


Fig. 70 — *Influence of the pollen flow on the quantity of brood. Vertically : brood cells (thousands). Horizontally : Months, Squares : Quantity of brood in an alpine valley (Lunz am See) with abundant supply of pollen late in summer. Circles : Quantity of brood in the Taunus hills near Frankfurt (Oberursel) with scarce supply of pollen beginning with mid of July. The influence of the location is much stronger than that of the race (black symbols : pure bred carnica ; white symbols : Buckfast hybrids. In Lunz drones are kept for one month longer, and corresponding longer is also the season for queen rearing than in Oberursel.*

of the beekeeper. It has to be considered that nurse colonies must be manipulated according to a fixed plan, independent of the weather and day light.

1.3. *Influence of external factors*

The management of no other domestic animal depends so much on external factors as beekeeping, especially queen rearing. In Chapter VI no special importance is given to feeding and weather conditions during queen rearing. This may be true for places where the activities of the colonies are maintained by nearly daily flight. Those, however, who have to work in climatically unfavourable regions (as for instance the breeding station at Lunz) will regard the climate as an important factor and support the colony with feeding when necessary.

1.3.1. **Weather**

One month before the start of queen rearing brood stimulating weather should prevail, otherwise nurse bees of the right age will be missing. A long period of bad weather with daily temperatures below 8° during the time of rearing will impair results. However, a short period of bad weather after a honey flow will have a positive influence on cell building (this is just the situation when swarm cells are built in normal colonies). The larvae are not sensitive to cold as shown in Chapter V (Weiss 1962) and the beekeeper has to provide the necessary conditions by doing the work in spite of cold weather and contrary to the natural rule, putting up with a higher labour expense and perhaps some stings.

Besides minor weather fluctuation, the general rise of temperature in spring should be considered. According to our experience a daily temperature mean of 15°C should be attained for successful cell production (the daily temperature mean is the sum of max. and min. divided by 2). The maxima should exceed 18°C for several days.

1.3.2. **Nutrition**

The honey flow has a great influence on the success of rearing. It is important weeks before the start of cell production to promote a great number of well fed nurse bees. As a rule in temperate zones good brood rearing conditions will arise after a good spring flow (salix etc.) and if the bees are able to collect large quantities of pollen from apple or dandelion blossoms some time later.

During the time of brood rearing, the colony has to "swim" in an abundance of nectar and pollen, then the larvae will swin in brood food. Ample brood food in the brood nest is the best indicator of a good nursing capacity ; on the other hand a colony with badly nourished "dry" brood will rear neither good nor many queens. (The larvae in the breeder colony must likewise "swim" before grafting). HAYDAK and DIETZ (1972) observed that certain amino acids are necessary for brood rearing. MELNICHENKO (1963) found more amino acids in the brood food of Caucasian bees used as nurses than in the jelly of the Northern bee. The amino acids maybe the, as yet unknown, key as to how the quality of some pollens (willow, fruit trees, rape) influence queen rearing better than others (fir trees). A honey flow may be simulated by stimulative feeding at the right time (see later), but the indispensible pollen can be substituted only to a certain extent by pollen candy. Pollen substitutes are of little use in queen rearing as shown by PENG (1976) by laboratory experiments. The beekeeper should be familiar with the preservation of pollen and pollen combs.

As a measure of the pollen provisions of a bee colony, TABER (1973) advises the beekeeper to pay attention to the drone brood :

1. All stages of brood present = good pollen provisions.
2. No drone brood = little pollen in last 48 hours.
3. No drone brood = too little pollen during last 7 days.
4. Adult drones prematurely expelled = high pollen deficiency for 2—4 weeks.

A nurse colony ready for work with very well covered combs has to have provisions of at least 4 kg honey and two combs of pollen. A colony cares for queen cells best shortly after a honey flow.

During a heavy honey flow, however, (one kg or more of nectar or honey dew daily) the queen cells are neglected. The frame with the queen cells is filled with burr comb and the larvae are poorly fed ; some-

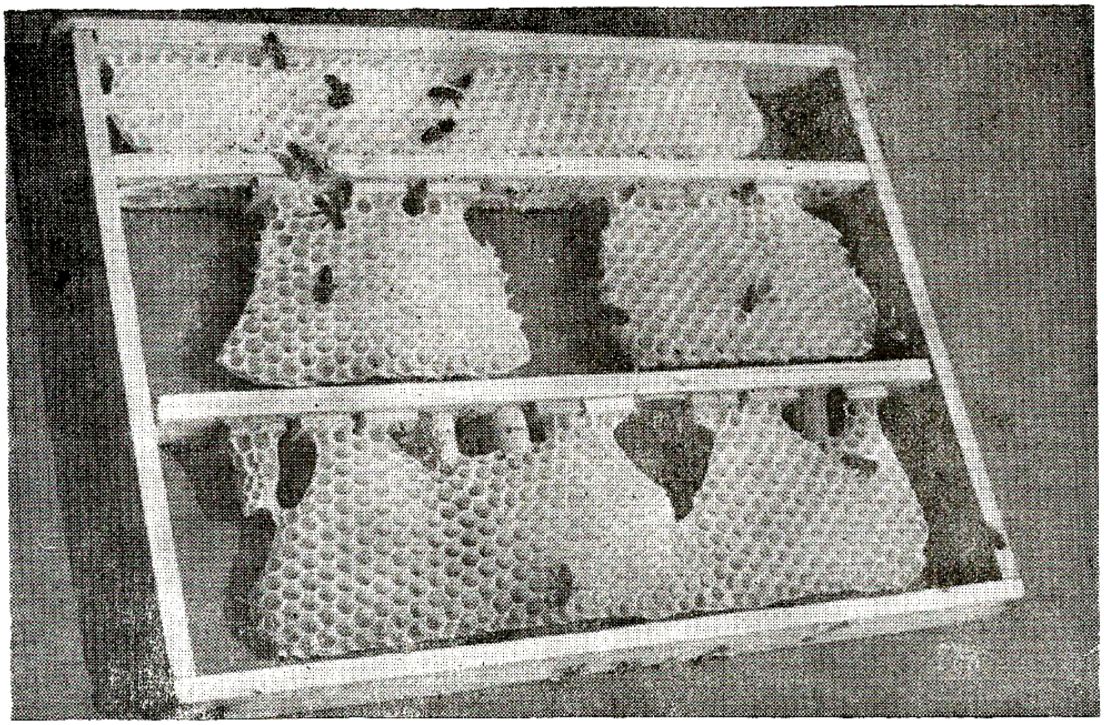


Fig. 71 — *Burr comb covering queen cells, constructed during heavy honey flow*

times the queen larvae will even starve — as every beekeeper knows, even natural swarm cells may be destroyed during a good honey flow. Some specialists (LAIDLAW-ECKERT 1962) advise putting an empty super on top of the colony.

During a light but continuous flow, well fed queen larvae are obtained. This is why many beekeepers are convinced that thin stimulative feeding, up to 1/4 liter honeywater will enhance queen rearing (see however Chapter V). The same effect is achieved by transferring honey combs from the super into the brood nest as is done during in a queenright colony.

During long periods of cold weather with temperatures below 8°C preventing any flight, brood rearing is largely reduced, especially of the Carnica bee. Opening a hive during such a period the half paralized bees will direct their sting towards the beekeeper and make a buzzing noise but not fly up.

The absence of a natural stimulus to rear queens may be substituted, at least in part, by feeding a warm solution of honey and sugar.

1.3.3. Time of queen rearing

Early breeds can be forced during favourable weather to raise queens but experience has shown that frequently these queens are of poor quality. For instance, according to Kreil (personal communication) queens bred too early do not have fully developed venom glands.

The urge to raise queens wanes at the end of the summer honey flow. A good indication for the duration of the rearing period late in summer is the presence of drones in large numbers. With the *expulsion of drones* queen rearing is finished too. In regions with a late honey flow, as in the mountains, the expulsion of drones occurs much later then in the plains, even without any honey or nectar. This is why in the mountains the results of queen rearing and mating are good even in August. In some regions queen rearing is possible for 6—9 months.

In the southern. Mediterranean area (North Africa, Israel) two seasons for queen rearing mostly exist. The main season during the increasing colony development in spring and a second season in autumn (October/November) when the winter rains first start and bring about a slight yield of nectar and pollen. These examples are good evidence of the importance of the available flowers, independent of the time of year.

1.3.4. **Colony strength**

A colony can be encouraged to a mature state by appropriate nursing, but this condition is not to be achieved by force. The colony should be naturally at its peak, shortly before swarming. There may be queen cells, but only with eggs and young larvae — no large old larvae. Colonies for cell breeding are kept somewhat more compressed than is usual for honey production, but never-the-less they should cover 24 combs. In other words, the total area of space between the combs occupied by bees, not the surface of the combs, should be about 2 m^2 (24×800 cm^2); or a hive with a volume of 80 litres should be full of bees. To achieve this we do not use a queen excluder in the build up period, thereby achieving a fully expanded brood nest. In Lunz, for instance, colonies

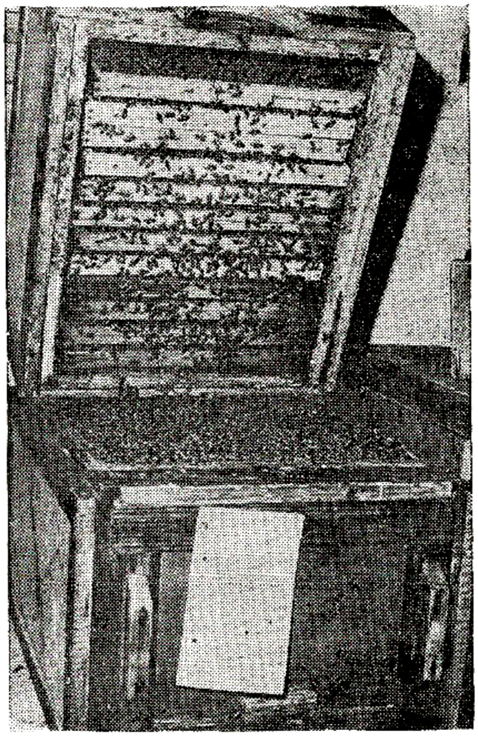


Fig. 72 — *Before starting queen rearing the nurse colony must have ample space for free development*

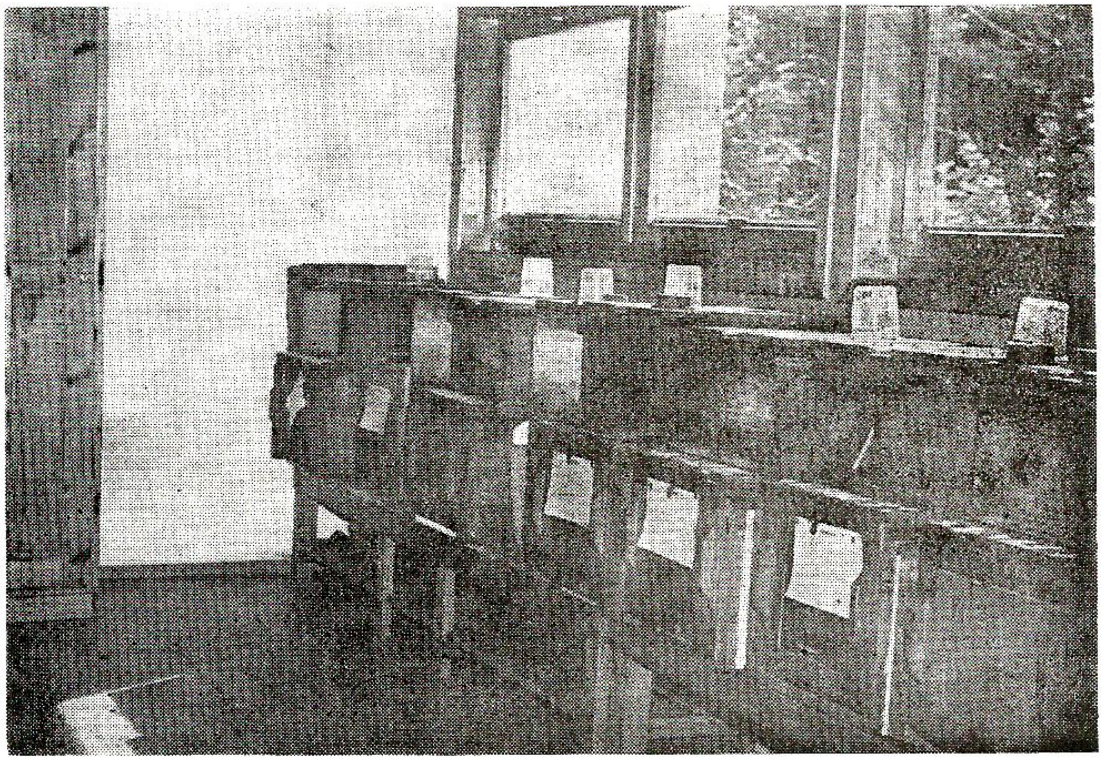


Fig. 73 — *A bright room in a bee house is convenient for queen rearing manipulations.*

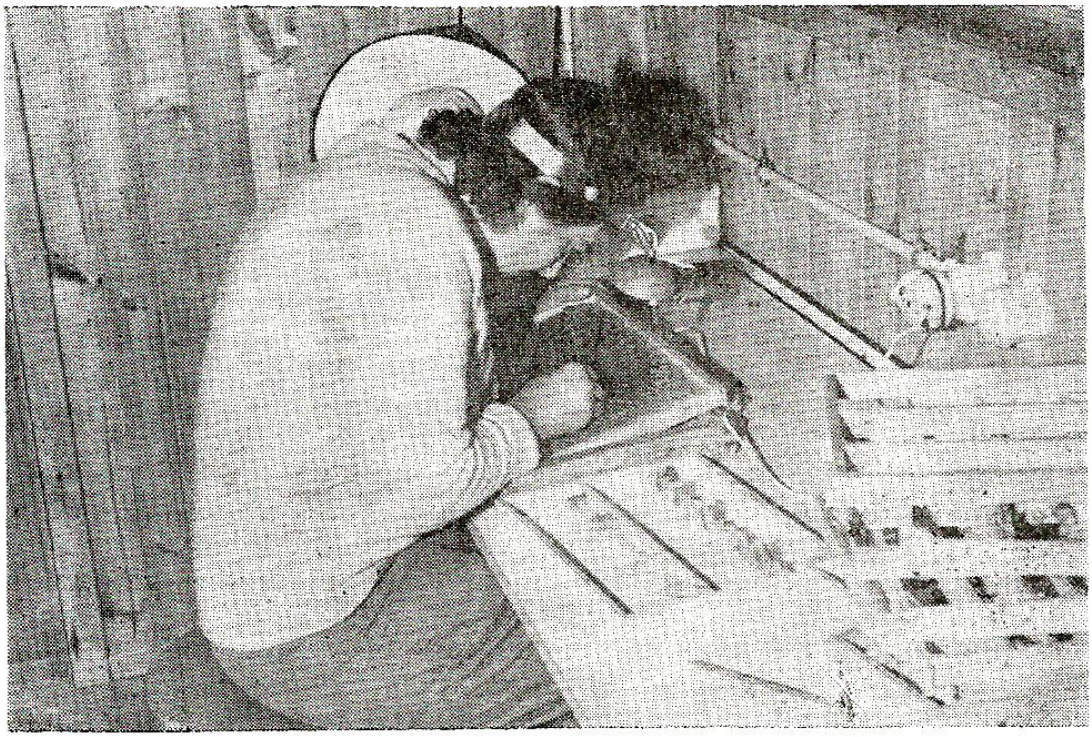


Fig. 74 — *The grafting place. A dentist's lamp with mirror is used as source of light.*

which are to be ready for nursing on 15th May must have at least eight large brood frames and the drone comb has to contain well fed larvae. Colonies which construct worker brood on an empty frame instead of drone cells are not ready for queen rearing.

Optimum external factors will not turn up every year nor at every place. Different methods were developed to overcome these unfavourable factors. Queen rearing and mating (VIII 4.3.) is possible even during severely adverse conditions, but this is not reasonable commercially. At certain times queens can be reared even in Iceland or Norway. In fact, as long as young larvae are present queen raising can be achieved at nearly any time (without consideration of number and quality it is true), this is quite the contrary with the rearing of drones.

1.4. *Housing*

1.4.1. **Hive**

Simple cell production is practicable in nearly any hive. For a larger rearing programme, however, it may sometimes be worthwhile to use special boxes. As combs are frequently changed from one colony to another during rearing, the nurse colony should have the same sized combs as the whole apiary. For convenience the hive should be of a type which is worked from the top. Large brood chambers with frames in the plane parallel to the front of the hive, expandable to 14 frames and reducible to any volume, have been found to be comfortable and handy. If there is spare space it is easy to shift combs, make new space between combs, insert a vertical queen excluder, to shake or feed bees. During the period of preparation this horizontal hive has a super with another 12 frames (size 33 $\times$ 25 cm). But in the standard type of hive the colony can also be managed in a suitable way of queen rearing.

1.4.2. **The bee house for queen rearing**

The bee house is becoming popular for queen rearing even in countries where it had been unknown. The bee house must have enough space ; 4 m. depth behind the hives is convenient. Above the hives there are windows with bee escapes. On the opposite side of the room window should be able to be covered. Next to this room, but separated, is a workshop with a bright working area with a movable light. A low voltage spot light is useful. For grafting the beam should come over the left shoulder (if the person is right handed). Another good source of light for grafting is a dentist's head lamp. The workshop is equipped with a work table with drawers, with water and electricity (or gas) for cooking and heating for cool days, with cupboards for combs and different tools, and with an incubator. There should be a cool and dark cellar close to the beehouse in which to place nuclei. The approach road must be accessible even in weather.

1.5. *Preparation of the nurse colony*

The old adage that it is difficult to make up in spring for the care that was neglected in autumn is particularly true of nurse colonies. After the harvest no shortage of food should occur, the queen must always be stimulated to lay so as to produce a large number of well nourished autumn bees.

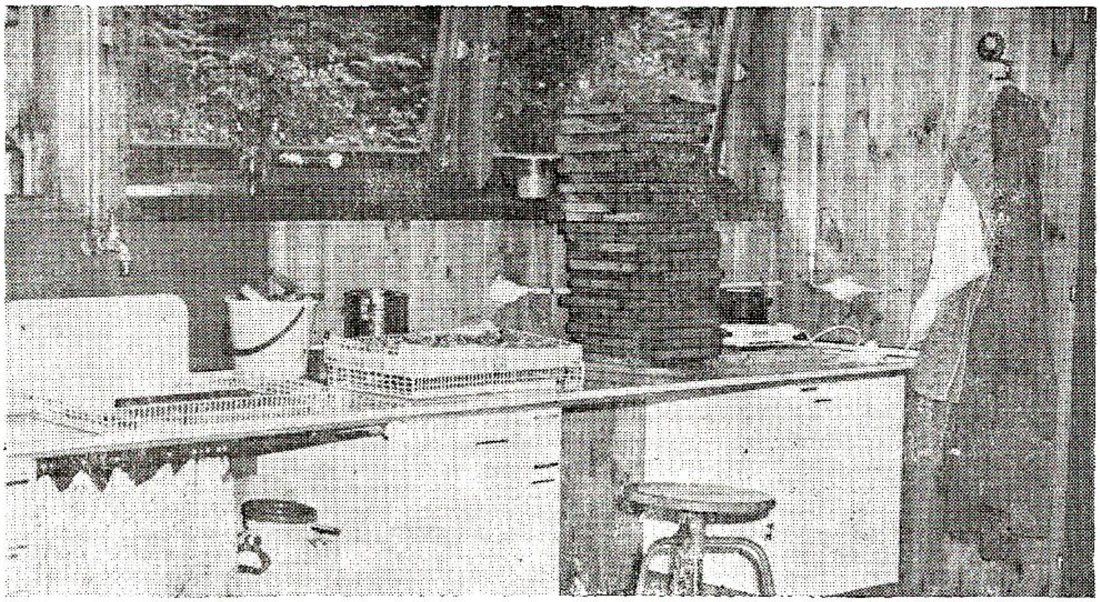


Fig. 75 — *The working place in the queen rearing shop. Swing windows provide ventilation.*

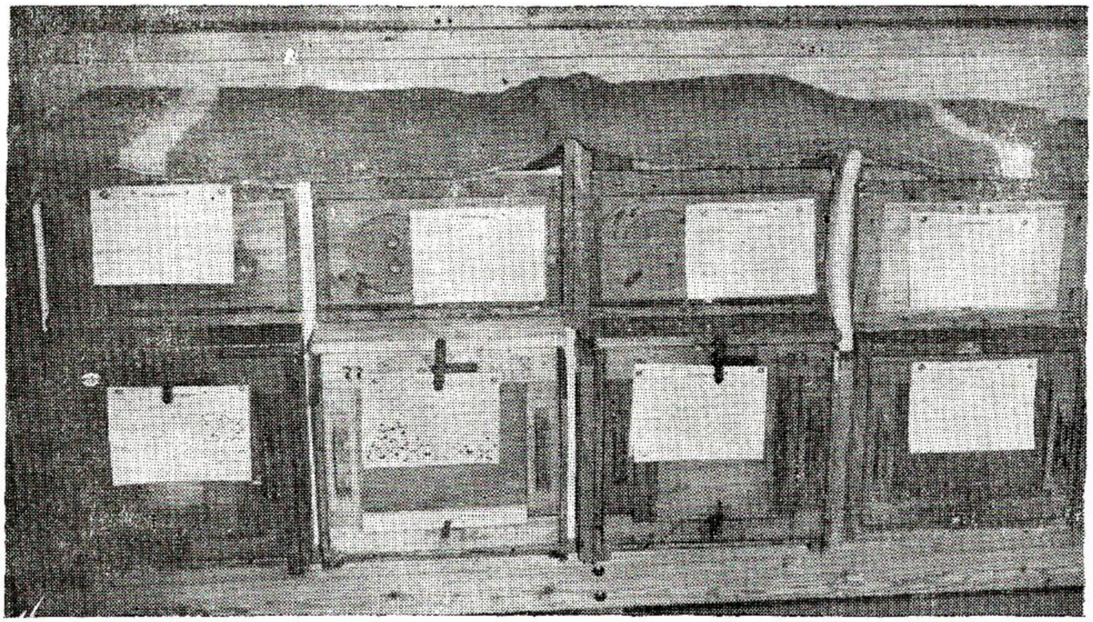


Fig. 76 — *Two queen colonies late in summer result in strong colonies next spring.*

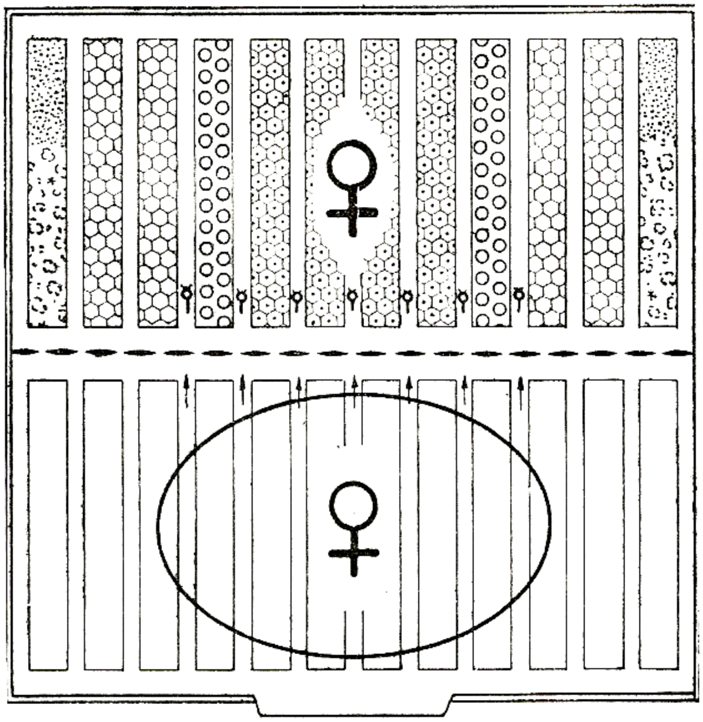


Fig. 77 — *A spare queen is placed in a hive body, freshly put on top of a prospective nurse colony*

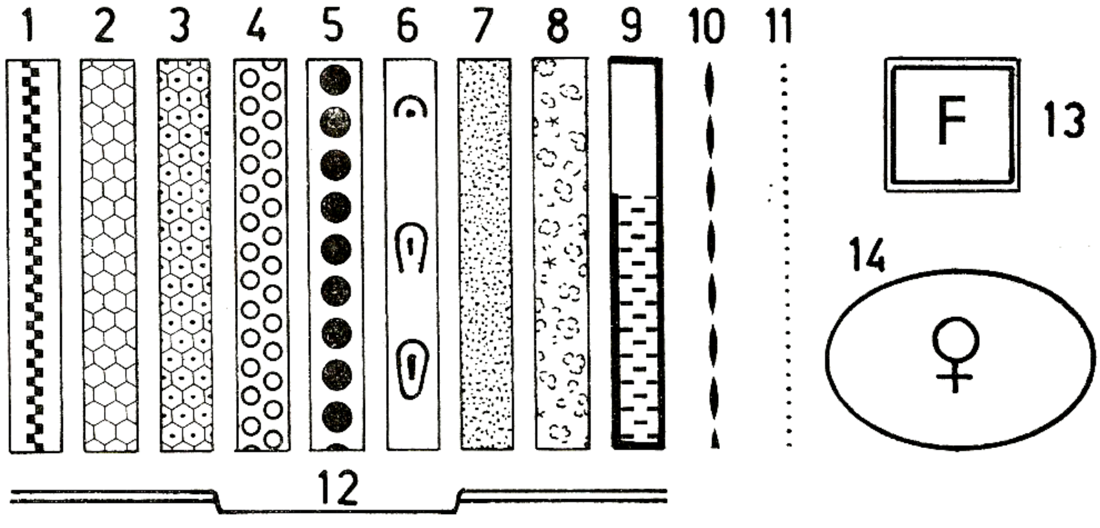


Fig. 78 — *Definition of the symbols used in the following diagrams, showing the composition of nurse colonies for the rearing methods described.*
1 — comb foundation, 2 — empty comb, 3 — comb with open brood, 4 — comb with capped brood, 5 — drone comb, 6 — frame with freshly grafted cups (top), with open (centre) and capped queen cells (bottom), 7 — comb with provisions, 8 — pollen comb, 9 — feeder, 10 — queen excluder, 11 — wire gauze (bee tight), 12 — entrance, 13 — finisher (F), 14 brood nest with queen

To some extent this can be achieved by feeding, but a good yield of nectar and honey works better. We made a comparison of the amount of brood at Lunz and Oberursel. In the mountain forests of Lunz colonies of the same genetic origin and the same initial strength produced in

August nearly doble the amount of brood as sister colonies at Oberursel (Fig. 70, F. & H. RUTTNER 1976). For this reason experienced breeders move their hives intended as nurse colonies during the next season to a place with rich pollen sources.

1.5.1. **Two queen colonies in autumn**

To prepare a strong nurse colony in the autumn of the preceding season temporary two queen management gives good results.

(a) The old queen remains in the hive body as before near the entrance.

(b) All combs and bees are removed above the queen excluder.

(c) The space in the super is supplied with empty combs for the eggs of the new queen and with pollen and honey combs.

(d) In the middle of this super, several combs with eggs and larvae are given with an uncaged queen but *without any worker bees.*

Young bees from the main colony ascend to care for the brood, the second queen is accepted and starts a second brood nest.

If there is sufficient mature brood, a temporary division with a young queen is recommended. Instead of a queen excluder, a wire gauze is inserted for the first week. The super, without bees, is equipped with empty combs, provisions and two combs of hatching brood (again without bees).

The next day when enough young bees are on the combs, the queen is added, without a cage. Immediately she will start to lay eggs. One week later the wire gauze is replaced with a queen excluder.

In these cases the young colony in the super does not have an entrance of its own. The double colony remains as such until the second queen is needed elsewhere or at the latest until feeding for winter. The second queen and the excluder are removed together. This method results in very strong colonies. Attempts to over winter both queens failed in every case in our climate, as both colonies unite during winter.

1.5.2. **Two queen management in spring**

In spring too, it may be of advantage to keep two queens temporarily in a prospective nurse colony. This is the case for instance in the following situation : At the beginning of the rearing season a strong nurse colony is available which has to be made queenless, as early queen rearing succeeds better in a queenless colony. At the same time there is another good colony as yet without a super which needs reinforcing. A number of brood combs are added above the queen excluder and in the middle a comb with eggs and the queen from the nursery colony (again without any worker bees). As soon as the hive is closed young worker bees cover the brood combs in the super and as a rule the queen is accepted and starts a second brood nest.

The same result may be achieved by uniting two healthy reserve colonies. In this case both queens are made to work simultaneously in the same colony for 3 weeks. As soon as plenty of young bees are present, one queen is removed and the other remains in the section near the entrance. Thus this colony is ready for rearing in a queenright colony (see 3.3).

1.5.3. **Stimulative feeding in spring time**

The stimulative effect of a flow is simulated by feeding small portions of sugar-syrup mixed with honey ($^1/_4$—$^1/_2$ litre) every day except if there is a gain of this amount from natural sources. If this is started 4—5 weeks before cell production starts plenty of young bees will fill the hive. To prevent Nosema, Fumidil B should be added to the syrup according to the directions.

1.5.4. **Feeding during nursing (see also Chapter V)**

Feeding is not necessary as long as there is a light nectar flow until the cells are sealed and bees are flying well. Otherwise the beekeepers start feeding with small quantities the moment the young larvae are added ; or honey combs are placed in a way that the bees will transfer the honey. Feeding 200 ml. syrup in the morning and at noon yielded more accepted queen cells than a daily feed of 400 ml. fed in the evenings (TARANOV). At Lunz we use jars with a small feeding surface (Fig. 7a) using 0.75 l within two days. Honey jars with well fitting lids

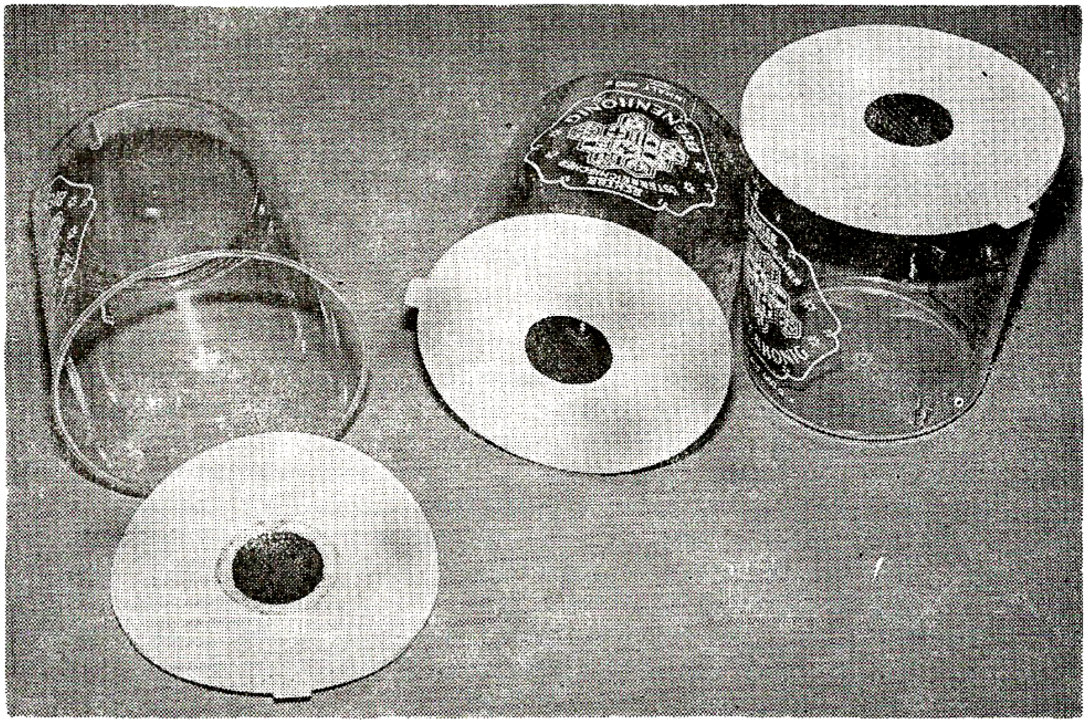


Fig. 79 — *Honey jars (1 kg) with an insert of wire gauze in the plastic cover are used for stimulative feeding*

of plastic make excellent feeders. 20 holes are made in the lid with a hot nail or fine wire gauze with a diameter of 30 mm is melted into the plastic to close a central opening.

An abundant supply of pollen in the form of combs of pollen are added, or a mixture of pollen with pollen substitute, preferably as candy with 30% protein content.

1.6. *Timetable*

The period of development of the queen shows only small variations; this is why an exact time table can and must be followed. In our time table the day "O" is the date when larvae (not more than a day old) are given to the nurse colony for royal care. The days marked "—" represent the time of preparation as described, the subsequent "+" days signify the time of development of the queen *i.e. the* days when the beekeeper has to make some manipulation.

All specifications of time in the methods described on the following pages refer to this time table.

TIME TABLE — QUEEN REARING

Day	Nurse Colony	Breeder colony
—35		
—28	Start of stimulative feeding	
—21	Stimulative feeding.	
— 9	Intervention according to method	
— 4		Add comb for egg laying.
0	**Start of queen rearing (grafting etc.) perhaps stimulative feeding**	
+ 1 (or + 2)	Adjust (poss. transfer of cells from the starter to the finisher)	
+ 5	Cells capped, end of feeding ; no disturbance best. First possible date of transfer to incubator (34.5°C).	
+10 (or 11)	Isolating of cells (possibly making nucleii with cells)	
+12	Hatching of queens, marking and introducing to artificial swarms (Afterwards 3—5 days in the cellar).	
+15 (or 17)	Queens to the mating yard, free flight	
+ ~20 15—25)	Average time of mating	
+ ~25 (20—30)	Start of egg laying	
+30	Check for eggs and larvae.	
+33	Queens not yet laying are discarded (at the latest) As a rough guide : It takes 4 weeks from grafting to laying	

2. Methods of rearing

The natural reproduction and rejuvenation of queens may take various courses (see Chapter I).

(a) In the presence of the mother queen by swarming or supersedure

(b) From young worker larvae after the sudden loss of the queen by emergency rearing

Imitating these variations the beekeeper, in the course of time, has developed a great number of variations in rearing methods. Consequently, only the most current systems are described.

First we shall deal with the general principles, valid anywhere. Later special procedures are mentioned as practised by some of the leading operations.

2.1. *Rearing in a queenless colony*

The removal of the queen is the oldest and most reliable method of so called "artificial queen rearing". The moment to do this is different according to the method used.

2.1.1. Utilisation of the queen

Usually we like to make use of the egg laying capacity of the queen. The best way to do this is to introduce her into the super of another colony (see 1.5.2.) ; soon she will produce some more combs of brood there. This will be of interest to the beekeeper who intends to make nuclei with the first young queens. It is not recommended to make a nucleus with the queen and bees of the nurse colony because precious bees are withdrawn. Besides it is questionable whether the presumably old queen will have the vigour to build up a colony of full strength.

2.1.2. Protection against foreign queens

Queenless colonies will attract young queens from elsewhere. As soon as a colony gets dequeened a queen excluder is inserted between the bottom board and the hive body. In hives with transverse combs and a fixed bottom a queen excluder extending to the bottom is inserted behind the front comb. It is important to place the excluder within the dark interior of the hive ; otherwise it may become blocked with drones. This is why excluders in front of the entrance are not suitable Moreover they are a greater obstacle to the flight of the bees.

2.1.3. Protection against desertion by the bees (Fig. 80).

Large operations use a bee yard for queen rearing which is separated from other colonies, amongst other things to prevent robbing. The nurse colonies are transported to this yard and placed apart from one another. If, however, a bee house is used, a division is placed between the hives to prevent the exodus of bees from queenless colonies (see I).

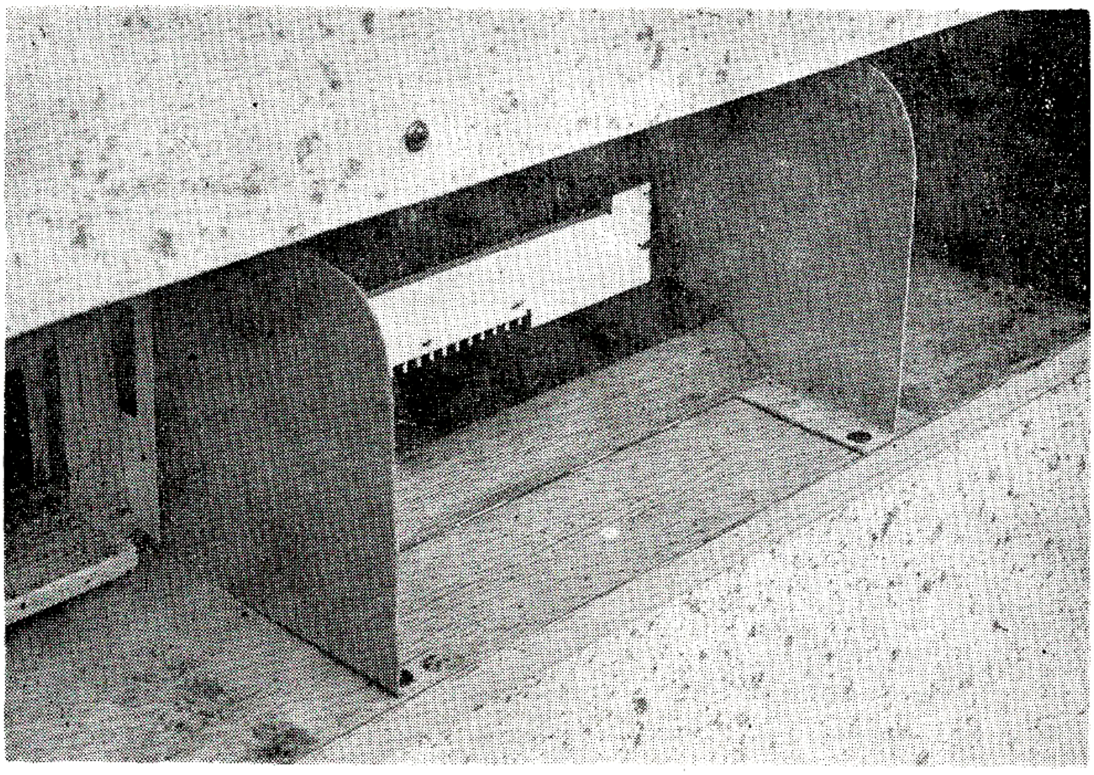


Fig. 80 — The bees of queenless colonies must be prevented from desertion to the neighbours if several colonies are placed one close to the other

2.1.4. **Position of combs**

What is the best kind and arrangement of combs for a queenless nurse colony ? (Fig. 81).

(a) Honey combs outside near the hive walls.

(b) Combs of pollen on both sides in the next position.

(c) Towards the middle several combs with capped brood (some beekeepers prefer to have open brood on both sides of the grafted cells).

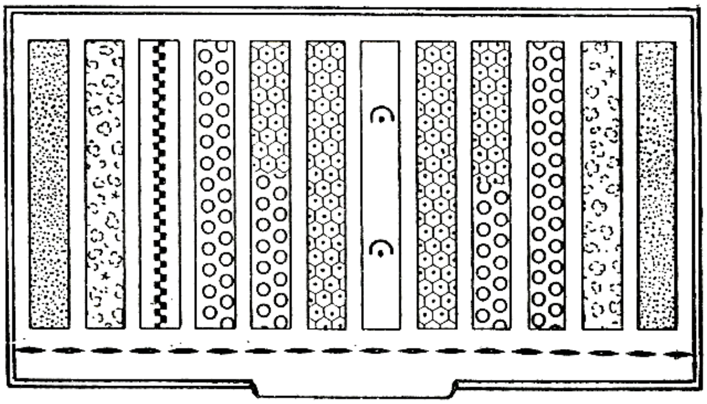


Fig. 81 — Position of combs in a queenless nurse colony. A queen excluder is placed between the combs and entrance (See caption Fig. 78).

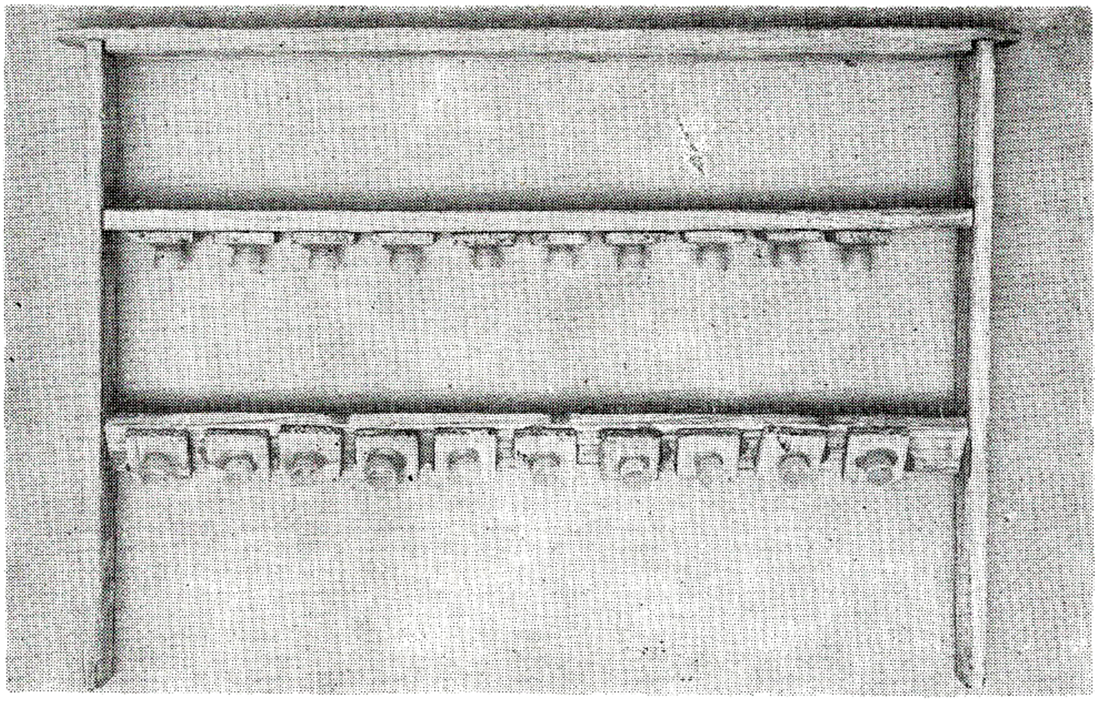


Fig. 82 — *A grafting frame without bottom bar promotes the formation of the cluster round the queen cups*

(d) In the centre, a space of about 35 mm. is left between the brood to accept the frame with the larvae. TARANOV (1972) says that heavier queens are produced if the bees have time to be assembled in this space for 4—6 hours before the grafting frame is inserted. He advises that the bottom bar of the frame should be removed so as not to disturb the bees (Fig. 82). The grafting frame has no spacers so as to create close contact between the queen cells and the brood combs and also make for easy use. The feeder should be close to the grafting frame.

2.1.5. Quantity of bees

It is not the number of combs that is decisive, but the number of bees per comb. It is held as a general rule of thumb that each comb should be covered with double the amount of bees that is usual in strong honey producing colonies.

For instance, when a colony with 20—24 well covered combs and 12—14 combs of brood is to be set up as a nurse colony it is compressed to 8—12 combs. This was proved with the Carnica bee. In the U.S.A., super-strong ligustica colonies in two or three stories are used for queen rearing according to LAIDLAW and ECKERT (1962) (see 3.3.2).

2.1.6. Utilisation of surplus brood

Dispensable brood combs are brushed off and distributed without bees two by two to supers of colonies which are to become finishers later on (see 3.2).

2.2. *The chief variations in rearing in a queenless colony*

2.2.1. Rearing in a colony queenless for nine days

This method is mainly of historical significance, yet it is still sometimes recommended. KRAMER (1888) and Zander (1919) taught the European beekeepers to change from simple queen propagation to modern queen breeding using separate breeder and nurse colonies. KRAMER utilized colonies after swarming without open brood to care for the breeder larvae ; ZANDER on the other hand tried to maintain the full strength of the colony.

Procedure

(a) The queen in the nurse colony is removed or caged. Now the colony will construct emergency cells on the brood combs.

(b) On the ninth day all emergency cells are destroyed. The bees are brushed off the combs so as not to overlook one of the cells.

(c) The colony which is now hopelessly queenless is presented with grafted larvae from a selected breeder colony (Ch. VI).

(d) 10 days later the queen cells are isolated (VIII 3.2.).

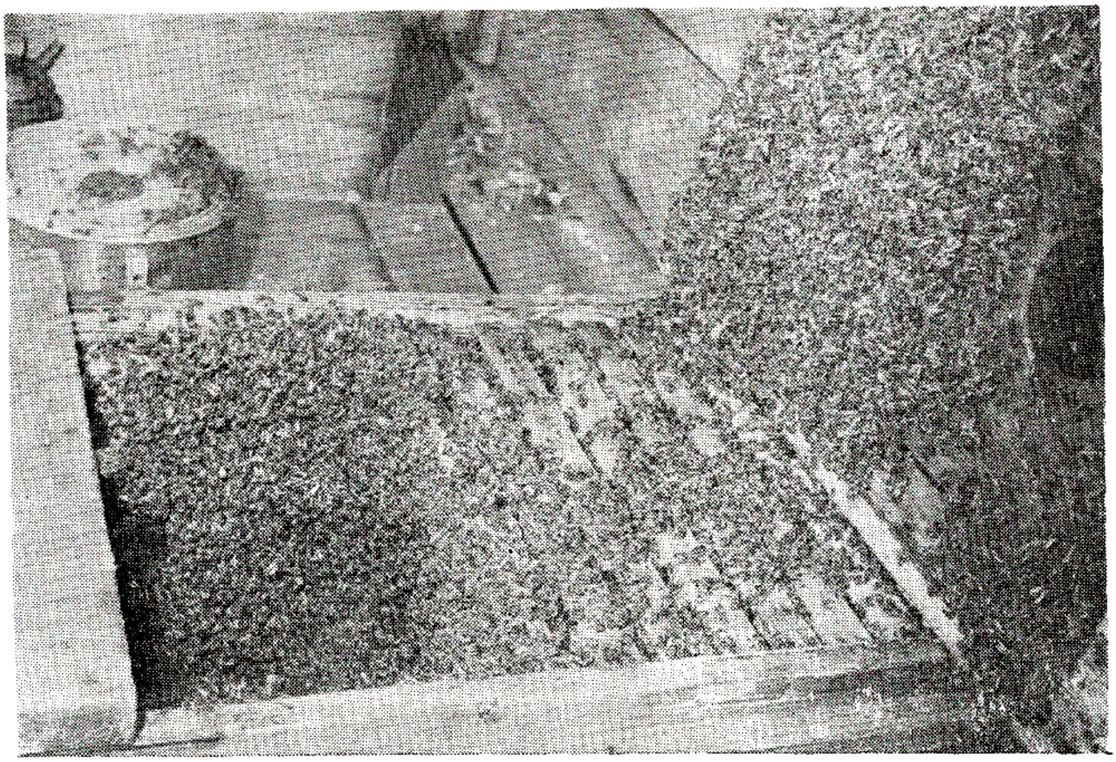


Fig. 83 — *The nurse colony must be abundant with bees, the number of combs is of secondary importance*

Evaluation

The intention of this method was to prevent the destruction of the queen cells by a premature emergency queen. On the other hand it was assumed that now the whole brood food was available for the royal larvae and not shared with worker brood. This assumption is out-dated. A colony without open brood diminishes the production of brood food. Thus the first flow of royal jelly is wasted on the production of emergency cells. Also it is not at its optimum when, after 6 days, there are only old larvae in the colony to feed as no brood food for young larvae can be deposited until the 9th day. Anyway the nurse bees of such a colony will care for a second "real" series of larvae, but not successfully for any further series (see Chapter I, 3).

2.2.2. The nurse colony with the queen isolated for nine days

This variant has several advocates. The last to advance it was JORDAN (1953). With this method brood of all stages is present in the colony until the start of rearing at least in small quantities. The flow of brood food is not interrupted.

Procedure

(a) Nine days before the start (that is day 9 on the time table), the queen is separated by an excluder. The compartment for the queen contains 3—4 combs — two combs of hatching brood and one or two empty combs for egg laying. The queen compartment may be situated in the hive body with access to the entrance (Fig. 84A) in hives with longitudinal combs. Two excluders are needed to isolate the queen, a horizontal one below the frames and a vertical one ; or the queen is confined in a compartment in the super.

(b) On the starting day the queen is removed from the queen compartment together with three combs of open brood. The brood combs of the main compartment, all of them capped in the meantime, are carefully checked for queen cells.

(c) and (d) as in 2.2.1.

Evaluation

The colony is definitely queenless without a chance to raise other queens from larvae. However, nursing activities have been kept going for all stages but in a reduced way. Only a few uncontrolled queen cells are started. Frequently it is recommended to remove the queen, together with three combs of open brood and all adhering bees on day "O". It should be considered, however, that in this way a great many nurse bees are taken away — just the ones that are needed for the care of queen cells. Thus the brood combs should be removed without bees. (utilisation of the brood — see 2.1.6).

Brother Adams method (1969) :

A colony with 12 Dadant combs is supered (above a queen excluder) by a dequeened colony with 10 brood combs and two honey combs. 10 days later — the colony is fed during this time if necessary — all queen cells in the super are destroyed. After a further three days the super is placed on the bottom board and the bees of 6—8 combs of open brood are added. The remaining colony with the queen and all the open brood is set aside. This nurse colony will raise about 69 cells when European bees are used. Oriental bees, e.g. from Armenia, nurse 200—300 cells at the same time.

There are opposing opinions amongst specialists whether or not better and more queens are raised next to open brood instead of capped brood. BILASH (1963) observed a greater amount of jelly in queen cells reared close to open brood. We found that queens reared close to open brood — especially if nursed in a queenright colony — were especially suited to artificial insemination on account of their size. It should be remembered that natural swarm cells are also nursed close to open worker brood.

2.2.3. **Dequeening at the start of queen rearing**

Today the following dequeening method is recommended in order to activate as many nurse bees as possible. It was described among others by G. SKLENAR (1974) and has been practised at Lunz for decades.

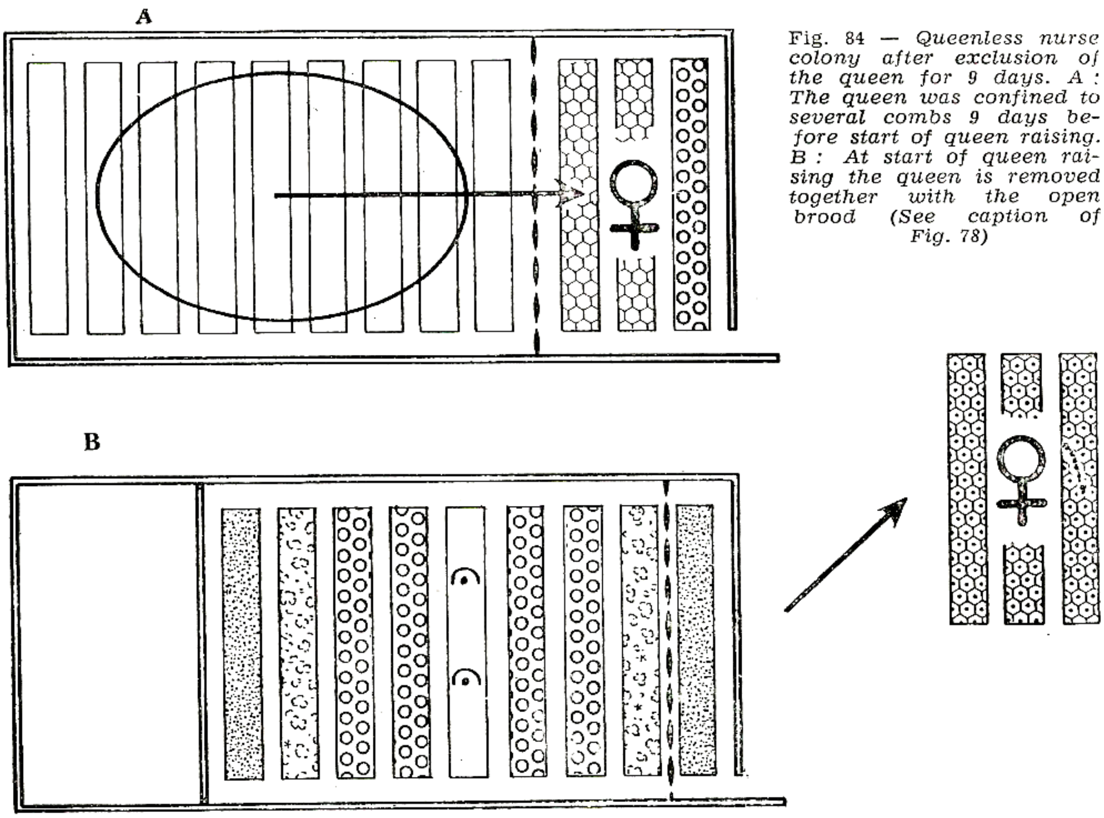


Fig. 84 — Queenless nurse colony after exclusion of the queen for 9 days. A : The queen was confined to several combs 9 days before start of queen raising. B : At start of queen raising the queen is removed together with the open brood (See caption of Fig. 78)

Procedure 2 (b)

(a) The nurse colony is dequeened 6—24 hours before grafting and, at the same time, checked for swarm cells.

(b) Arrangement of combs as in 2.1.4. Combs of brood are marked with drawing pins. About 4 combs of brood remain in the nurse colony, the open brood next to the empty space which will receive the frame of grafted cells. Surplus brood combs are distributed, two and two according to 2.1.6. in supers of prospective finishers (3.2.).

(c) Addition of the grafted larvae after the beginning of the buzz of queenlessness. Characteristically the colony "roars", the bees run nervously and searchingly on the front of the hive. This is Guido Sklenar's "golden hour" of all acceptance.

(d) 7—9 days later all the marked combs, containing open brood at the beginning ,are thoroughly checked for queen cells. Usually none are found as larvae in the hanging cups are preferred for nursing to work larvae in the comb.

(e) Distribution on the 10th day.

Evaluation

By the late dequeening a great number of active nurse bees is guaranted ; and also their concentration on the only two combs with open brood near the queen cells. Colonies of this kind capable of starting several series of cells, one after the other (3.2).

2.2.3.1. **Continuous queen rearing in a queenless colony**

Most of the commercial queen rearers in California use the same queenless colonies troughout the season as starters and finishers (ROBERTS and STANGER, 1969). The colonies are very strong (4.5. to 5.5 kg bees). Every three days they receive a new series of 45 cells. Thus there are permanently three series in the colony (it is true only two of them with larvae). These nurse colonies receive every 3—6 days one or two combs with *unsealed* brood from auxiliary colonies. By this measure a regular reinforcement is provided. Moreover the formation of laying workers is inhibited by the constant presence of young larvae (see Chap. I).

WENNER and KOEHNEN (Ordbend, North California) add besides $1/2$ kg of young bees to the nurse colony the evening before the insertion of a new series. Thus the queenless nurse colonies are extremely strong. These queen rearers have 100 starter colonies in operation from February 15th to May 1st.

Evaluation

In this method of mass production a great quantity of bees and permanent addition of young brood is used. In contrast to this, in the method described below (2.2.4), the supply of young bees is controlled only by the addition of capped brood.

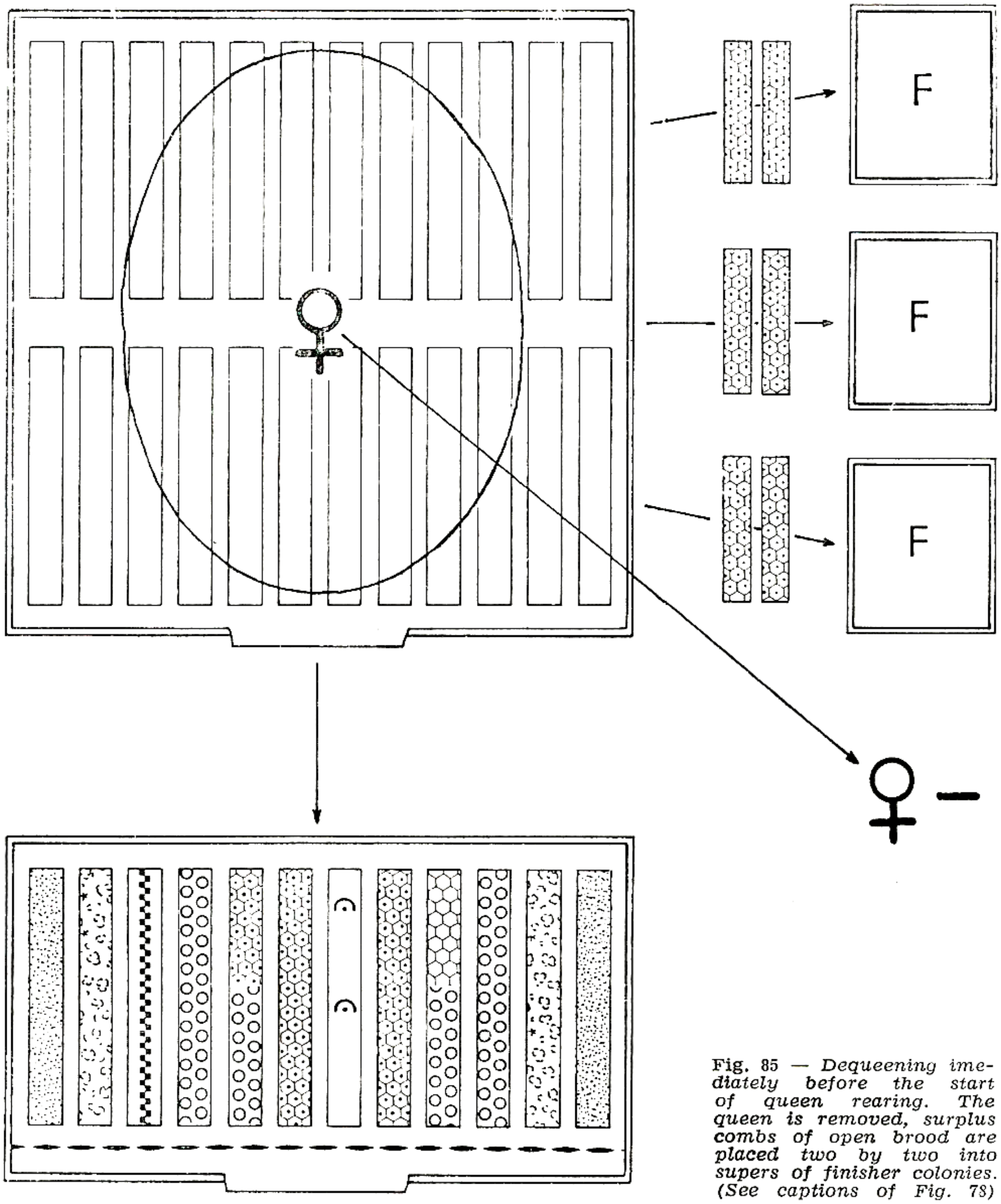


Fig. 85 — *Dequeening immediately before the start of queen rearing. The queen is removed, surplus combs of open brood are placed two by two into supers of finisher colonies. (See captions of Fig. 78)*

2.2.4. Collective brood colony

If problems of swarming arise in the yard and if it is desired to solve them by "milking", the following method applies :

Procedure

Several days before formation of the collective brood colony, capped brood combs are taken from colonies inclined to swarm and temporarily placed into the super of the same colony. As soon as enough brood combs are collected, an empty hive body is equipped with two combs each of honey and pollen, the remaining space is filled with the prepared brood combs from the supers, and more bees are added. The union is facilitated by scented water. It is an advantage if the bees come from a distant bee yard as the flight bees will not fly back. If a queen is available she is caged for several days in the midst of the brood combs to prevent emergency cells and desertion ; she is removed as soon as rearing is started. Feeding should be done in the evening only to avoid robbing.

The collective brood colony will satisfactorily nurse as long as abundant young bees are hatching ; this period is extended by the repeated addition of brood.

Evaluation

Nothing is wrong with this method as long as the collective brood colony is given only one frame with 20—30 cells. There are, however, beekeepers who construct in this way multiple storeyed giant colonies to raise 60—100 larvae of the same age simultaneously. This certainly saves a lot of labour to the beekeeper, but he has to appraise whether the bees are not overtaxed. Even the highly competing queen rearers of the U.S.A. mostly keep to the smaller series for the sake of the quality of the queens. In his experiments with collective brood colonies TARANOV got only 32.2% queens with a weight of more than 200 mg., whereas it was 51.7% in a queenright nurse colony.

2.2.5. The alternating colony

SKLENAR (1948) describes as "alternating colony" two constantly renewed nurse colonies which were used for queen cells in a rotating cycle (Fig. 86).

Procedure

A very strong colony is divided. The queen is transferred to a new hive (B) together with all brood combs and some honey combs. In the old hive (A) remain a part of the young bees and all the flight bees and a very good provision of food. The next day the first series is given to colony A, where it remains for 10 days until isolation of the cells. Now the queen with the total brood is taken back from colony B to colony A — without any bees however. Now colony B is ready to accept a second series. This procedure may be repeated several times and finishes up with two colonies.

Considering the satisfactory results found with queen rearing next to open brood — and in order to avoid a drift of the bees, the following modification is proposed ; Each series of cells to be surrounded by 2—3 combs of open brood.

Evaluation

The amount of work is considerable. If both halves of the colony are as strong as to be expected for a nurse colony, it will be difficult to always find the queen. On the other hand, several series can be raised successively within one and the same colony, and this colony is maintained at that.

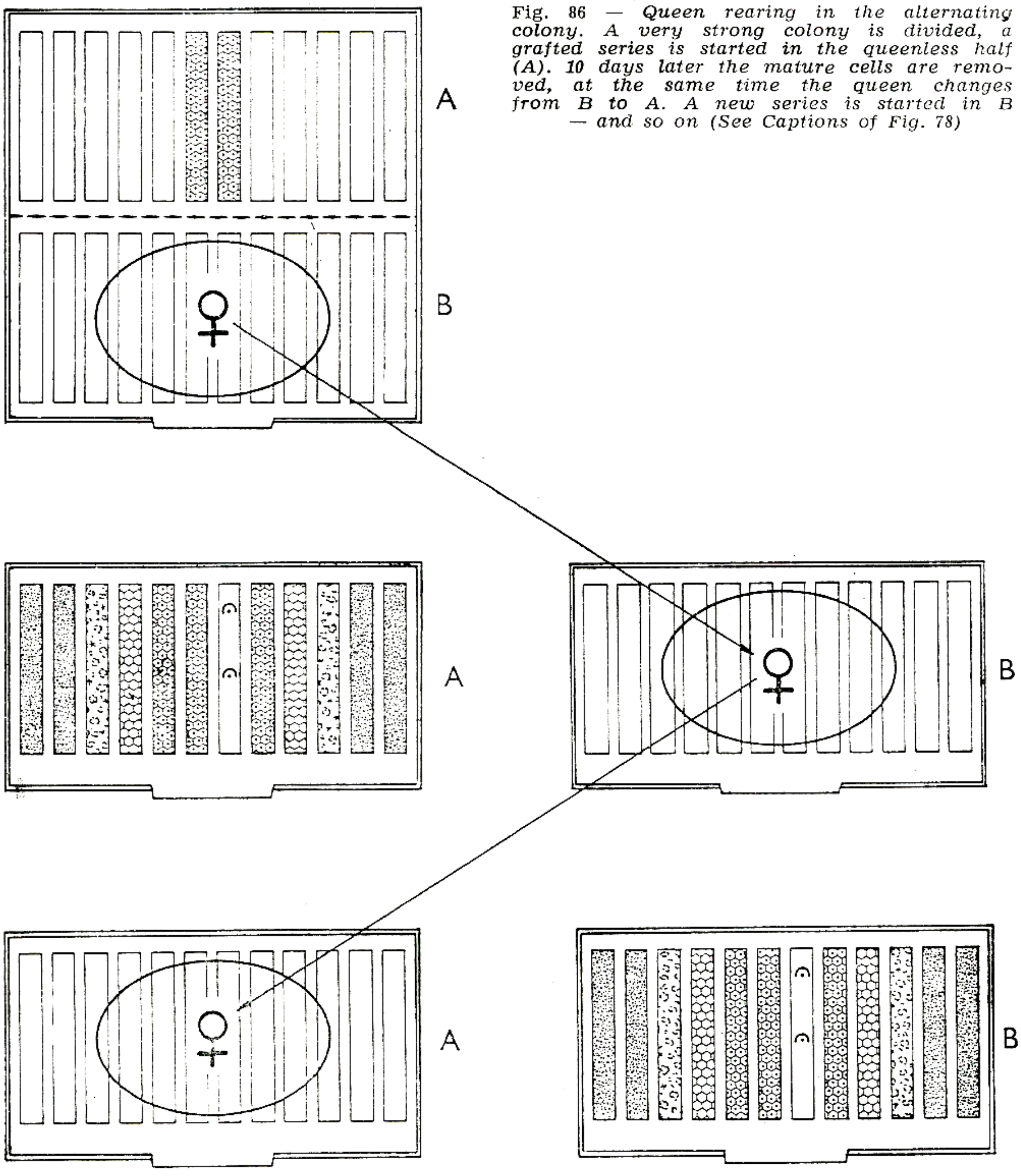


Fig. 86 — Queen rearing in the alternating colony. A very strong colony is divided, a grafted series is started in the queenless half (A). 10 days later the mature cells are removed, at the same time the queen changes from B to A. A new series is started in B — and so on (See Captions of Fig. 78)

3. Separate starting and finishing

3.1. *Calculation of economic efficiency in queen rearing*

It is necessary to start this section with some sentences on the calculation of costs. For queen rearing, knowledge and skill are needed, but in addition to this also a lot of equipment, much labour and a large quantity of bees. If precious queens are reared early in the season, the yield of the dequeened colonies is lost.

Using the methods described in 2.2.1. to 2.2.3. as a rule, only one series with 20—25 cells is reared per nurse colony ; subsequently it is divided to furnish the bees for the nuclei. 20—25% of the queens are lost later on during mating. Thus this labour results in about 17 queens, in place of a strong colony which is lost.

In our country the costs for bees, share of equipment and labour (44—48 minutes per queen) to produce 17 pure bred queens, equals the price of 35 kg of high quality honey (retail price). If a price of 3.57 kg honey was realised for a pure bred queen, there remains a profit yield equalling 25 kg of honey. The same yield can be extracted from one colony in a fairly good season — much more simply.

If the beekeeper produces queens of low price (mating not controlled) the costs to raise these 17 queens equal the price of 28.5 kg honey. But he fetches only the equivalent of 1.71 kg honey per queen. If he sells 17 queens for this price he gets only 0.6 kg honey as the yield from the lost colony — that is as good as nothing. This calculation was made for a beekeeper producing 100 queens and working with the conditions of Central Europe (Fig. 87). To rear queens with economic efficiency, a larger total number of queens has to be reared to make better use of the equipment, but also a larger number per nurse colony

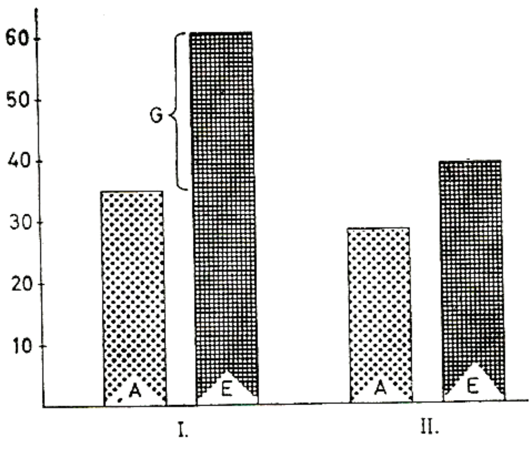


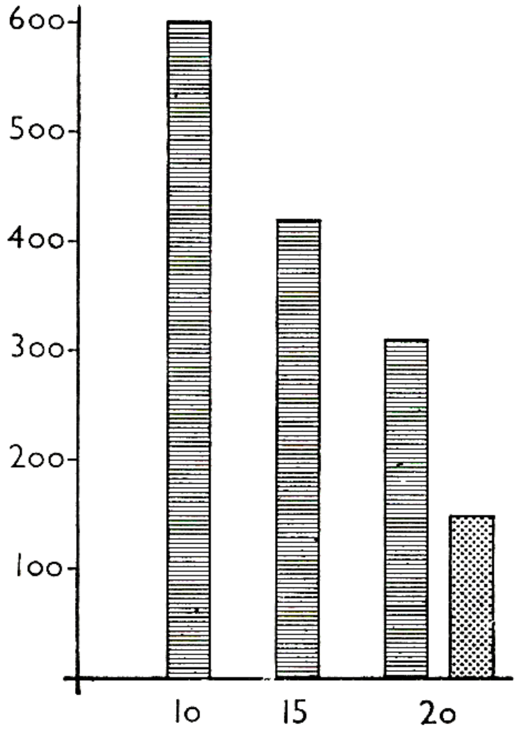
Fig. 87 — Profits of queen rearing, if only 17 mated queens are obtained from one nurse colony.

I. Pure bred queens; II. open mated queens for honey production ; A expense of wages, bees, material ; E gross receipts by sale of 17 queens ; G profit ; 0 — 60 values given in kg honey.

I : Results with controlled mated queens. The production of 17 queens from one colony equals the price of 35 kg of honey. By selling these queens gross receipts result corresponding the price of 60 kg honey. Thus a profit corresponding a honey yield of 25 kg is achieved. This profit by queen rearing is obtained also in bad honey years.

II : 17 queens with open mating are produced at lower expenses. However, the returns are not much higher than the costs. Except for suitable wages no profit was obtained. Thus rearing methods must be used which yield more than 17 queens per nurse colony.

Fg. 88 — *Quantity of royal jelly (mg) found in cells 48 hours old, if 10, 15 or 20 cells were nursed in queenright colonies, resp. in a queenless colony (column on the right according to Reinprecht)*



lost to honey production during this operation. Not 17 mated queens, but at least 60 should be the yield of a nurse colony.

The following methods demonstrate different ways of multiple utilisation of a nurse colony without charging it too much at the same time. The alternating nurse colony (2.2.5) and the queenless colony with permanent addition of open brood (2.2.3.1.) are already steps in this direction.

3.2. *Start in a queenless colony, finish in a queenright colony*

The queens are reared in a practically unchanged colony next to open brood, except at the start.

It is easily understood, as stated in Chapter VI, that the quantity of the remnant royal jelly in queen cells does not say anything about the weight of the queen. But the remnant of jelly may give a measure for the quality of the method. For the producer of royal jelly it is cash money. (REINPRECHT 1972) found 150 mg jelly per cell, 20 of them reared together for 48 hours in a queenless colony. He changed to method 3.2.2. — that is short start in a queenless colony and finishing in the super of a queenright colony — he got the following quantity of jelly after 48 hours (Fig. 88).

For 10 cells per colony 600 mg, for 15 cells 420 mg and for 20 cells 310 mg per cell. This is the double quantity of jelly compared to rearing in a queenless colony. This agrees with the results of HOFFMANN (1966) ; see Chapter V. Thus there is by no means an overstress of the nurse bees, rather on the contrary a stimulation. In strong queenright colonies much more royal jelly was deposited than in queenless colonies.

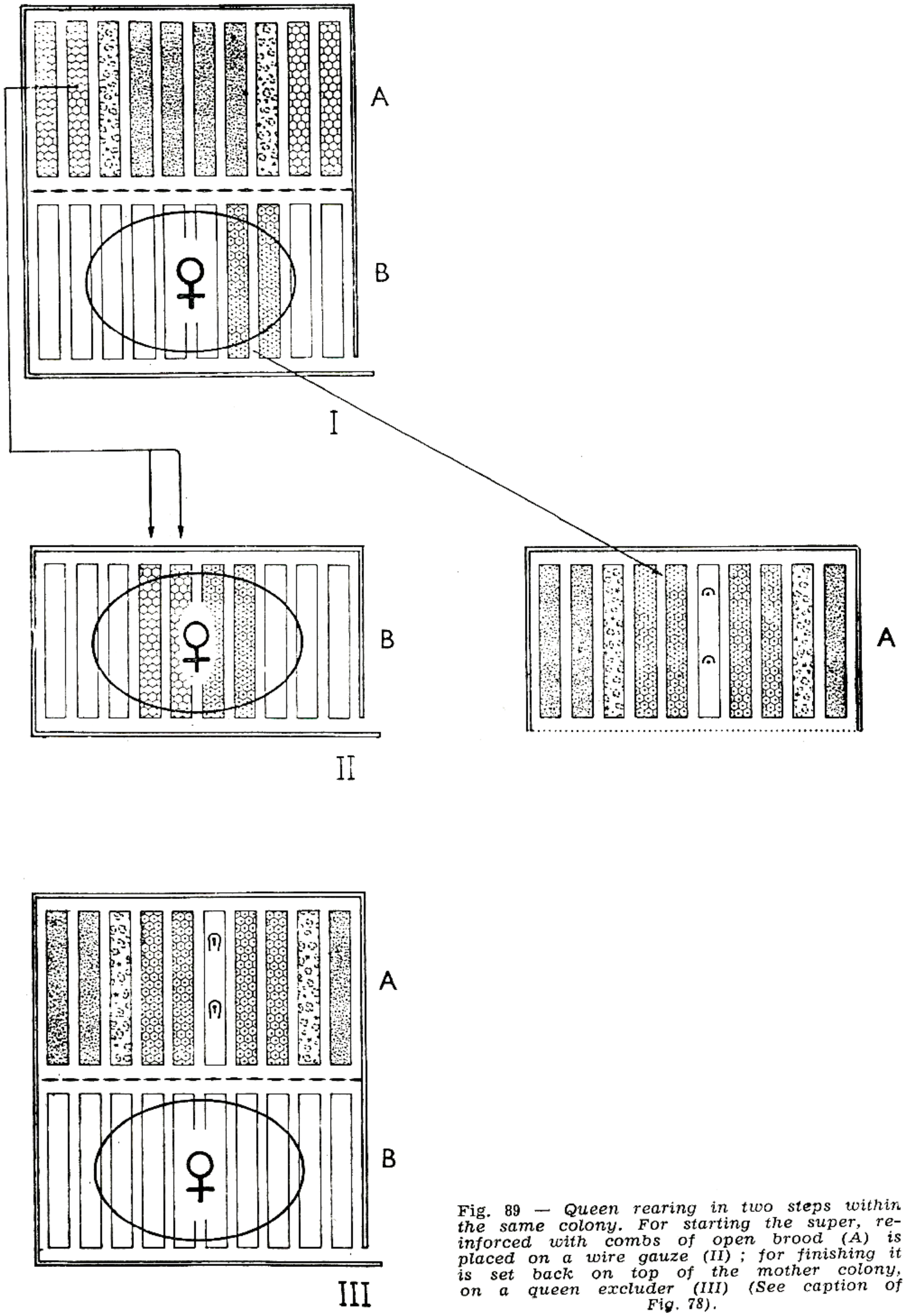


Fig. 89 — *Queen rearing in two steps within the same colony. For starting the super, reinforced with combs of open brood (A) is placed on a wire gauze (II) ; for finishing it is set back on top of the mother colony, on a queen excluder (III) (See caption of Fig. 78).*

3.2.1. Separated rearing in one and the same colony

Beekeepers who need only a small number of queens shrink from sacrificing a colony for rearing purposes. For this situation SKLENAR (1948) recommends a simple rearing method, which is frequently used with various modifications (LAIDLAW-ECKERT 1962).

Procedure

The super is removed from a strong colony suited for queen rearing and put on a frame covered with wire gauze, without an entrance. If necessary more bees are added to this queenless part of the colony, or the space is reduced in the super. One hour later the frame with grafted larvae is inserted in the central space prepared before. Thus a kind of artificial swarm is made where the larvae get the first nursing. 24 hours later the super is returned to the original position on the old colony, separated only by a queen excluder. Thus the finishing takes place within a queenright colony (Fig. 89). As a marginal note the recipe for Sklenar's bee tea recommended for stimulative feeding is included here. Ten grams of a mixture of five dried herbs *(Melissa officinalis, Achillea millefolium, Artemisia absinthii, Matricaria chamomilla, Mentha pulegium)* and orange skins are cooked in water and the decoction added to 25 l sugar syrup 1 : 1 mixed with some honey.

PESCHETZ (1966) and others describe the same method varied for hives to be treated from behind. Here the super, well occupied with bees, is separated from the hive body by a metal sheet inserted above the queen excluder while the grafted larvae get the initial nursing. Ventilation is given by use of a wire gauze. 24 hours later the separating sheet is removed again. The queen cells remain in the super until maturity.

These methods are based on the opinion that open brood should never be next to young queen cells. As opposed to this idea BLOEDORN (1963) and BÖTTCHER (1971) added combs of brood to the temporarily separated rearing compartment.

Evaluation

This method is widely used in many countries. The pre-conditions for its success is the over-crowding with bees of the super temporarily separated from the colony.

Frequently this procedure is called "queen rearing in a queenright colony". This is not correct, as the cells in the critical phase of acceptance — separated from the queen together with their nurse bees — are started queenless.

3.2.2. Separated starting and finishing in different colonies

The main point is, that the queenless nurse colony (for instance as in 2.2.3.) is fully exploited by frequent change of the rearing frames to always another finisher respectively for about one week. Mostly the series are changed three times with 48 hour intervals each ; the fourth series remains in the starter to the day for distribution of the cells. Instead of rearing only one series with 20 cells from beginning to end, 4 series are produced with a total of about 80 cells from one nurse colony within nearly the same time. Under favourable conditions, the change can be made every day during the same period, and to some colonies a grafting frame with 25 cells can even be offered in the morning, at noon and in the evening. The stress to the colony is not increased by this, because the amount of food given in the first hours is small (Fig. 90).

The artificial swarm too can be used several times as starter (3.2.3.).

A number of beekeepers rearing queens with ligustica bees used to keep capped queen cells in the starter. But according to TARANOV this is not the best solution as more young cells are accepted and the weight of hatched queens is greater by 15 mg. in absence of capped queen cells.

The important thing is that enough colonies to continue nursing (called "finishers") are at one's disposal. It is of general experience that each strong queenright colony will go on nursing young royal larvae, if these were fed earlier with royal jelly for several hours or days.

The method of separate nursing in starter and finisher colonies practiced at the Federal Institute of Apiculture, Lunz am See, Austria, for more than two decades is very efficient and economic. The beekeeper is able to work with success even in the relatively adverse climatic conditions of Central Europe though he never will get the turnover of beekeeper of warmer regions. His season is very short (see VII, introduction), thus it has to be well utilised. In the difficult phases of the season, that is at the beginning and the end, the method of starting in a queenless colony is used as described in this chapter. In the main season, that is between June 1st and July 31st, the start in a queenright colony is preferred (see 3.3) ; we utilise the peculiar experience, that the bees of a queenright colony can be "trained" to nurse royal larvae. If they once rear a series of started cells to the end, they will nurse also freshly grafted larvae right from the beginning.

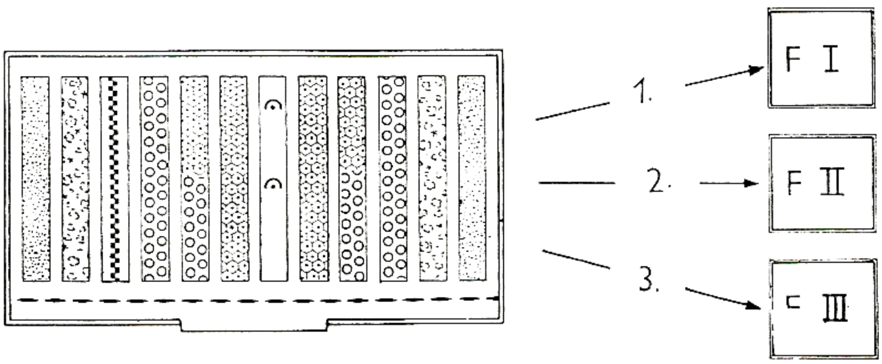


Fig. 90 — Separate start and finishing in different colonies, method Lunz. A new series is started in intervals of 1—2 days (1., 2., 3.) ; the preceding series are transferred to different finisher colonies (FI—FIII) between combs of open brood (See caption of Fig. 78)

The nurse colonies are located in autumn and in spring in a good pollen flow. They are managed in a way that the bees cover 24 combs of the German Normal or Kuntzsch Frames = a volume of 80 liters before the start. This corresponds to two LANGSTROTH units with 10 frames or 2.7 shallow Dadant supers. At the same time the brood nest is extended to 12—15 combs.

Procedure

(a) Start in a queenless colony as described in 2.2.3. The queen is removed several hours before insertion of the larvae. In the colony remain the combs with honey and pollen and moreover 4—6 combs of brood, partly sealed, and all the bees. The remaining brood combs are distributed to colonies which later on are to become finishers. The colony is reduced to half the previous volume. A wide beeway is prepared to accept the frame with 20—25 grafted cups.

(b) Continuation of nursing (after 24 or 48 hours starting) in strong, queenright colonies above queen excluder between several combs of unsealed brood. The equipping of the super with unsealed brood may be done in different ways according to circumstances :

1. Colonies strongly over-wintered are kept without queen excluder in the early nectar flow. Before inserting the queen cells, the queen of the colony is confined to the hive body. The brood in the super is arranged in a way that at least two combs of unsealed brood are on both sides of the frame with the queen cell.

2. Addition of brood combs out of the dequeened nurse colony (see item 1).

3. Removing the second queen ending a two-queen management (1.5.2.). Roberts and Mackensen (1951) thing that the presence of drone brood when rearing the grafted cells is also useful.

The queenless starter receives immediately after removal of the first series a second one. In most cases this is still repeated twice more. The fourth series remains in the queenless starter to the 10th day ; after this its bees are used to make nuclei and the remaining small colony gets a queen cell and becomes a mating nucleus.

(c) The cell finishing super has to have full strength of bees and ample provisions of pollen and honey. If necessary food is given near to the queen cells. Roberts (1965) makes a “rearrangement” in regular rotation instead of feeding, by transferring honeycombs to the lowest storey in order to have the honey transported to the super (see 3.3.2.).

(d) A finishing colony should never be given more than 20 queen cells to nurse at the same time, 10—15 cells being better. Frequently a well accepted series will be distributed to two finishing colonies. To be sure a good colony may nurse even 30 cells and more, but the queens become smaller.

(e) 4—5 days later the finisher can receive a new series with a new rearrangement of brood ; only after 9 days new combs of unsealed brood are given to the cell compartment. TARANOV and H. RUTTNER observed that the presence of sealed queen cells interferes with the care of young royal larvae. This is why the sealed queen cells are transferred to any other super or to the incubator as soon as young cells are given to the finisher colony.

(f) The brood combs added 9 days earlier are examined for uncontrolled queen cells.

(g) The queen cells of the series are removed on the 9th or 10th day. However, they can be put in the incubator immediately after sealing.

(h) Each frame with grafted cells has to be marked with the day of grafting and the breeding strain, otherwise control is lost.

Evaluation

In this method, as the starter cells in the queenless starter colony are exchanged every 12, 24 or 48 hours for new ones, several queenright colonies (finishing colonies) are associated with each starter colony. The finishing colonies are preserved as normal honey yielding colonies, they become even stronger by the rearrangement of brood and the addition of bees which are introduced together with the unsealed cells. It is true, the bees to make the mating nuclei are to be taken mainly from other colonies — sometimes to prevent swarming. The presence of unsealed and sealed queen cells in the finishing colony surprisingly does not provoke swarming tendencies.

This economical method is spread world-wide with small modifications by the commercial queen producers.

Method De Bessonet (Louisiana)

Also a temporary separated queenless compartment can be used as starter.

Procedure

A half depth body with a screen at the bottom is prepared with honey and pollen combs and with plenty of bees. Moreover two combs of unsealed brood are added "because this is more natural" (De Bessonet). This corresponds to a recommendation of LAIDLAW (1962) to place a comb of unsealed brood at one side of the cells and a comb of pollen on the other. 5 hours after the praparation of this unit, a frame with 28 larvae grafted into primed cups is inserted into each of two comb spaces previously left.

This cell building body is placed without its own entrance on top of the remaining queenright starter colony, separated by a ventilation screen. 24 hours later the screen is removed together with the queen cells. Thus united again the starter colony is left alone for 24 hours ; on the 4th day a queenless cell starter compartment is separated again ; only one

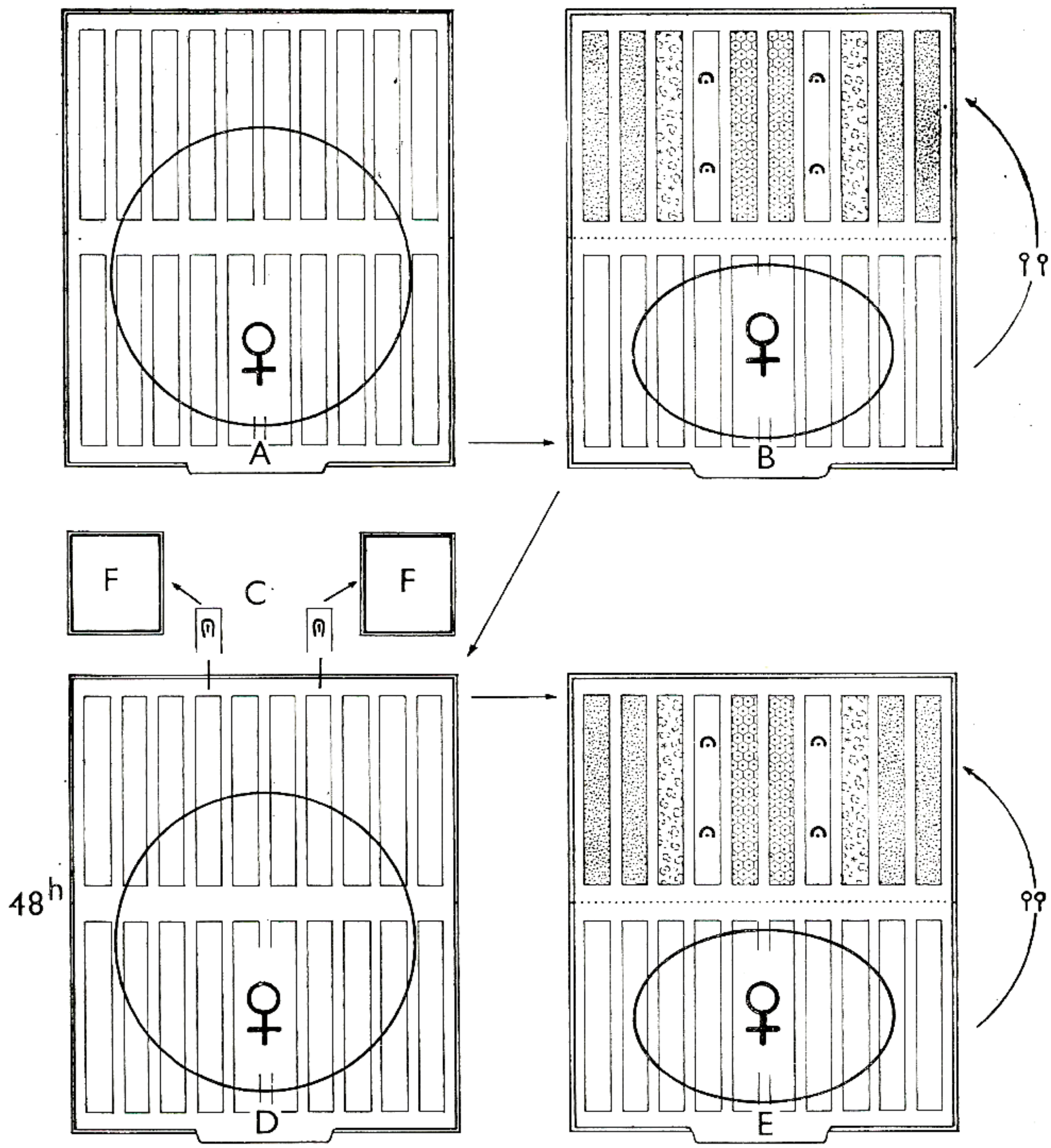


Fig. 91 — *Separated start and finishing in different colonies, method De Bessonet. Start : A very strong colony (A) is divided by wire gauze, bees are shaken into the upper chamber (B) and 5 hours later two grafted frames are added. One day later : The cells started for 24 hours are transferred into two finisher colonies (C) and the wire gauze is removed (D). The 2nd and 3rd day : The queen is allowed to lay eggs without restriction for 48 hours (D). The 4th day : Start of a new series (E) (See caption of Fig. 78)*

bar of the removed cells is given to one cell finishing colony ; thus for each starter colony two finishing colonies must be provided (Fig. 91, 92).

The finishing colonies are colonies with two brood bodies and a laying queen. Above the queen excluder is a hive body with stores and several combs of unsealed brood, which are replaced regularly every 3—6 days by rearrangement. At the same time empty combs are placed in the lower bodies. This acts also as swarm prevention.

The finishing colony receives a series of cells three days old every third day; the previous series is sealed in the meantime and placed on the side. The series grafted nine days ago is removed and used. At the same time the brood is rearranged and the combs with unsealed brood brought into the cell building body 6 days ago are examined for uncontrolled queen cells.

In the apiary of De Bessonet, Louisiana, queens are reared continuously in this way, using 3 × 12 starter colonies and 3 × 24 finisher colonies. 12 × 56 cells = 672 cells are grafted every day.

3.2.3. Start in the swarm box

This device, also called nurse box or starter box, is very popular mainly to start larger series. A densely crowded, well fed mass of bees is temporarily confined to a well ventilated box. At the latest after 24 hours the cells are transferred to a finishing colony.

Standard swarm box (3—5 combs)

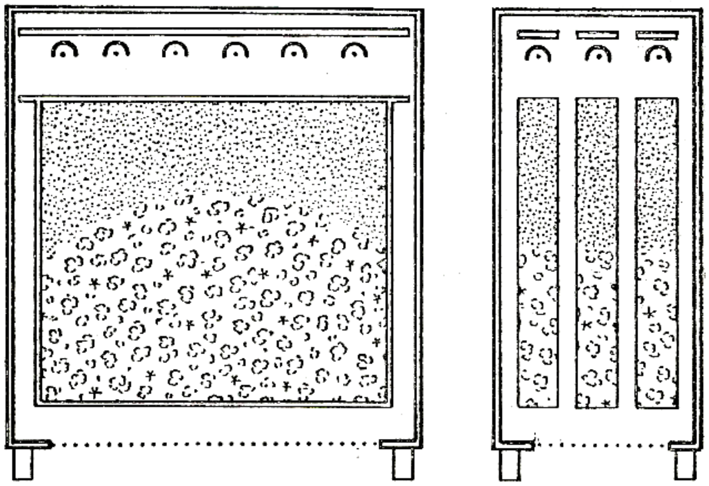
Device and operation

ALLEY (1883) describes not only the method of cutting worker comb with young larvae into strips, but also the swarm box. Today in the U.S.A. mainly a box is used with a large screen for ventilation, but without an entrance, holding five frames (LAIDLAW-ECKERT 1962).

First three combs containing unsealed honey, pollen and some water are put into the box. Two comb spaces remain free for the frames

Fig. 92 — Queen rearing apiary De Bessonet (Louisiana). Two rows of finisher colonies (F_1, F_2) are affiliated to one row of starter colonies (S).

Fig. 93 — *Swarm box with three combs according to Fischlein. The queen cups are situated above the combs. The inner cover has 15 holes to insert the bases of the cups.*



with the grafted cups. The 2—3 kg mix bees are brushed off from brood combs into the swarm box. As a rule of thumb 1 kg bees are taken for 35 cells. Next the box remains without queen cups for 3—5 hours in a cool and dark place supplied with liquid food. Some beekeepers place a comb of unsealed brood in each of the two comb spaces which, however, are removed again at the end of the period of rest. Then 60, frequently even 90—120 queen cups are grafted, inserted in the box and kept there for 24 hours. The further cell building is made in several finishing colonies, while a second and third group may be started in the swarm box. After three days the swarm is disbanded.

A similar variation using full depth hive bodies was described in 3.2.1.

The swarm box used in the F.R.G. according to Fischlein holds only three frames. A board with about 36 drill-holes for the bases of the queen

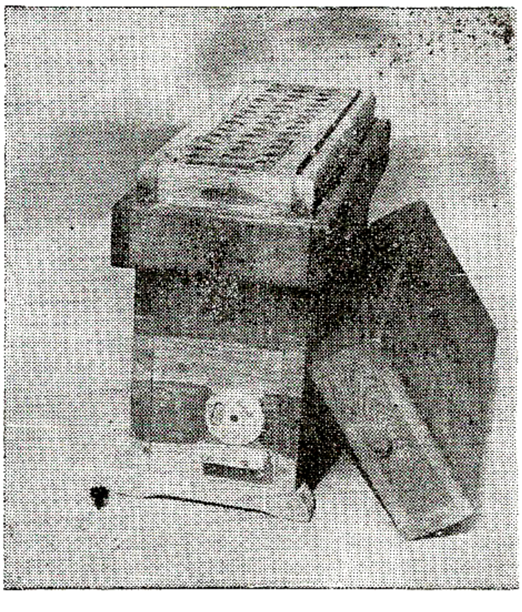


Fig. 94 — *Swarm box according to Fischlein*

cells is placed 20 mm. above the frames. The bottom of the box is a screen. Bees of 6 well covered brood combs are shaken into this box.

All details of minipulation are the same as with a larger swarm box. As the bases with the queen cells may be removed singly it is very easy to make a second or a third series without any loss of bees.

With a swarm box more queen cells can be started than with other starter colonies and this procedure succeeds even during adverse conditions. This method is mainly recommended if a great number of queen cells is needed at the same time. It is decisive for the quality of the queen that the finishing colonies are charged with only a few cells — about 15—25 depending on the colony strength and the conditions.

To make the artificial swarms requires more work and the risk of Nosema is greater than with other methods.

3.2.4. The big swarm box and the course of queen rearing with Roy WEAVER

Weaver Apiaries in Navasota (Texas) is a family plant, involved in large scale queen rearing for more than 60 years, and is one of the best known and biggest queen rearing enterprises of the United States. Navasota is situated on 30° of latitude and influenced by the humid and warm climate of the Gulf of Mexico. During the winter the brood is greatly reduced in the colonies, but the first pollen is already harvested by about the 10th January and a strong stimulus for brood rearing is produced by then. Soon drone eggs are laid, supported by stimulative feeding of pollen and honey. Usually the colonies are developed between February 16—22 to such a degree that grafting can be started.

An especially large number of queens is needed during a restricted period of time for shipping of package bees. This is why big starting units are used in some operations where the production of queens is very large.

The Weaver Apiaries have 6 frames with queen cells in each swarm box, each frame with two bars with 13 queen cups each, that is altogether 156 queen cups.

The Weaver swarm box is a standard-Langstroth hive body with 10 frames, closed on bottom and on top by a screen. In the bottom screen there is closeable entrance. The grafting frames are only 19 mm wide, without frame spacers. This hive body is equipped with spacers which position four frames of honey and pollen ; between these combs there are three spaces each for two of the narrow grafting frames. The sequence of the frames is shown in Fig. 95. A frame of honey and pollen is against one side wall of the hive body, a division board feeder against the other.

The swarm box is equipped with the four frames of honey and pollen, but without grafting frames, and is taken to an outyard where queenless bees are shaken into it. The quantity of bees needed varies with the season. Early in the year, at the beginning of the season when the weather is cold, 4—5 kg of bees are needed ; later on 3.5 kg will be enough. This box of hopelessly queenless bees is brought to the grafting yard in the afternoon, a division board feeder is placed in the empty space against one side wall and filled with sugar syrup with

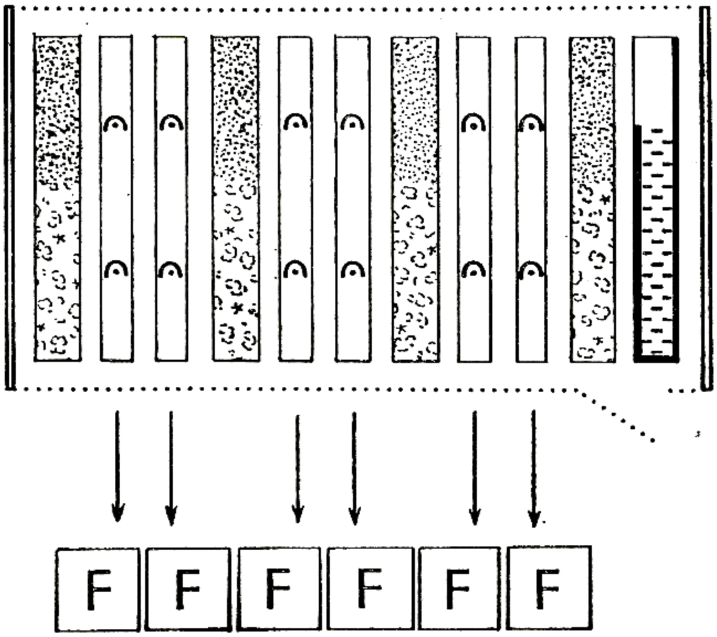


Fig. 95 — Weaver's swarm box. A Langstroth hive body is supplied with 4 combs of pollen, one sideboard feeder and 4 kg of bees. 1 day confinement in a dark room. Then, up to 6 grafting frames are started for 24 hours; after this, each single frame is transferred to one separate finisher colony (F) to stay there until maturity of the cells.

Fumidil B — in it; an over-wintered caged queen is brought in to keep the bees quiet; they are then left undisturbed over night.

Next morning (or next morning but one, because the swarm may also be kept for two nights, for instance for grafting on Monday, the bees are shaken on Saturdays), the queen is removed and the grafting frames are inserted with another feeding of syrup.

It is dry grafted. No advantage was ever seen by placing the larvae on royal jelly, whether diluted or undiluted (see Chap. VI). After adding the larvae, the swarm box is placed in the open and the entrance is opened.

Usually the larvae are very well accepted. Out of the 26 grafted larvae of a frame, 18 are accepted on the average early in the spring and 22 later in the season. The result varies of course according to the condition of the bees and of the weather. It is of more importance to use the experience of many years of work than to stick to rigid rules. Sometimes it makes no sense to give more than 4 or 5 grafting frames with larvae to a swarm, whereas at another period the larvae of all 6 frames are nursed execellently.

24 hours later the grafting frames with the queen cells are taken out and distributed among six queenright finishing colonies. Thus each finishing colony receives only one grafting frame with about twenty queen cells. At the same time the number of accepted larvae and the quantity of royal jelly are observed. If the acceptance is poor, the bees of the starter swarm are used to reinforce the finisher colonies. If, however, a good rearing performance is shown, the swarm may be used for a second series. This time only 3—4 grafting frames with young larvae are given.

Occasionally it is grafted into the swarm box for a third time. However, early in the year bees rapidly loose their ability to feed queen cells well so, the third time, only one or two frames are grafted for each swarm. Only afterwards (that is after 2—3 days) they are used elsewhere. This much for Weaver's starting method.

The grafting frames of a given day are marked with thumb tacks of the same colour. Thus mistakes are avoided (especially in the finishing colonies, see later).

For finishing the queen cells, strong queenright colonies are used. These colonies have two and one-half storeys (with 10 standard frames each) full of bees.

The preparation of the finishing colonies begins in fall. They are transported to a good location with ample supply of pollen to provide them for wintering with many young bees and stores. These colonies are selected for outstanding strength and for an excellent mother queen as they are also to supply a great number of drones to work with the young queens. In these cell builder-drone colonies, combs are used which most honey producers would discard ; old brown combs with sections of drone cells are scattered over the surface. Moreover two solid drone combs are placed in the brood nest.

Late in December and early in January a shallow super full of honey is put on the bottom board of the colony, with the brood nest next, and the deep hive body of honey on the top. The colony does not have a queen excluder on it at this time. The bees start moving the honey up from below and this seems to stimulate them to start expanding the brood nest. However, in order to start the bees to producing drones early enough to mate with the first queens, it proved to be necessary to begin feeding these colonies pollen patties late in December or early in January. One half pound soft patties made of trapped pollen, sugar and honey (or sugar syrup) is put on top of the brood frames of the lower hive body. The bees usually start bringing in fresh pollen on warm days about 10th January, and with the stimulative feeding of pollen to help them, they start producing drone brood and building up rapidly. All of these colonies have entrance holes bored in the front of every hive body so the drones will have an exit when the excluder is placed on the hive.

Grafting is started round February 20th, with the conditions of Texas. On the same day the first group of finishing colonies is prepared to accept the queen cells. At this time the cell finishing colonies have at least six combs of brood. The queen is left with the oldest combs of brood in the bottom hive body, a queen excluder is placed on it and 3 combs of young brood placed in the hive body above the queen excluder. The combs in the top hive body are arranged in the following way — starting at one side wall there is a comb of honey, a comb of honey and pollen, three combs of brood, honey and pollen, a comb of honey and a division brood feeder. A slight space is left at one end between the two combs of brood nearest the centre of the hive so we can see where to make the space for the frame of queen cells the following day.

During this preparation work, the finishing colonies are classified. Only those of maximum strength are taken for immediate use. Weak colonies that are coming along well are marked to be strengthened by adding brood and bees. Other colonies that do not develop well are moved out of the yard of the finishing colonies.

At the beginning of the rearing season, that is from about 20th February until beginning of March, the bees used in the swarm boxes are used to strengthen the cell finishing-drone production colonies. During the next two or three weeks enough young bees of their own queen hatch and the colony remains at optimum strength. Usually at about the last week of March, these colonies will soon be reaching swarming strength ; to give them additional room could interfere with working them for queen cell production. Weaver's solution to keeping the colonies at optimum strength is to now begin taking brood and bees from them. Thus the cell finishing colonies produce also bees along with queens to make new colonies for the next season's work.

The art of keeping the cell finisher-drone producing colonies in optimum condition for production is one of the most difficult parts of this system. It requires close observation and the ability to act upon judgment, which is based on experience. It cannot be completely systematised "because conditions are seldom the same in successive years" (Roy WEAVER).

The frames with the started cells are taken out of the starter box after 24—48 hours and put into finishing colonies in one of the outyards. Each finishing colony receives only one frame with 20—23 queen cells in the prepared space between two frames of brood ; experience has shown that rearing of a greater number of queens in one colony at the same time is done only at the expense of their quality. That means, for practical work, that for the queen cells originating from a single swarm box, six finishing colonies are needed. After insertion of the cell frames, sugar syrup is filled in the side board feeder (from a tank mounted on the utility truck).

In former years, the transportation of the queen cells to the outyards several kilometers away was done in specially constructed insulated incubator boxes. Later on it became evident by our own and by the experiences of research (see Chap. V), that larvae can be kept easily outside a colony for 1—2 hours. Dry warmth is much more dangerous for them than a decrease of temperature for a limited time. This is why the grafting frames are transported now without any precautions within a simple box.

4—5 days after addition of the first series (by now just being capped), the finishing colony receives a second series in between two combs of brood. Further 4—5 days later series I (by now 9—10 days old) is removed and distributed to the mating nuclei. One day later a new series out of the starter box is given to the finishing colony.

For commercial queen rearing it is of decisive importance that the whole course of work passes off according to a well devised scheme, which can be pursued over the whole season. Weaver arranged 4 groups of cell buiding colonies (A, B, C, D), each of which receives the started series on a certain day. The grafting frames of one day are marked with thumbtacks of the same colour. On the 5th day, group A receives the second series. Every day is grafted from Monday to Saturday. To maintain the course of labour over Sundays, the larvae grafted Saturdays remain in the starter box for 48 hours until Monday, and two series are removed from the finishing colonies not on the 9th, but on the 10th day. This system gives exactly a rhythm of 14 days. Exactly after two weeks, Group A of the cell finishing colonies receives a series marked with the same colour as the first series.

This system yields in the average 20 cells per grafting frame. A period of 9—10 days results in two grafting frames per cell finishing colony. As there are unavoidable accidents here and there (badly nursed larvae, to be discarded ; entering of a queen through a gap in the queen excluder, etc.), a production of four queens per day per finishing colony may be expected. This does not seem to be very much compared to the high quantity of bees invested. It is, however, a permanent production and the queens are of top quality.

Course of Weaver's queen rearing programme

Day 0	Shaking 3.5—4.5 kg of bees into a large swarm box ; feeding ; a caged queen to keep the bees quiet.
Day 1	Removing the queen ; inserting 6 grafting frames with 26 grafted cell cups each ; placing the box in the open, entrance free.
Day 2	The 6 grafting frames are distributed individually to 6 strong cell finishing colonies. Possibly inserting a second (smaller) series into the same box.
Day 3	The grafting frames of series 2 are distributed to another group of finishing colonies. Favourable conditions given, possibly a third series in this box ; subsequently the bees are used to strengthen the cell finishing colonies or to make mating nuclei.
Day 6	Adding a second freshly started series of cells in the same finishing colony.
Day 10—11	Removing cell series one. Adding series three.

3.3. *Start in a queenright colony*

It is well known to the beekeeper that emergency cells are built sometimes on brood combs transferred to the super. If a frame with freshly grafted cells is given between brood combs in the super of a cell finishing colony the cells usually are readily accepted, especially if the colony was "trained" before by finishing series of cells which were started elsewhere.

It is recommended to use royal jelly for grafting into a queenright colony. In Lunz, however, dry grafting is always practised. It is mentioned in Chapter VI that grafting on royal jelly is of advantage if older larvae are used. However, that is not the case with very young larvae. Thus the old discussion whether to use dry grafting or not is decided not by the method of rearing but by the skill of the beekeeper and the age of the larvae.

A new series is added in regular intervals of five days at the latest — that is as soon as the cells of the preceding series are sealed. It is very important that no break occurs, because nursing queen larvae seems to become a "habit" to the bees which should not be interrupted. Otherwise the efficiency of queen rearing diminishes rapidly. There should exist no pause between the removal of the older, sealed cells and the insertion of the frame with freshly grafted cells. Three hours may be sufficient for the construction of many wild queen cells — and then the grafted larvae are badly nursed. If, however, larvae are permanently present in cell cups of 9 mm diameter, emergency cells will be rarely constructed from worker brood.

For this method Standard Hives with supers are suited as well as horizontal hives with a vertical queen excluder to restrict the queen. On this principle the various methods described below are based.

Evaluation

Queen rearing in a queenright colony does not "consume" the colony. Thus this method is excellently suited for a steady permanent production of queens of high quality. The number of accepted cells is lower ; 15 cells on the average, sometimes up to 25. The efficiency in cell building is even less predictable than in a queenless colony, but soon colonies with good cell production ability will be found because no special preparations are necessary. As soon as a colony is raising queens, no interruption should be allowed but newly grafted cells should be given regularly every five days.

3.3.1. Starting in a queenright colony with two hive bodies (Lunz am See)

Colonies are used with two hive bodies with 12 Kuntzsch frames (33 × 25 cm) each, selected on account of outstanding strength the last autumn and especially cared for at favourable places. As mentioned before (3.2.2) queen rearing in queenright colonies is practised in Lunz am See during most of the main season (June-July). The same colonies were used before as cell finishing colonies. Thus the bees were trained to the location of nursing and the production of brood food.

Operation (Fig. 97)

(a) A cell building colony is prepared by transferring 4—5 combs of open brood from the brood chamber to the super. A space is left for the grafting frame. The queen is moving freely in the lower hive body, separated from the super by a queen excluder.

(b) Several hours later a restricted series of 15—20 cups (during favourable conditions, up to 25) is dry grafted and placed in the free space amidst the brood combs in the super. If necessary sugar syrup is fed near the grafting frame (Fig. 96).

(c) After 5 days the cells are sealed. They are moved to the side or withdrawn to finish their development in the super of another colony or in the incubator. The acceptance varies between 8 and 25 cells, on the average 15 very well fed and well developed queens are produced. Open brood is again introduced into the super and a freshly grafted frame is added.

This rhythm of work is maintained until middle of July. As soon as drones are expelled the start in the queenright colony is finished. Cells are started again in a queenless colony or in a swarm box, as in May. A high quantity of bees to fill the swarm box is at disposal at this time of the year. Cell building colonies must not be weakened. If bees are withdrawn, either for mating boxes or nuclei, the number of accepted cells is diminished instantly to 5—8.

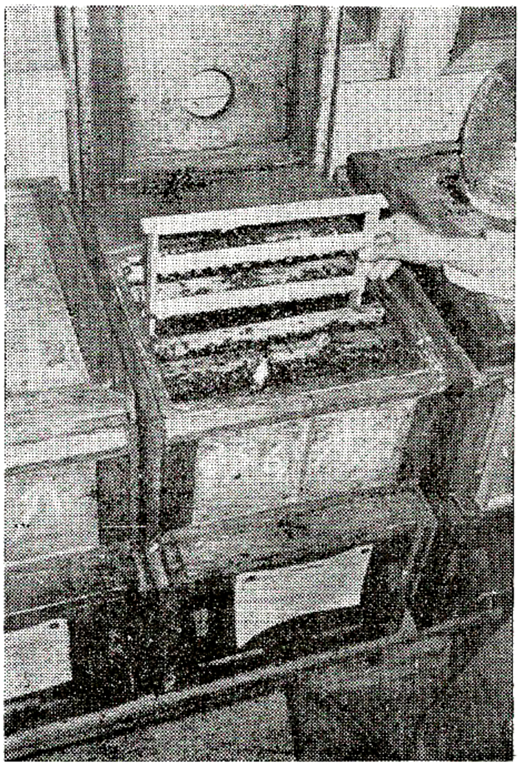
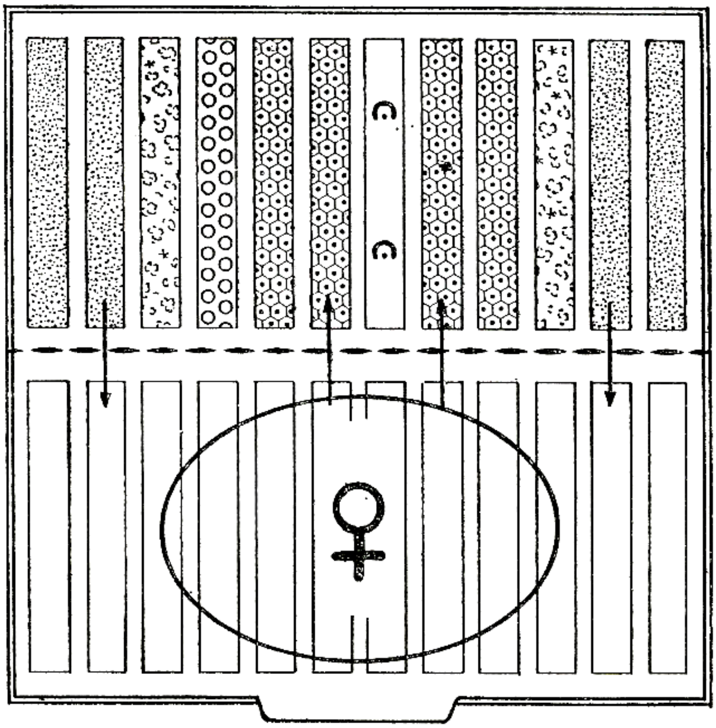


Fig. 96 — *A grafting frame is added into the super of a queenright colony*

Fig. 97 — *Start in a queenright colony with two hive bodies. In intervals of 5 days combs with open brood are transferred upwards, to the newly grafted cells, and combs with unsealed honey or capped brood downwards (See caption of Fig. 78)*



3.3.2. **Queen rearing in a queenright colony with several supers (according to William C. ROBERTS — 1965)**

Dr. W. C. ROBERTS worked for decades together with Dr. O. MACKENSEN at the Southern States Bee Breeding Investigations Laboratory at Baton Rouge (Louisiana) and he contributed essentially to the knowledge of mating biology, instrumental insemination and genetics of the honey bee. His experiences of various queen rearing methods are outstanding, especially as he needed queens of high quality for his work.

Baton Rouge is situated on the edge of the warm and humid delta of the Mississippi, near 33° latitude. Drones are present from the beginning of February ; the main rearing season is from March to June, but queens can be reared until October.

Starting point of this method was the usual starting of cells in the swarm box and finishing in a queenright colony. Double grafting was used supposedly to increase the quality of the queens. During the practice of many years it was found that the same good results are achieved by using a very much simplified method : Starting in a queenright colony with single grafting on a drop of royal jelly.

Queen rearing takes place in a modified Dadant hive with 4 shallow bodies (11 frames each, 44.8 × 15.9 cm). A strong queenright colony is used (Fig. 98).

The queen is free in the lower three bodies. The uppermost body, separated from the others by a queen excluder, contains six combs of open brood, two grafting frames, a comb of pollen, and two combs of honey, only partly filled. The grafting frames are placed between the combs with open brood.

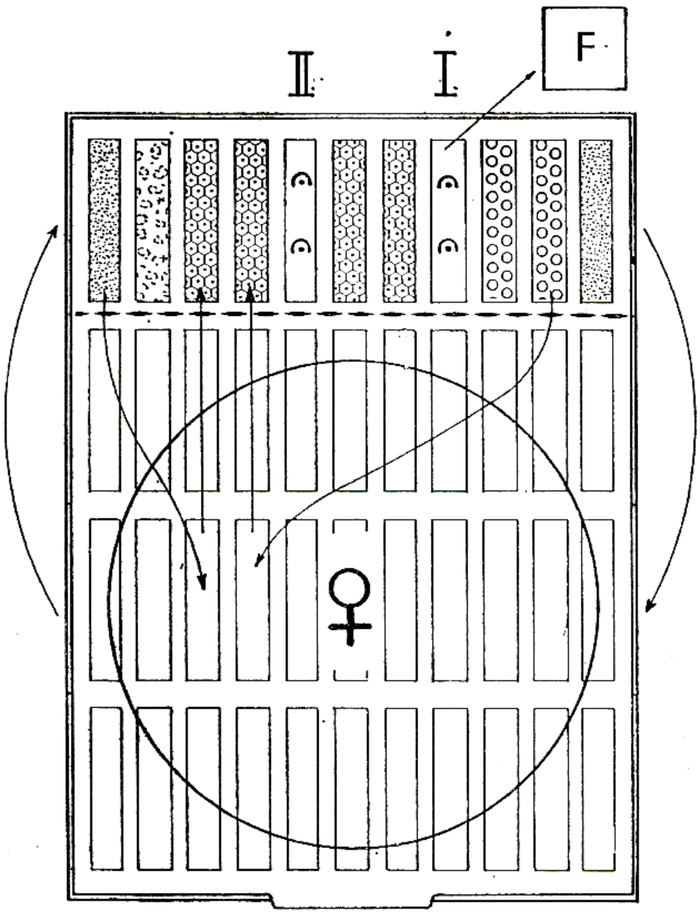


Fig. 98 — Queen rearing in queenright colonies with several units. If shallow supers are used, whole layers of brood may be transferred above the queen excluder at the start of queen rearing. Change of combs and queen cells in 4 day rhythm (combs with provisions and capped brood from top downwards, empty and open brood combs from below upwards = "rearrangement") (See caption of Fig. 78)

The sequence of the method is as follows :

Day 0 — Four combs of open brood are moved from the brood chamber to the top super, the grafting frame with freshly grafted cups is inserted. For grafting the larvae are placed on a drop of royal jelly, diluted with 10% water. The jelly is preserved for months in a deep freezer. Moderate feeding only in the absence of nectar flow.

Day 4 — Combs with unsealed honey are moved from the top to a lower body. They are replaced by two other combs of open brood. A second grafting frame is added.

Day 8 — Sealed brood and unsealed honey are moved from the top to below, 2—4 combs of unsealed brood from below to the top. Grafting frame 1 is removed with its sealed cells, grafting frame 3 is added with freshly grafted cells.

The queen larvae are nursed continuously among open brood with this method — in the same way as during spontaneous rearing of queens. The "rearrangement" every four days is the main point of the method. The queen has permanently ample space for egg laying, i.e. swarming tendency will not arise therefore. Together with the sealed brood, honey combs are moved to the bottom storeys. This is against the natural order of the brood nest, and therefore the bees will have the tendency to transport the honey to the top again. This re-distribution will create the effect of a permanent stimulative feeding, and mostly an additional feeding will be superflous, and the bees will not be diverted from their nursing activities.

3.3.3. Queen rearing in a queenright colony in horizontal hives (Giulio Piana, Italy).

The beekeeping dynsty Piana (Castel San Pietro near Bologna, Italy) has supplied for decades the best known and greatest queen producers of Europe. Compared to the big queen rearing plants in the U.S.A. and Australia, this enterprise is situated in a much higher geographic latitude (44—45°). This is why the rearing season only starts in April and in some years it is cold until late in May. The summer, however, is warm and dry, thus matings take place within a short time and queen rearing can be extended until September (4—5 months). Further favourable conditions for queen production are a permanent slight nectar flow and ample supply of pollen. Bologna is the centre of rearing the Ligustica bee, and a great many of the queens are exported.

Hives with standard Dadant frames are used. Cell building occurs in queenright colonies with 15 frames in longitudinal position. The hive is divided into two compartments by a metal sheet division. In the centre of the sheet is a queen excluder of about 2 dm^2 surface. The one

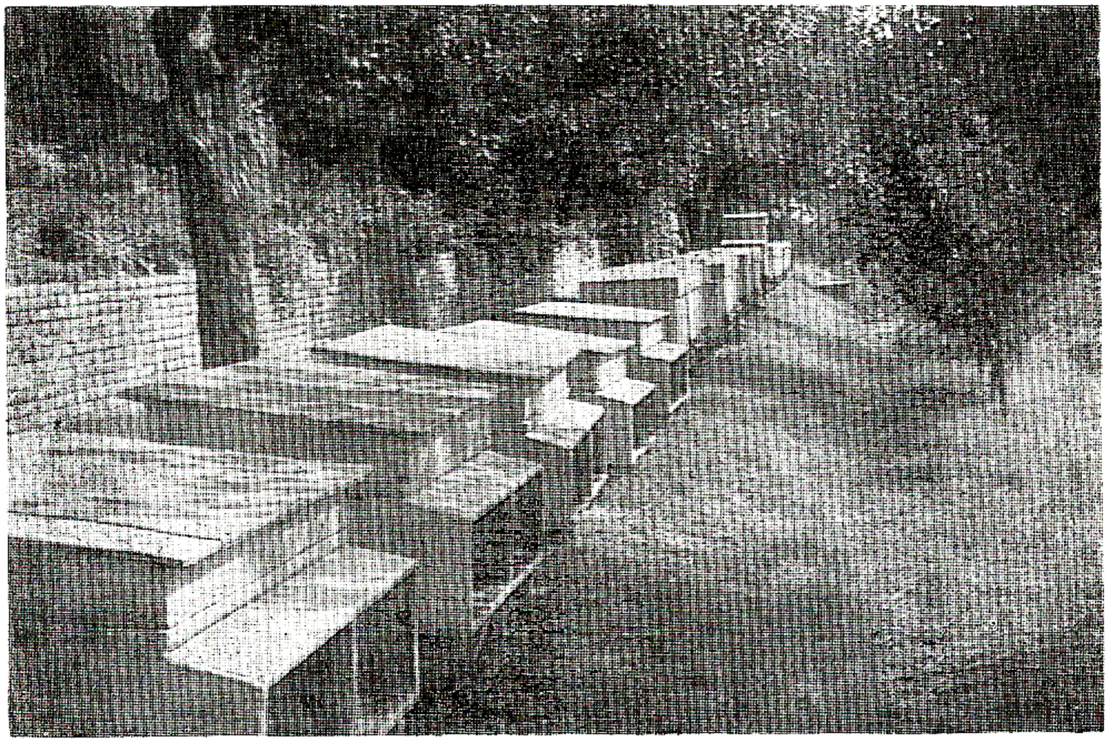


Fig. 99 — *The Piana queen breeding station at Castel St. Pietro (photo PIANA)*

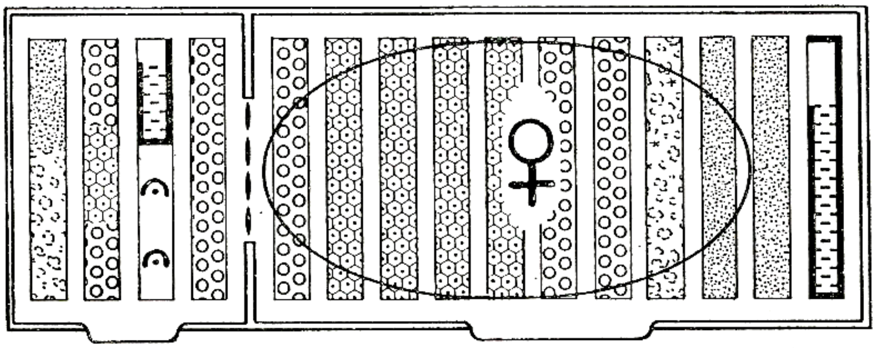


Fig. 100 — *Rearing in a queenright colony in a horizontal hive. Exchange of combs with open, respectively capped brood every 5—7 days is very easy in horizontal hives (See caption Fig. 78)*

compartment holds four frames and the other 11. The bees in the small compartment have no queen and receive the grafted cells. A laying queen is in the second compartment. A small super with 10 frames can be put on the queen compartment during a honey flow. Each compartment has it own entrance. For queen rearing, four combs covered with bees are moved into the cell building compartment in the sequence as follows (from outwards — inwards, e.g., towards the queen compartment, Fig. 100) :

1. On the side wall — honey and pollen
2. Brood — mostly sealed, partly with older larvae (3—5 days old)
3. Grafting frame with feeder.
4. Sealed brood, due to hatch within 3—4 days.

This sequence is restored for each new rearing series.

The colony selected for queen rearing has to have at least six brood combs (DADANT size). Only as soon as this quantity of brood is present and, as the first drones hatch, can queen rearing be started (usually during April).

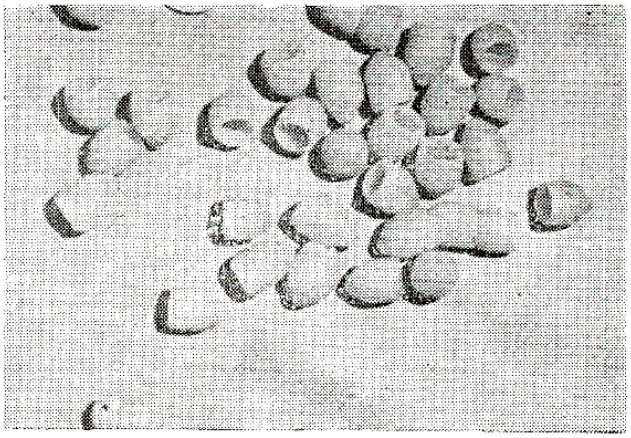
The cell building compartment is equipped with combs as described above prior to the start of queen rearing and remade in the same way of each of the later series. In the big compartment with the queen, brood combs are placed immediately beside the queen excluder and then the other combs, corresponding to their natural sequence. Thus the colony has even now a brood nest in one body, however divided by a queen excluder of relatively small size.

Immediately after this new arrangement, the colony is fed with syrup and then left undisturbed for the day. 24 hours later, a small series (14 cells) is grafted and placed into the queenless compartment. The queen cups are made from pure wax of cappings out of the solar wax melter box. The inner diameter of the cups is 8.8 mm, the same as natural queen cups. Thickness of the wall 0.7—1.0 mm (Fig. 101).

Grafting is done on a drop of fresh royal jelly.

At the first inspection on the following day, 8—10 accepted cells will be found. This figure varies with the season.

Fig. 101 — *Queen cups at the apiary Piana (photo Piana)*



On this occasion the colony is fed again. A feeder is in the upper third of the grafting frame, that is immediately above the queen cells, containing 3/4 l, syrup (Fig. 102). Feeding is repeated on the two following days. It is important that the food is incorporated by many bees simultaneously, because then a great number of the bees of the colony will be full of food and forced to produce and to deliver brood food. Seven days after grafting, the sealed cells are removed and stored in a queenless colony until they are inserted into mating nucleus shortly before hatching. The cell builder receives a new series.

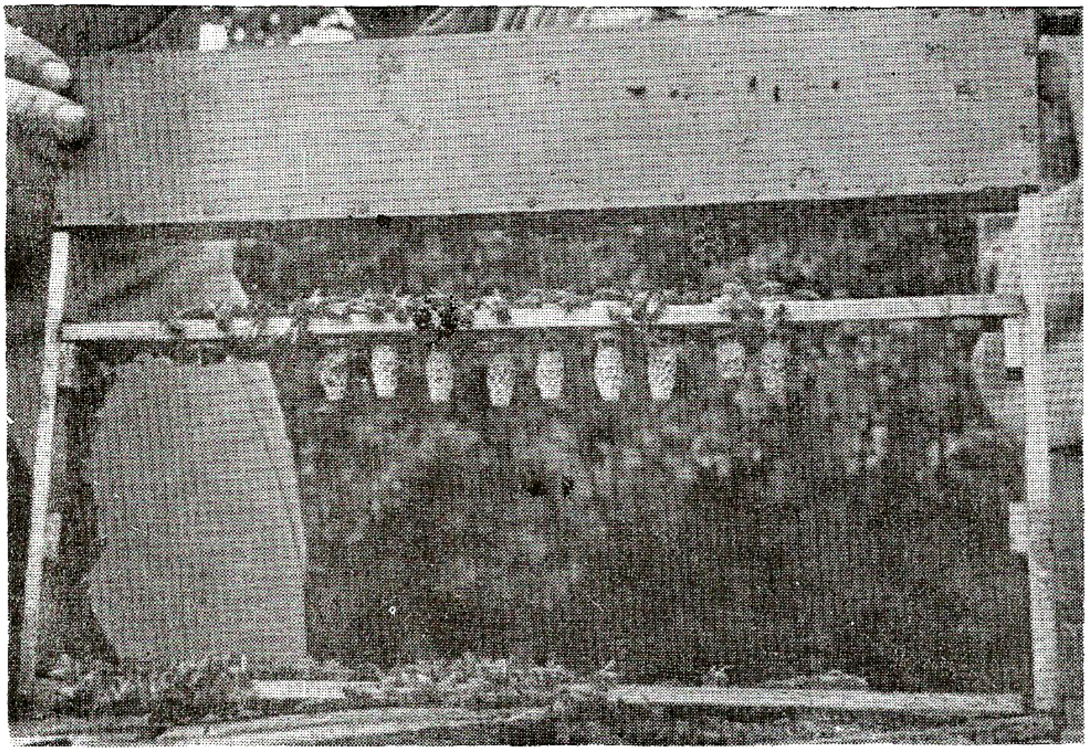


Fig. 102 — *Grafting frame (Piana) united with a feeder (photo Piana)*

3.3.4. **Queen rearing in a queenright colony with controlled brood cycle (Norman RICE)**

The queen rearing plant of Norman Rice, Beaudesert, Queensland, is the largest in Australia. He produces not only for the demand of Australian beekeepers but also for export. Besides the colonies needed directly for raising of queens, 2000 more colonies are maintained for production of bees to stock mating nuclei and for honey production. The average yield of colonies managed exclusively for honey production is given for this region as about 60 kg.

Beaudesert is situated at the 28° South latitude, that is in the sub-tropical region. Two factors that must be emphasised in relation to climate and vegetation :

1. High average temperatures and low precipitation, thus mating of queens with high probability at the earliest possible date.

2. Long lasting light nectar and pollen flow from different species of Eucalyptus.

All this ensures a long queen rearing season, with all operations synchronised to a predetermined schedule. Queen rearing starts in August, that is in the third month of winter and ends in April (eight months rearing season).

An individual method was developed, based on experiences in the U.S.A. and Canada, ensuring a steady queen production over a long period. The queens in the nuclei are changed every 15 days. A mating nucleus yields on the average (provided fully used during the whole season) seven queens, sometimes even twelve, 50—70 mated queens are

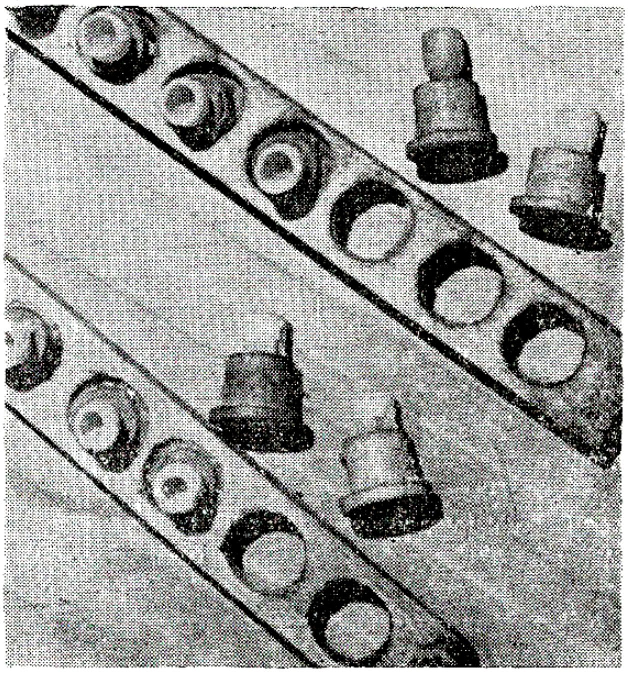


Fig. 103 — *Bars with cell bases (photo Piana)*

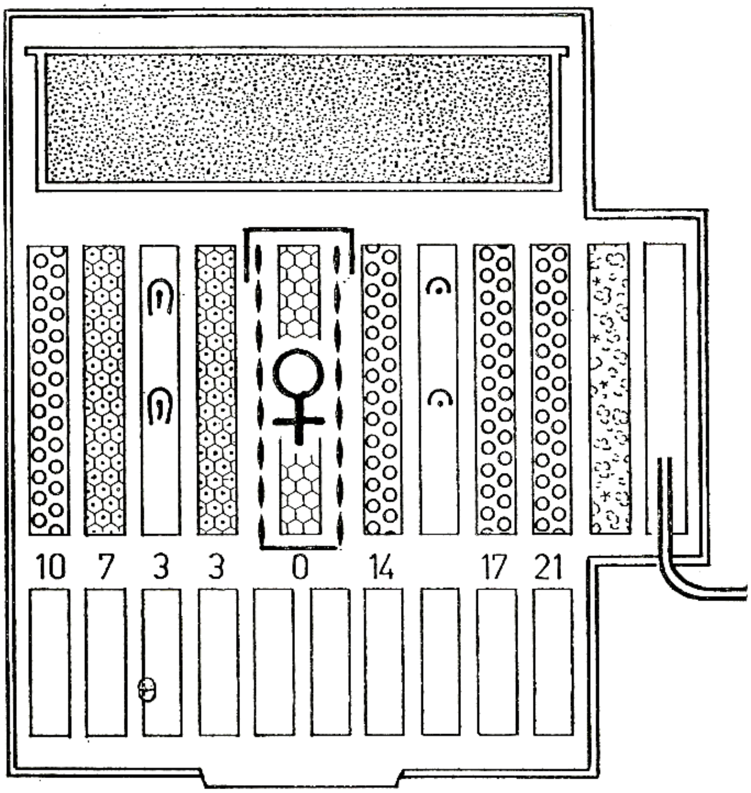


Fig. 104 — *Queen rearing in a queenright colony with controlled brood cycle. With N. Rice, the combs rotate every 3—4 days. The queen is permanently confined to one empty comb which is regularly changed; open brood is placed next to elder queen cells. The figures 0—21 indicate the age of the brood. The queen remains in the comb case during the whole rearing season (See caption of Fig. 78).*

obtained from 100 grafted queen cells, according to weather conditions. At the peak of the season 8000 nuclei are in operation.

The characteristic of the method is the confinement of the queen to a single brood comb in the centre of the colony. The queen compartment has queen excluders with large surface on both sides and a tightly closed bottom. On top there is a removable telescopic cover of metal. The entrance is open over the total width of the hive.

Every three days the comb with eggs is transferred from the closed queen compartment to the free accessible part of the hive and replaced by an empty comb. During regular rotation six combs of brood and one comb of eggs are permanently in the cell building colony. The arrangement of the brood combs and the two grafting frames can be seen in Fig. 104.

Course of queen rearing :

Day 0 grafting, grafting frame 1 into the hive body, next to the feeder

Day 3 grafting frame 1 to the other part of the hive, grafting of frame 2

Day 7 shift grafting frame 1, insertion of frame 3

Day 10 mature cells of frame 1 to the nuclei. Insertion of frame 4

Two bars with 15 cups each are on each grafting frame. This gives on the average 20—24 queen cells per colony every 3—4 days, that is about 6 queen cells per day. Using 36 cell building colonies, 200—250 queen cells can be produced per day.

Norman Rice uses a large hive body holding 12 standard frames. One compartment is separated for two combs of honey and brood for reinforcement, and for the automatic feeder.

As very strong colonies are needed, stronger than the 10 Langstroth combs can hold, the hive body is placed on a shallow super with 10 frames. Another shallow super with honey combs is placed on top. It may be tilted 90° to give access to the rearing compartment.

This arrangement of the nursing colony may be varied in different ways. Gretchen Wheen, Richmond N.S.W., for instance, puts the 12 framed hive body on the bottom board and a standard Langstroth body with tight frames and the feeder (on top) as super.

The rhythm of queen rearing is adapted as far as possible to the demand. Frequently it is suitable to work in a 7-day rhythm to do the same operation at the same day of the week. Thus one time grafting and rearrangement is done after three days, the other time after four days. Furthermore, for routine work, synchronising of the different operations is important. Gretchen Wheen shifts the brood combs of the queen compartment at each rearrangement one place ; thus the newly laid comb ends back in the queen compartment again after the hatching of the bees.

The rearrangement of the combs and the insertion of a new series are done at different operations so as to bring the freshly grafted larvae into an undisturbed colony.

The main advantage of this method consists in maintaining the quantity of brood on the same level during the whole season by confining the queen to a single comb for three or four days. Thus no swarming tendency will arise. Each comb has uniform brood of determined age. There is no time consuming search for brood combs of known age or for the queen, each operation can be synchronised to a large extent.

At the beginning of queen rearing, the colony should have at least six combs of brood. At first it is reinforced by transferring the egg comb of the queen compartment to another colony and adding a comb of sealed brood to the cell builder instead. Or by simply adding of additional brood combs. Near the end of the season, as soon as brood rearing activity decreases, the queen is released from her compartment — this is a further advantage to always find the queen on the same comb. This method proved good especially with the conditions of Australia with its unsually long rearing season (August-April) being bee saving and time saving and at the same time very efficient.

Also in this case it is evidently not yet quite clarified whether it is best to place unsealed or sealed brood next to the freshly grafted larvae. N. RICE holds the result of acceptance better in the latter method, while other queen rearers prefer to have unsealed brood next to the young queen cells (W. C. ROBERTS, see 3.3.2). According to BILASH

(1963), queens reared in between unsealed brood show better provision with brood food, a greater weight at hatching and a higher number of ovarioles than those reared between sealed brood.

3.3.5. Queen rearing in a double colony (Krasnaya Polyana)

In the U.S.S.R. queen rearing is concentrated in the South of the country. The most important centre is in the Caucasus Mountains in the valley of Krasnaya Polyana near Adler between the 43° and 44° latitude. The climate is relatively humid and mild, thus queen rearing can be started around 20th April. During the whole summer there is a sufficient flow of nectar and pollen. This allows extension of queen rearing until end of August. The queen rearing yards are distributed from the coast to high in the mountains. There are areas with pure bred selected strains to ensure controlled matings. A total of 135,000 queens was produced by the Queen Rearing Station Krasnaya Polyana in 1971 (RUTTNER 1971).

The nurse colonies are wintered in big hive boxes with three compartments, with 12 Dadant frames each. One colony is placed in each compartment. At the start of queen rearing, round 20th April, the queen is removed from the middle colony and the division boards separating the two lateral colonies are replaced by queen excluders. Thus a big queen rearing compartment with brood of all stages is created between two queenright colonies.

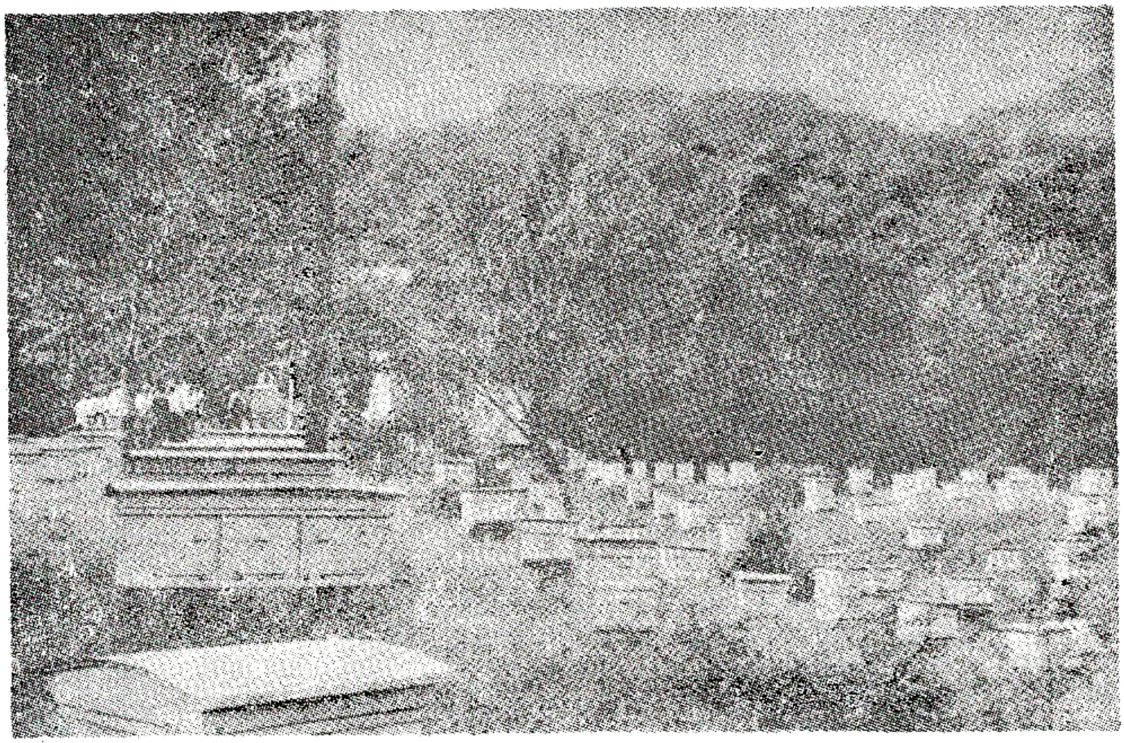


Fig. 105 — *Queen rearing apiary Krasnaya Polyana*

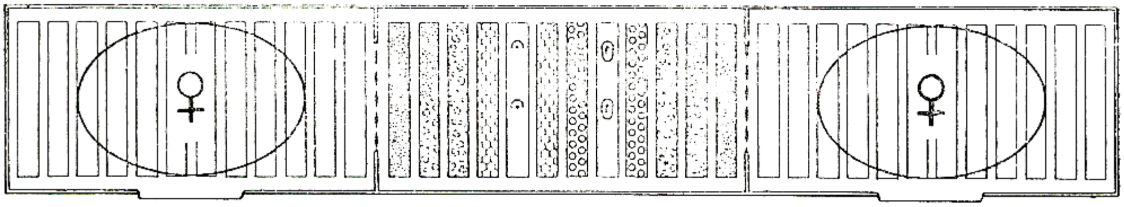


Fig. 106 — *Three strong colonies are united in Krasnaya Polyana in a way to obtain a common rearing compartment. Every 5 days open brood and a new series is added to this compartment.*

Here grafted larvae are placed between combs of unsealed brood. Five days later, as soon as the cells are sealed, a second series with freshly grafted larvae is added, again between unsealed brood (which is transferred, if necessary, from the two queenright compartments).

Again, 5 days later, the third series is started ; at this date the first series is mature and is withdrawn (in new experiments, however, TARANOV has stated that larvae next to sealed queen cells will develop to less perfect queens — weight, number of ovarioles — than with unsealed. The method described can be modified, however, by removing each series already after five days to have it finished in the incubator or in the super of a normal colony. For the sake of quality of the queens, not more than 18—20 larvae are offered at the same time for nursing. In one double colony, about 20 series are started during one season, one after the other (F. RUTTNER 1971).

The method of the double colony is practised also at other places (Bulgaria, Hungary, Poland, Cuba) though the results are not always favourably correlated with the expense necessary (J. WOYKE, personal communication). The reason might be perhaps that the method works well only with the Caucasian bee, according to the statements of the queen producers.

4. Appendix

4.1. *Rearing of queens and drones during the cold season*

There are regions in the tropics, e.g. in the North of Australia or in the South of Brazil, where queen rearing can be practised all the year round, if nececsary with additional feeding with pollen or sugar. St. TABER (1974) was able to show that queens and drones can be reared during the whole year even in regions with a pronounced cold season, provided that certain rules are observed.

It seems to be a pre-requisite for “queen rearing in winter” that the periods with weather where bee flight is not possible do not last longer than a few days. At Tucson, Arizona (32° North latitude) where Taber made his experiments, the mean temperature of January is 17.0°C. During the ten days around the turn of the year 1970/71 when the experiments were made the temperature was higher than 14°C. on five days. It is of little importance, as against this, that slight frost was recorded on two mornings and that the minimum of temperature was —8.8°C. in

January, because an important and quick rise of temperature occurs during the day by sun radiation.

Colonies not specially treated will nurse only a small amount of brood and only a few drones during winter. It is not the exterior temperatures that prove to be the decisive factor for the queen rearing tendency of the bee colonies at Tucson, but the conditions of nutrition, especially the provision with pollen. The number of drones and of larvae in the combs was used as criterion of the nutritional condition of the bee colony. The drone brood is the appropriate indicator that the bee colony is developed far enough and sufficiently provisioned with pollen and honey to rear queens. It is useless to start queen rearing as long as no drones are present.

The hypothesis was made that the disappearance of drones in autumn is not caused by such seasonal factors as the length of day, temperature etc., but only by the deficiency of pollen. Not only the quantity of pollen is of importance but also the position where the pollen is stored in the bee colony ; only stores of pollen quite near to the larvae have an influence on the nursing activity. This is why the colony should be supplied with combs which have small patches of drone comb in various places for drone rearing beyond the season — that is with combs discarded by a proper beekeeper. Moreover, holes are made into these combs to facilitate the passage of bees from one comb to the other.

The pollen provision is ensured by a pollen cake made according to the following receipt :

Pure pollen	1 kg
Water	220 ml
Sugar	1 kg

Three grams Fumidil are added in winter as a precaution against Nosema. The paste is placed as flat cake on top of the frames. If the paste is "moving" cellulose powder is added to make it dryer.

Strong colonies with at least 40,000 bees are used for nursing. Beginning in November they were continuously fed with the pollen cake. The daily consumption was 300—400 g.

Queen rearing was done during the months November-January, the cells being started in a swarm box, out of 240 larvae offered as nine consecutive series, 228 were accepted and 184 fed to the end. In February queen rearing was continued without pollen feeding as enough natural pollen was available.

To be sure the rearing season can be extended remarkably in areas with a colder and long lasting winter by methods similar to these — provided that there exist requirements compensating for the considerably greater effort and investment.

4.2. *The queen rearing methods of the "Big Ones"*

Queen rearing is very labour intensive. Everybody working commercially will endeavour to use expedient, rational methods, especially in consideration of the permanently rising costs of labour. The quality of the queens, however, is of equal importance as the costs of production. Only those who offer excellent queens will be successful in the long term.

Thus it is to be expected that the large queen rearing plants use methods to produce a high number of well developed queens with as low expenditure of labour, bees and money as possible. A survey of the methods used by these operations might give some useful information.

We know of five regions on earth with queen producers of a capacity of more than 10,000 queens per year.

1. The South of U.S.A. (Texas, Louisiana, Florida, Georgia etc.)
2. The West of U.S.A. (California)
3. Australia
4. Italy
5. The South of the U.S.S.R.

In 1969, W. C. ROBERTS and W. STANGER published the results of an enquiry of the producers of queens and package bees in the U.S.A. The result, based on the answers of 46 queen rearers with a production of 607,000 queens — about one third to one half of the total production in the U.S.A. — gives a realistic picture.

Common to all producers is the method grafting worker larvae to artificial queen cups. All queen rearers feed their colonies permanently, except for periods of sufficient yield. As to the rearing methods, clear regional differences can be seen. In California, two thirds of the queen rearers have the cells started and finished in the same queenless colony. The nurse colonies are strong enough to fill two standard hive bodies with ten frames each (4.5—5.5 kg bees and brood of all stages). These queenless colonies receive 45 cells to start every three days. Usually every three or every six days 1—2 combs of unsealed brood from other colonies are added. Thus a permanent use of the queenless colonies is achieved.

It the South of U.S.A., however, a closed swarm box as the starter and thereafter a queenright finisher are preferred. The latter get 25—30 cells every three days, and once a week two combs of open brood are moved from the hive body to the super.

In Australia and in Europe (frequently, however, also in the U.S.A.) the method of queen rearing in a queenright starter is used. The method is modified in different ways (see method Piana, 3.3.3. — method Lunz 3.3.1., method Rice 3.3.4., and method Roberts 3.3.2.). The number of larvae offered at the same time is usually below 20, but as every 3—4 days a new series is added and as the queenright colonies are self-sustaining throughout the season — not needing additional bees, the number

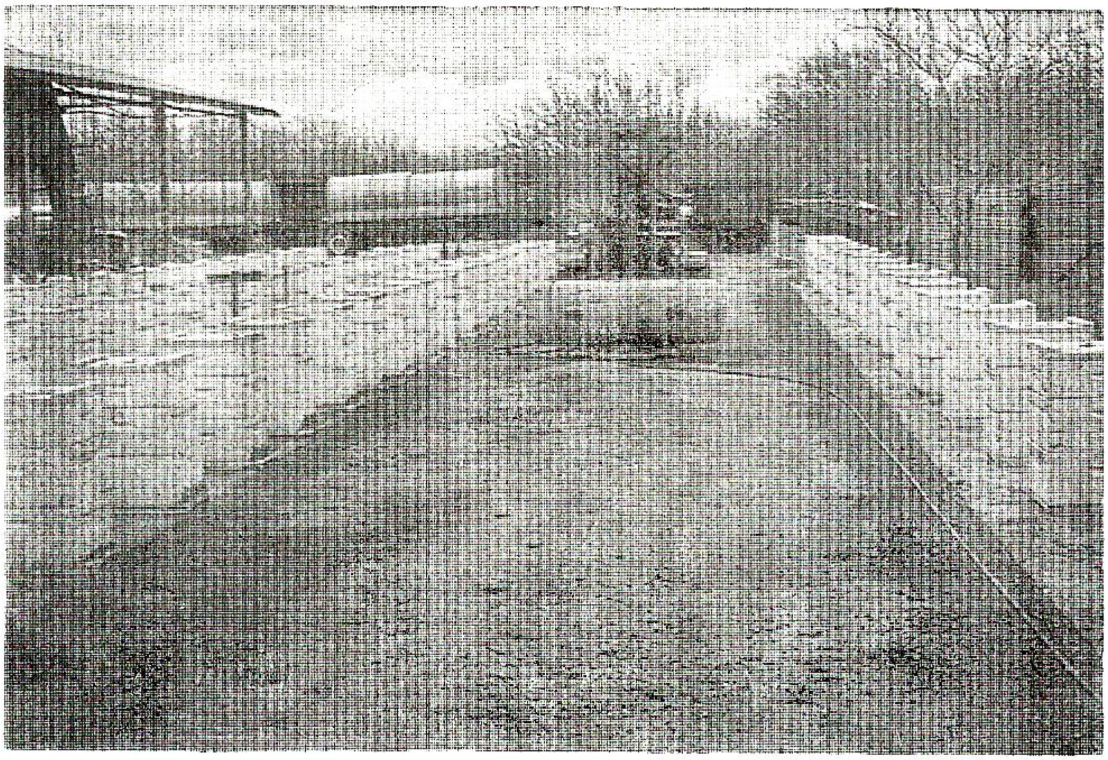


Fig. 107 — *Nurse colonies at the queen rearing apiary KOEHNEN (California)*

of queens produced per day and hive is not lower than with other methods.

Most of the queen producers are situated in the warm temperate, sub-tropical zone. Rearing season thus starts already in the late winter (and in February on the Northern and end of August in the Southern hemisphere) and the season lasts in general 3—4, in some cases however, even more than ten months. Only in Europe the rearing season is shorter as a consequence of the northern latitudes.

The average daily production per colony is between 4 and 12 queen cells, for most queen producers it is lower than eight, and many of them emphasise that they renounce a high degree of exploitation in favour of optimum quality.

This synopsis leads to a very informative statement : All the important methods — queen rearing in a queenless and in a queenright colony, starter box, separate start and finish — have been known for 100 years, since the time of Doolittle. The local conditions and the demand decided which methods succeed in the long run. For the rush during a short period (as queens for bee packages in California) or in unfavourable external conditions (beginning and end of the season in Central Europe) the queenless colony is used, at least for the start. For continuous operation through a long period (Australia) and for Laboratories asking for maximum quality (as for selection and genetic research) queen rearing in a queenright colony has prevailed.

CHAPTER VIII

Maintaining queens during the mating period

H. RUTTNER

In the last chapter it was pointed out that the rearing of queens from young larva until pre-emergence is a biologically fixed process. When the necessary conditions are maintained, it is possible to program in advance the occurrence of specific events and production quantities.

The situation changes after the queens emerge. For each queen an individual colony must be made and she must complete her mating flights. This brings weather conditions into play and thus a factor of uncertainty which weighs heavier when weather conditions degenerate during the mating period. A large amount of effort is needed for stocking and maintaining mating hives. Queen loss during this phase (which always also mean a loss of bees, feed and labor) under good conditions is 20% otherwise up to 50%. In the U.S.A. it was found that the cost for mating queens was two to three times higher than that needed to rear them (ROBERTS and STANGER, 1969). In Europe the difference is even greater.

Each beekeeper tries in his own way to solve these problems. For that reason there are many different methods and equipment. But even in this phase there are general rules derived from the conditions under which each outfit works.

Before the queens emerge, they must be separated from each other. Either a queen cell is given to the hive in which the queen is to be mated or each queen cell is placed in an individual cage and later the emerged queen is given to the hive. Each method has its advantages and disadvantages. Thus it is worthwhile to study both. Queen cells that are allowed to emerge in a queenless hive are readily accepted. But one has to control two days after the emergence date to make certain that she has emerged. Also it is possible that the queen has body defects. In addition one cannot be completely certain that in the meantime a stray queen cell in the hive has emerged. Later it is very often difficult to distinguish between the real and "false" queens. In other words, it is not possible to be completely certain of the quality and origin of the young queen.

This uncertainty can be prevented by placing the queen cell in an individual cage and letting the queen emerge under constant temperature conditions — in a thermostat or hive. Before using the young queens can be inspected and individually marked. This method is mainly used where the quality and certainty of origin are important such as in controlled matings at isolated mating yards or in artificial insemination. In general it is more difficult to introduce queens than queen cells, at least in units that contain brood. For this reason queens are mainly utilized for small and large package bee swarms. Normally mating hives are requeened with queen cells. In any case methods will be described where colonies with brood can just as effectively be requeened with a queen as with a queen cell (IX, 4.2).

1. Types of mating hives

The size of the colony used for mating the queen varies widely from a normal sized colony to a handful of bees in a baby nuc. In normal normal sized colonies the newly mated queen quickly develops a large brood nest. But the loss is high if the queen disappears during the mating flights. Very small units require less bees and feed but under poor weather conditions they are difficult to maintain and often cannot be used again.

Transport weight is also important when utilizing distant mating yards.

1.1. *Queenless colonies of full strength*

Queen cells are used for production colonies when low labor input is necessary. If the introduction including the mating flight is a success, then a large broodnest will soon be built. If a colony is located close to other hives, a **30%** loss due to drifting should be expected. Drone colonies in mating yards are often dequeened so that the drones will be held longer. Later these colonies are requeened with another line to prevent inbreeding.

Most often queens are usually mated in smaller hives. In reality, in this area a large number of variations are possible.

Following the suggestion of H. LAIDLAW, we define the subsequent terms as follows in order to avoid ambiguity :

Small colony (division) : A hive with more than three standard frames (fig. 108, 109, 110).

Nucleus : Colony composed of one to three standard frames or two to four half frames (fig. 111, 112, 113, 114).

Baby nuc : Colonies on one to four small frames (fig. 117—126).

1.2. *Brood frame divisions*

Placed aside the general flight direction of bees nucs made with frames of brood can be made with few losses. When the mating is a success healthy colony can be obtained with little effort. If the division becomes queenless, then it is not wortwhile to requeen as the bees have become too old in the between time.

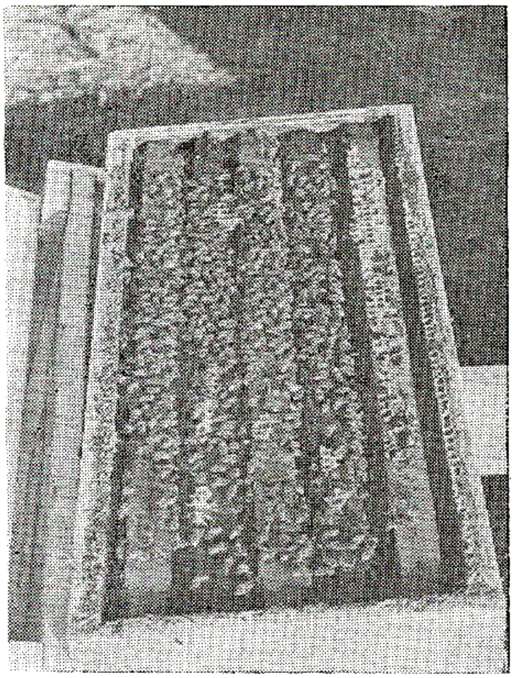


Fig. 108 — *When used as a mating hive a small colony composed of five standard frames requires many bees, but will however develop into a strong colony (photo LAIDLAW)*

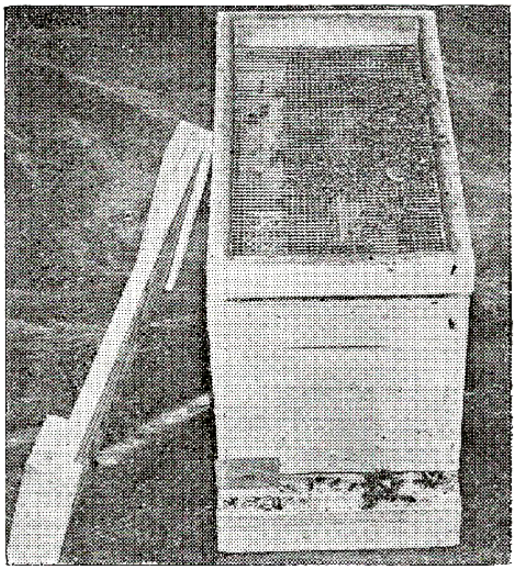


Fig. 109 — *Nucleus composed of 5 Langstroth brood frames with a screen feeding tray. The mesh openings are wide enough to allow the bees to easily pass through (photo LAIDLAW)*

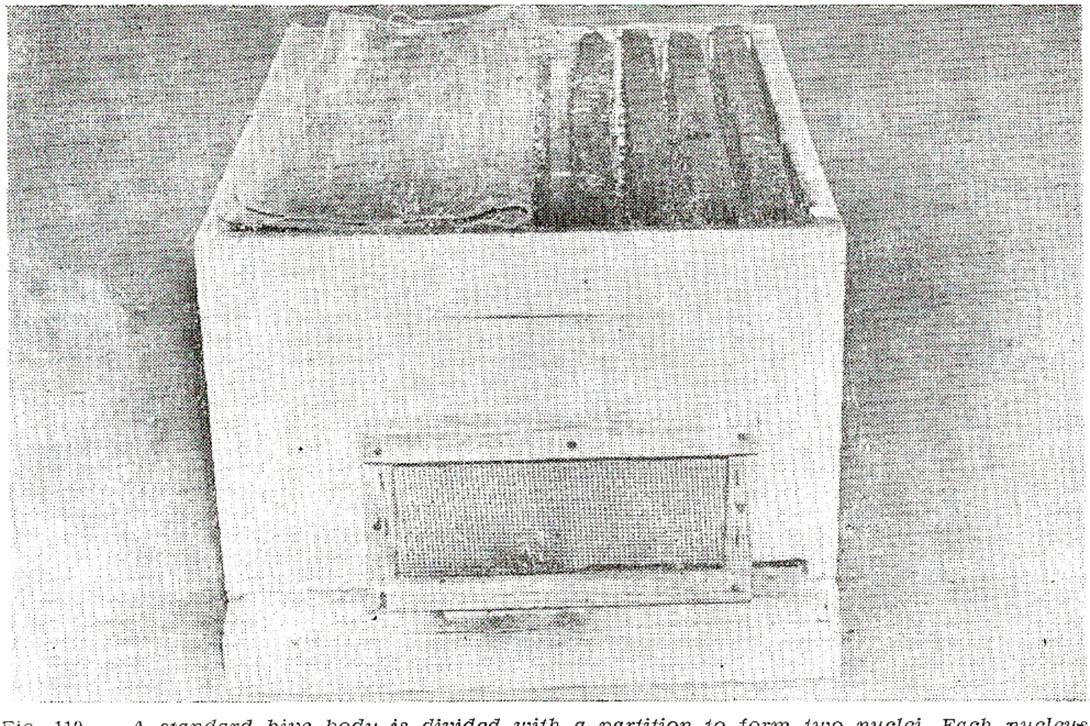


Fig. 110 — *A standard hive body is divided with a partition to form two nuclei. Each nucleus contains 4—5 frames. To prevent the entry of robber bees a screen is placed 1 cm from the wall of the hive. The flight bees enter at the lower bottom board entrance while the robber bees tend to search on the screen (photo LAIDLAW)*

1.2.1. **Dividing a hive**

The beekeeper with multi-story hives removes a super with bees, old brood and provisions. This super is then set back on the original hive with a bottom board, lid and a queen cell is pushed in. When the queen is mated, the two colonies are reunited. Such divisions, usually using a honey super, are often preferred when converting a pure breeding area to a specific race. They can be given a queen cell ready to emerge or even more economically, a queen cell that has just been accepted. After the queen is mated the division is reunited with the mother hive. After two or three years the process can be repeated with another breeding line from the same race. Then the pure breeding area can be left to itself for a longer period of time.

1.2.2. **Nuclei in standard frames**

A standard deep or shallow super is partitioned in the long way into two to four compartments. Each compartment has an individual entrance in a different direction and contains a brood, honey and empty frame, 1/2 kg of bees and a queen cell. After the queen begins to lay she is removed and utilized. This corresponds with the proceedure used for "babynucleus" which will be spoken about later. Twenty-four hours later a new queen cell is given or the whole nucleus used to requeen a colony. This is the advantage of working with nucs in standard frames. The introduction is simple and relatively certain. In addition the colony that is requeened is also strengthened. Building this type of nuc is simple, but a relatively large number of bees is necessary.

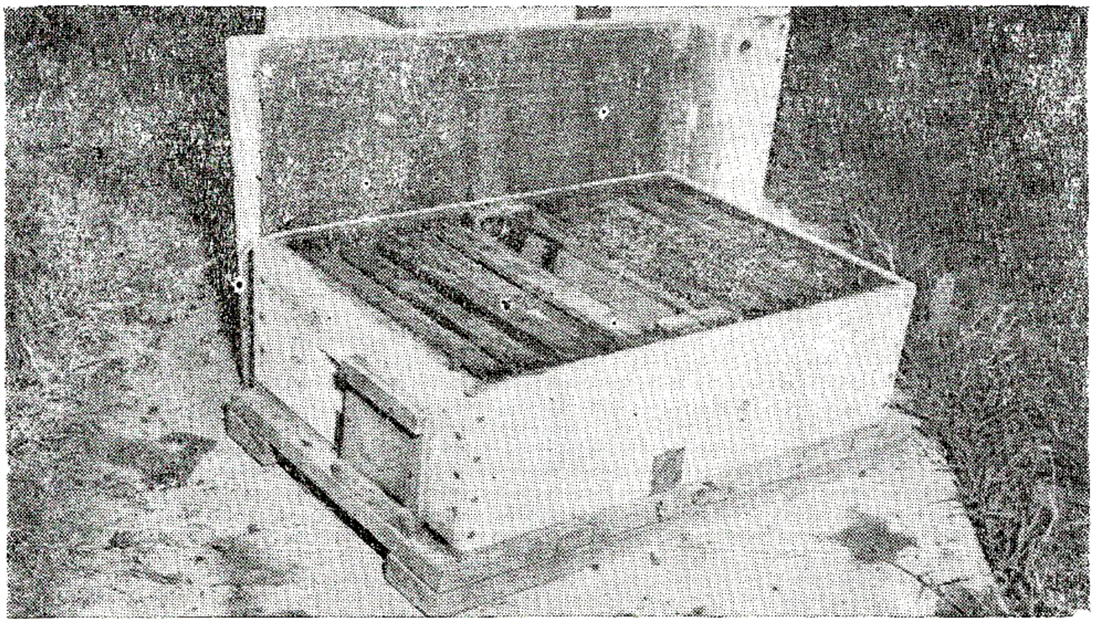
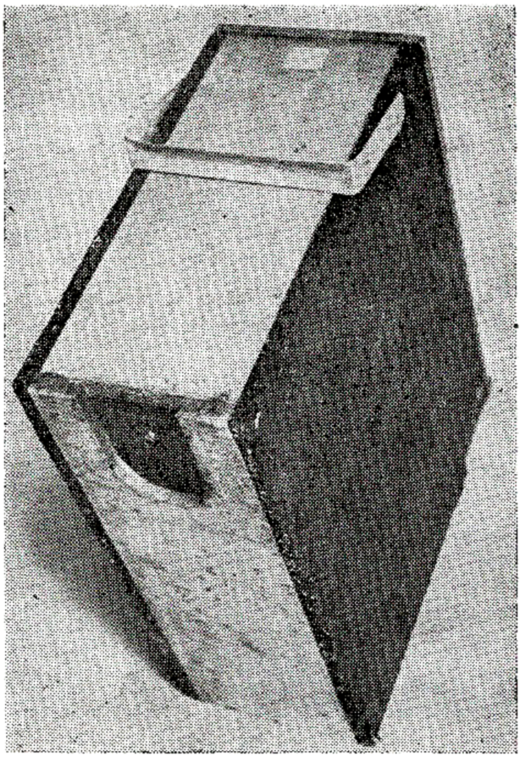


Fig. 111 — *It is more economical when shallow supers are divided and placed on bottom boards. On both sides of the partition there is a feeder for each nucleus. A robber screen protects the entrance without hindering ventilation (photo LAIDLAW)*

Fig. 112 — Nucleus box for 3 standard frames, excellently suited for transportation. The view from bellow shows a ventilation screen which can be shifted to open the entrance. When the metal handles are tucked up, they keep down the cover.



In the fall when the extra queens are removed, these nucs are reunited into a colony and overwintered. In the spring this colony is again divided into nucs.

1.2.3. **Individual standard 3-frame nuclei in light weight**

This is a modification of the multi-nuc system. It has the advantage that the small colony can be transported easier and is more versatile. Containers are utilized which are made out of bituminous impregnated insulation sheeting which hold three frames and a feeding chamber. But they lack of course, the heat economy features of the larger partitioned multi-nuc.

1.2.4. **Nuclei in vertically divided standard size frames (fig. 113, 114)**

The lodging of young queens in small colonies with divided standard frames has been used for many decades. When three to four small frames are used, a cubic shape is formed in which it is easier for the small colony to regulate its temperature.

Colonies on two standard frames in a long nucleus with only one bee space will vegetate whereas the same number of bees on four half frames in roughly a cubic shape and three bee spaces will develop splendidly even under poor conditions. Mating hives with only one single frame require much insulation (protective covering) while nucs composed of two half frames can be maintained throughout a whole season producing queens successively.

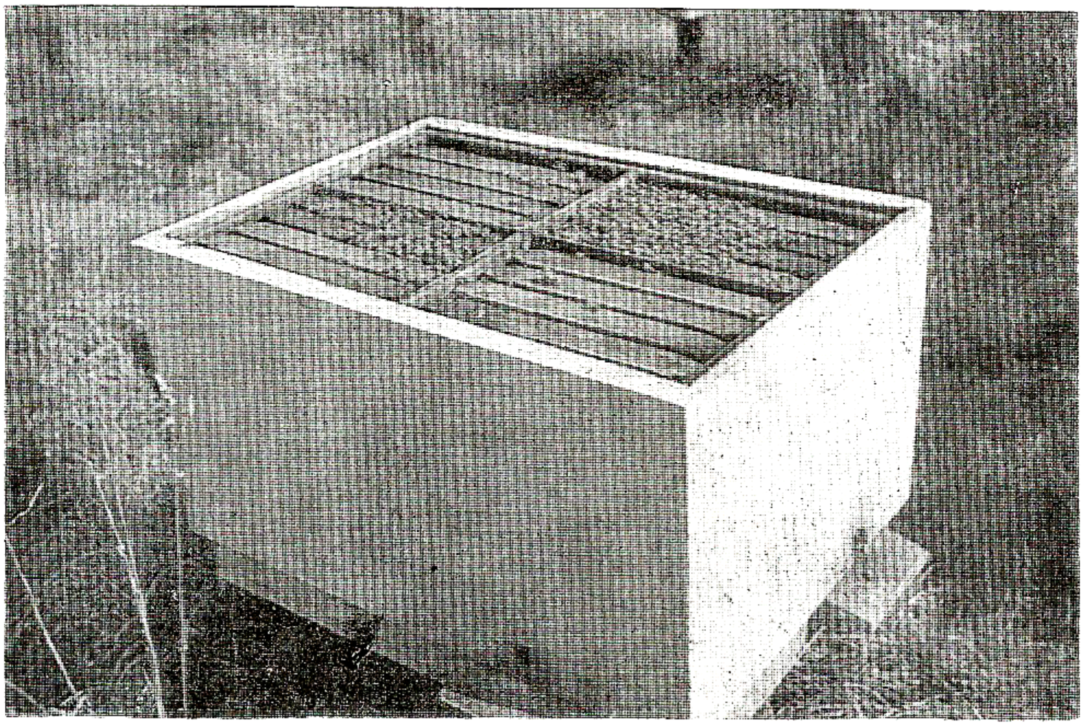


Fig. 113 — Whether the standard hive body is divided vertically in two halves (as in the picture), then four frames will not occupy a space of cubic shape. Brother ADAM unified 4 nuclei in one hive body, with the hive entrances facing four directions.

It is for this reason that many of the beekeeping operations from which we obtained our information work with this type of nuc (Br. ADAM, G. PIANA, N. RICE, R. WEAVER, Krasnaya Polyana).

Frequently the half frame nuclei are placed in groups of four in large boxes with square base. The interior of the boxes is divided in four compartments by crosswise inserted boards. The flight direction is to four sides (fig. 113). In many cases the four colonies are arranged in a row within a longish box, with entrances also to all four directions. According to TARANOV the mating results decrease if more than four colonies are united in one block.

Twin boxes holding two nuclei are very frequently used especially in larger plants (PIANA, WEAVER). Handling and transportation are easier in this type.

Roy WEAVER describes the nuc boxes used in Navasota as follows: "Boxes are divided into two compartments. Each compartment contains three half frames (Shallow Langstroth) and a feeder with an interior dimension of 32 mm. The box has a single lid which serves as a cover for both compartments. A 12 mm hole which can be closed serves as an entrance on the front right and back right sides. To work the boxes easier they have 25 cm long legs. Raccoons are a problem as they tip over the boxes and eat the contents. Losses often reach 100 boxes in a single night. For this reason the boxes are nailed to a stake and the lid fastened on with a heavy rubber band".

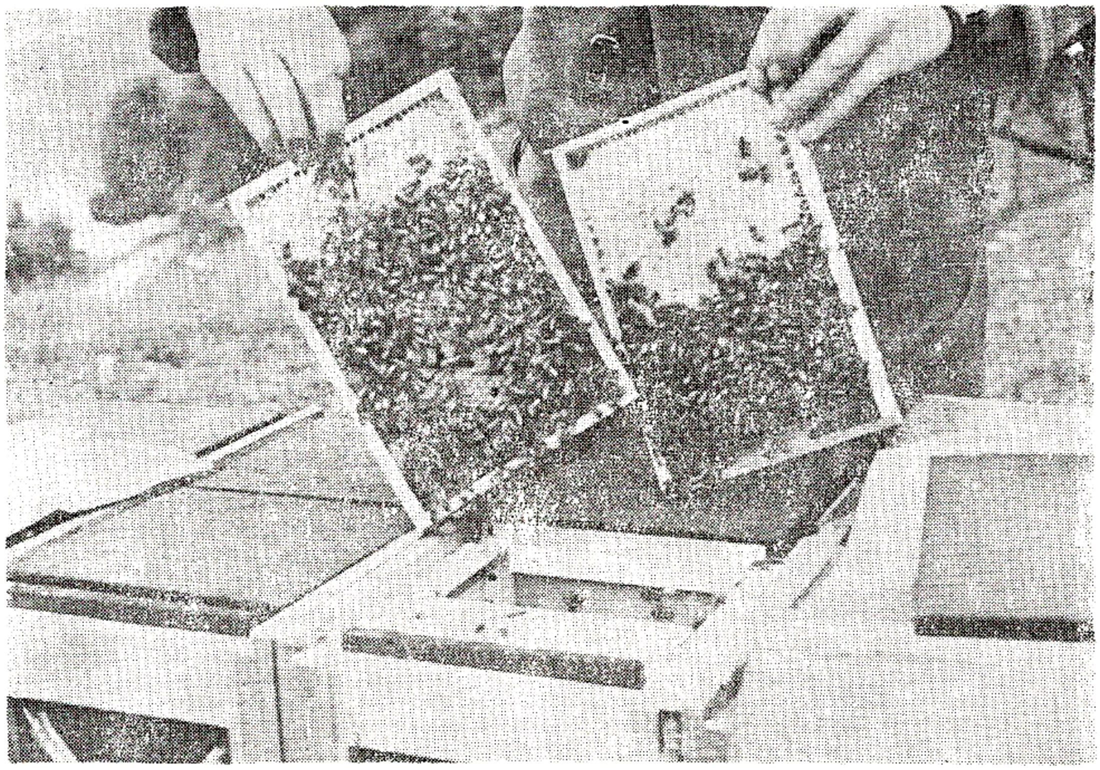


Fig. 114 — *Two half frames with brood that can be easily held together with a U-shaped heavy wire clamp when...*

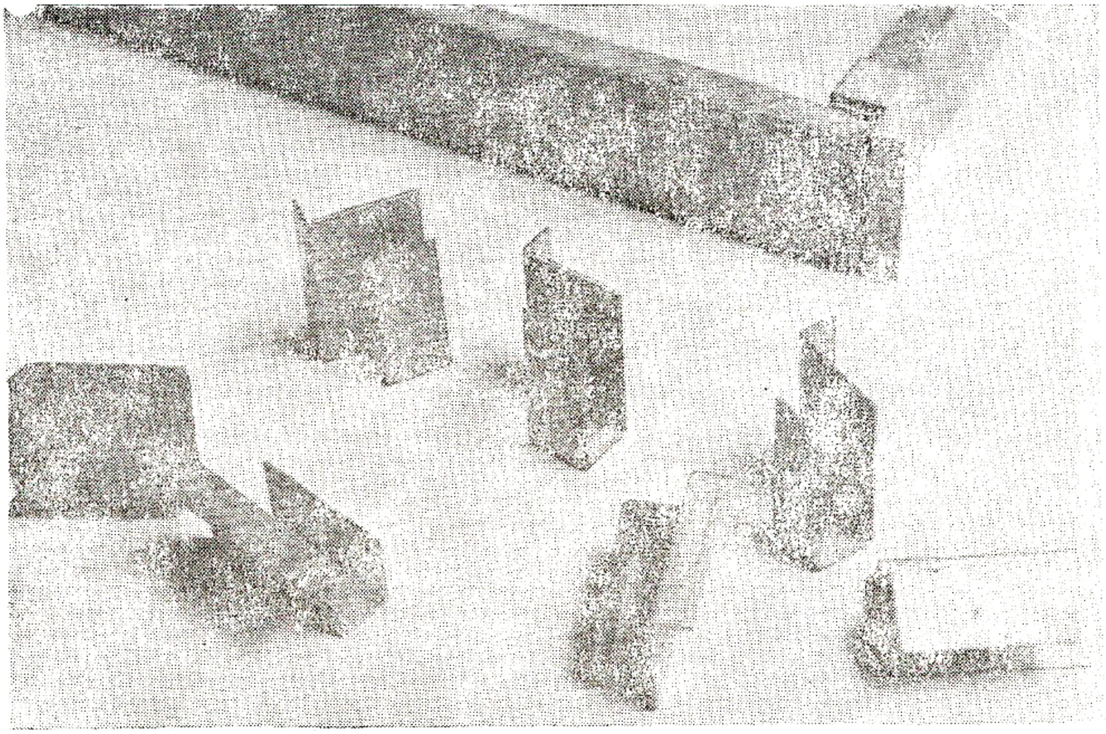


Fig. 115 — *... when attachable frame ears are utilized.*

The ideal strength for stocking a nucleus is a well filled frame of sealed brood thickly covered with bees, a honey frame and an empty frame (or foundation). The advantage of using half frames (and not any arbitrary size) is that they can be fastened together and placed in a normal hive. This way brood and food frames can be obtained from which nuclei can be made. The half frames can be held together with simple wire clamps and by using removable ears (fig. 115). A simple idea from Romania illustrates how two normal half frames can be attached together (fig. 116). It is possible to obtain many brood frames from nucs that have been overwintered from the last season. At the end of the breeding season in summer all the queens are removed except one and the united colony is overwintered in a locality with a favorable climate and good development. When the nucs used are composed of only two or even one half frame, whole groups of these frames are united and overwintered in a standard hive. In spring these colonies are split apart again. Of course they need longer time to develop and so for that reason, for the very first nuc colonies it is better to fall back on normal colonies.

The stocking of nucs will be covered in detail later (2.3.1.).

1.3. *Baby nucs*

In general, any container in which combs can be built and that can hold a few hundered bees can be used for mating a queen. The simplest and at the same time cheapest is a styrofoam flower pot (diameter 16—18 cm). A piece of wax foundation is attached with wax to the bottom and a clump of sugar candy is placed beside. Then a dipper of bees and a queen is tossed in and the opening closed with a cloth and rubber band. The pot is turned upside down and held for three days in a cellar (air coming in through the cloth). The nuc is fed again as it is placed outside by simply putting a clump of candy on the bottom board (fig. 117,

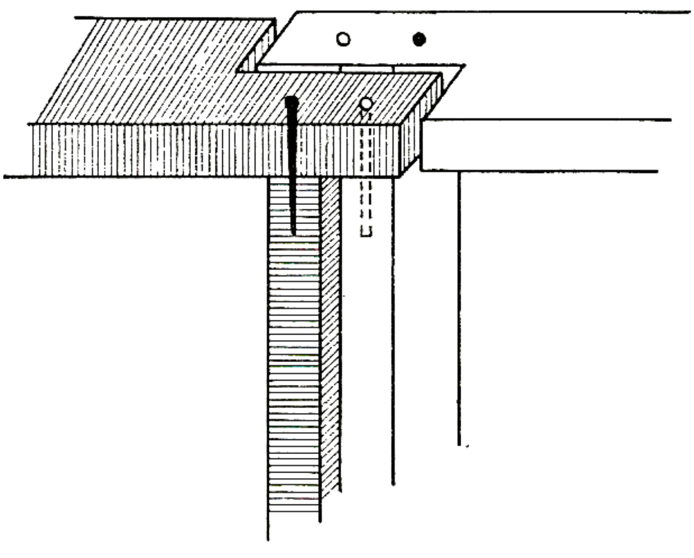


Fig. 116 — . . . *or when as in Romania the frames are pegged together.*

Fig. 117 — *A simple mating hive from a styrofoam flower pot. A clay pot is used to protect from wind, weather and sun.*

118). Styrofoam is a good insulation but in the blazing sun the colony easily deserts. A successful remedy is to place a clay flower pot over the first. This also adds extra weight to hold the nuc down. The queen is utilized together with the bees : the flower pot is simply placed on the queenless colony.

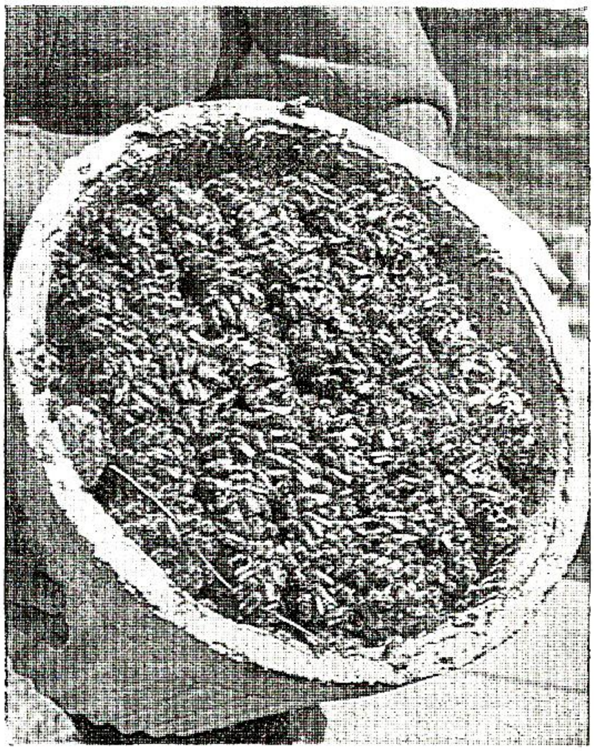


Fig. 118 — *A nucleus in a flower pot seen from beneath: the bees apear to be all right.*

1.3.1. **Wooden 3-comb nucs**

Large producers often use boxes containing three small frames and a feeding container. H. H. LAIDLAW described the most common type as follows : A typical nuc is 145 mm deep, 122 mm wide and 145 mm long (inside dimension). Sides, bottom, and lid are 1 cm thick wood. Before the entrance (a 10—15 mm hole closable with a sheet of metal) is usually a 2 cm wide landing board. On the rear side is a screened 25 mm hole for aeration.

The nuc contains three frames, 25 mm high and 100 mm wide plus a feeder. Usually a tin can of the proper size (eventually bent if necessary) is utilized after being coated inside with wax or paint. Floaters are usually made of wood, cork or styrofoam. Some use a wire screen as a ladder for the bees. A very effective method is to pour shellac or paint into and then out of the feeder. Then clean sand of a middle sized grain is shaken around inside. This gives a rough surface on which the bees can hold on to even when wet. If a floater is placed in at the same time one does not have to worry about drowning.

With various modifications, nucs such as these are found in many countries. Often the frames are attached to the lid so that with one movement the whole colony can be pulled out and inspected. This is the classical Swiss mating hive developed by KRAMER (KOBEL, 1974, p. 468).

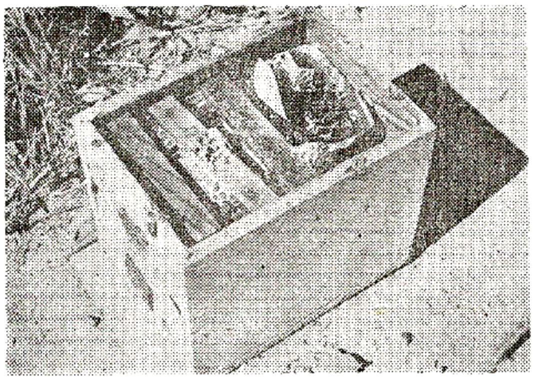


Fig. 119 — *A three frame mating hive with a tin can feeder*

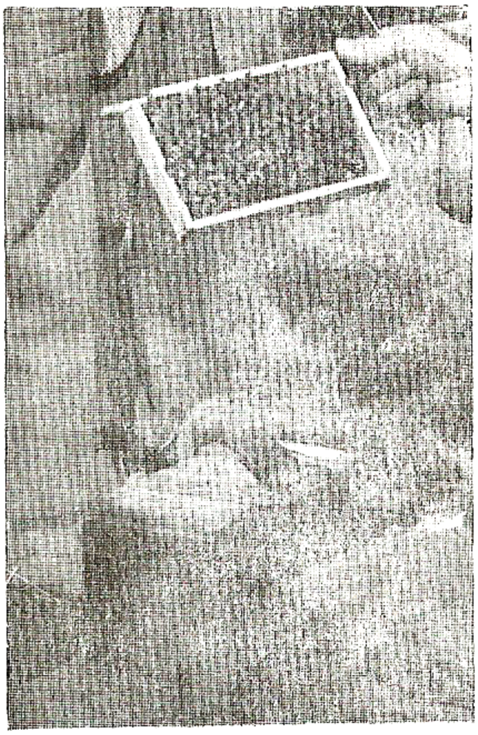


Fig. 120 — *More mating nuclei in one hive body are also used at Piana apiary (Bologna, Italy). A sac cloth hose is seen on the cover — the smoking device.*

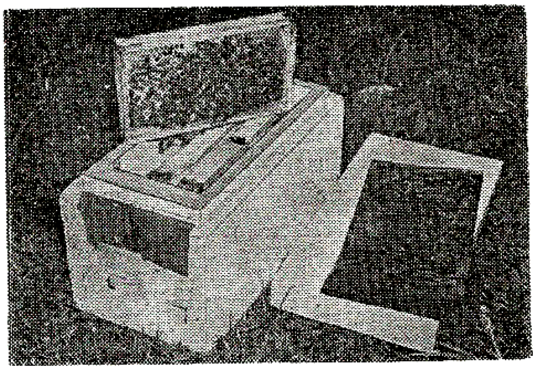


Fig. 121 — *Mating nucs from soft styrofoam as used in Austria. To prevent damaging by bees the interior is covered by a hard surface. The food chamber is suited also for sugar syrup.*

1.3.2. **Mating hives out of styrofoam**

A very promising development in the last few years has been mating hives out of styrofoam. This material is light and curbs the loss of heat so that even in cold climates not more than 110 grams of bees are necessary to fill it. Because styrofoam absorbs no water nucs can be placed on the ground even in very rainy areas. At the present time there are two types in use :

a) Austrian styrofoam nuc : The outside hull is out of soft styrofoam with an inside shell of hard plastic, weight 650 g, the three wooden frames 210 × 106 mm, food chamber for 1 kg candy (fig. 121).

b) Kirchhain mating hive (MAUL, 1971) : This is also out of styrofoam but pressed so hard that an inner wall is not necessary. The combs are built on only four flat top bars (170 mm). Because the walls slant combs are not fixed to the side walls. When the food chamber wall is removed there is room for six combs.Inside measurements: 150 l×160 w× 110 h (fig. 122).

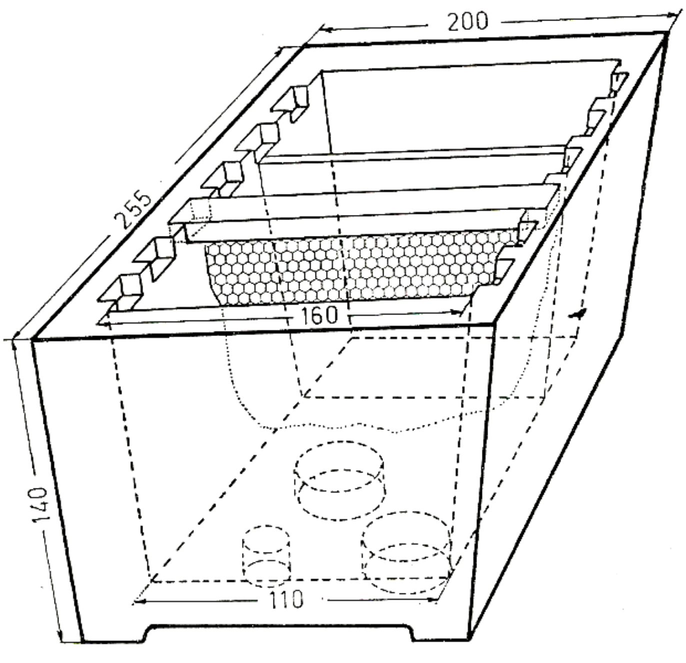


Fig. 122 — *In Germany the same styrofoam is moulded harder and thus not attacked by the bees. In the Kirchhain mating hive it is interesting to note that the internal dimension at the bottom is about 50 mm smaller that at the top.*

The entrance and aeration is incorporated in the bottom. The incorporated feet form a flight canal which protects the entrance very well. The Kirchhain mating hive was developed for storing inseminated queens. It is well suited for mating where positions are not often changed. Long transport may result in comb breakage.

1.3.3. Single frame nucs (German EWK)

Because of practical conditions in Germany and Austria a small single frame mating hive was developed. The glass pane walls of this nuc allow inspection for freedom of drones and for egg laying without having to come into direct contact with the bees. One dipper with 110 g of bees is used for filling. A small chamber containing space for 550 g of candy is located above the frame. Often starvation occurs when mating is delayed. The so called EWK in West Germany is standardized and has the following exterior dimensions : length 220 mm, width 55 mm, height 230 mm. The entrance can be closed with a round turnable metal disk. This disk contains two openings (fig. 124). The smaller acts as a queen excluder when placed over the entrance and lets only workers through. The larger opening also lets the queen fly. This tested system

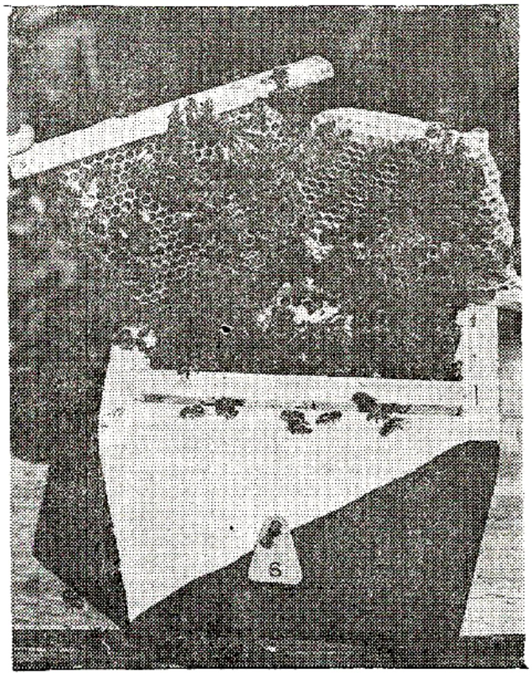


Fig. 123 — The freely built combs in the Kirchhain mating nucleus are not attached to the inclined walls of the nucleus and for this reason frames are not necessary.

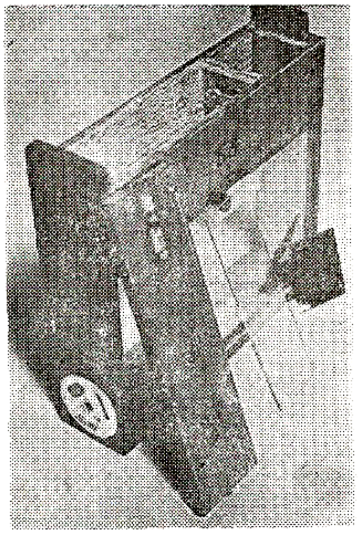
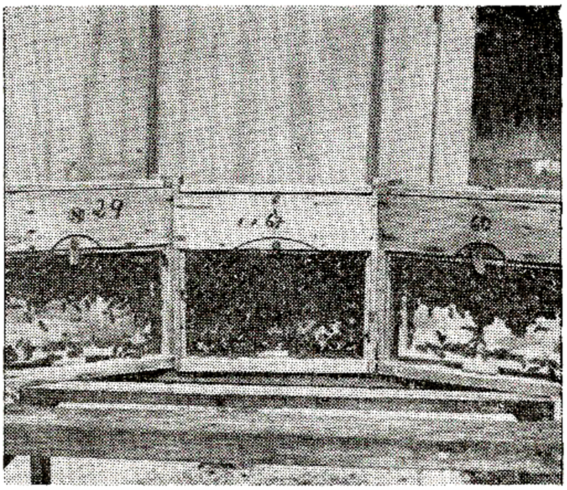


Fig. 124 — The German single frame nucleus (EWK) has a long glass covered feeding chamber at the top plus an ascending chamber. The frame which is not shown in the picture can be observed on both sides through glass windows.

Fig. 125 — *The frames of these single frame nuclei have a 2 cm wide band of foundation attached at the top. The frames are not built out because the nuclei have just been filled. Number 29 on the left contains 75 g of bees and is too weak. The nucleus in the middle (number 67) contains 250 g of bees and is too strong. It may suffocate during transport. The nucleus on the right (number 60) contains 110 grams of bees and is filled correctly.*



can naturally be used with other nucs. Air enters through a bottom screen.

The EWK is at technical disadvantage under both high and low temperatures. When temperatures are extreme bees leave the comb. When it is cold they cluster in the food chamber or swarm away when hot. For that reason EWK's are usually placed in groups of two in well insulated protective housing.

In Austria the standard interior dimensions of these are 244 mm long $\times$ 144 mm wide $\times$ 260 mm high. The flight entrances are on the right side when viewing from the interior.

Handy screened transport cases exist that hold six EWKs. Thus it is easy to ship them by train or boat to the mating yard.

Small EWKs: Looking for smaller and more economical mating hives, PESCHETZ (1954) developed a small EWK with a 12 $\times$ 12 cm frame. A small introduction cage is bored into the approximately 2 cm thick top bar.

At the Bayerischen Landesanstalt für Bienenzucht FRANZ developed the small Erlangen EWK (fig. 126) which is now widely used in that area. To be successful with this EWK, it is important that four such nucs are maintained in a well insulated protective housing (BOTTCHER, 1963 ; p. 136).

These frameless nucs with a bee cluster space of only 11.5 $\times$ 10 $\times$ 4 cm and a food chamber of 6.5$\times$10$\times$4 cm have proven to be better than the larger EWK. Only 50—60 grams of bees are required. Of course for each subsequent queen it must be restocked again.

The EWK is a fully-developed construction. Perfect for transportation over long distances making possible the often long and difficult transport to isolated mating yards. Also it is simple to control due to its visibility.

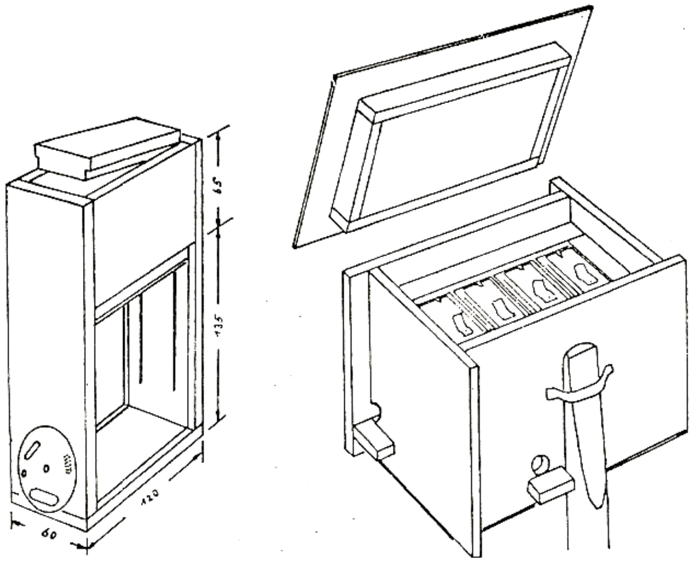


Fig. 126 — *The exterior dimensions of the Erlangen mating nucleus is 120 × 200 × 60 mm. This dimension is supposed to function better than the larger model on condition that the nuclei are maintained in groups of four in a protective case, well insulated at all sides. A flight entrance is located on each side (after Böttcher).*

1.3.4. **Larger or the smallest mating hives possible ?**

Only larger units can be maintained continuously throughout a whole season rearing queens one after the other. For this reason they are found where a long breeding season is necessary and where it is wished to hold queen in nucs for longer periods (Institutes, Br. ADAM). Here the greater investment in feed is worthwhile. Small nucs can be built quickly and at a low cost but are ment to be used for a relatively short season. For this reason, they are favored by breeders who produce queens for package bees (California) or in situations where they must be transported a long distance.

2. Stocking and maintenance of mating hives

2.1. *Preparation of mating hives*

All breeding work encourages the development of Nosema. For this reason it is important that each empty nuc be well cleaned every year. Afterwards they are washed with a 2% lye (NaOH) or for better protection with a hospital disinfectant. Empty frames are cut out. When good frames containing stores are to be used again, they should be stored in a closed recipient containing vapor of 60—80% technical glacial acetic acid. These vapors kill both Nosema spores and wax moths. The empty frames are not completely filled with foundation but with a 2 cm wide band.

2.2. *Food needs of the mating hive*

Small nucs can only maintain themselves when there is a good honey flow. For that reason they must have enough provisions to last to the first check. The feeding procedure should not encourage robbing.

2.2.1. **Capped honey frames**

The best way to feed every nuc is to give it a frame of honey. In the fall we arrange the best frames in shallow supers, shake in the bees from the disbanded mating hives and feed a sugar syrup containing Fumidil B. During this period the last brood emerges. Then the food frames are removed and handled as in section 2.1. and stored until spring. The bees wear out quite fast and it is scarcely worthwhile to overwinter them.

The small colony will not have any feeding problems even in cold weather when there is a honey frame. In an unfavorable situation the colony must be fed at the first check.

2.2.2. **Liquid feeding**

Sugar syrup feeding is usual in nucs with more than one frame. A thick syrup must be used so that good comb building will take place. Appropiate measures must be taken to prevent the following disadvantages :

a) moisture condenses at night on smooth surfaces (metal, plastic) and bees slide into the feed and drown : the feeder must have a roughened interior with a floater (see 1.3.1).

b) syrup can be shaken out during transport : estimate amount of syrup.

c) thin syrup may go sour : Take two parts sugar to one part water.

d) higher robbing danger than by all other types of feeding : we give a honey frame first and then feed with syrup at the first check. The comb is built out by that time and the syrup is quickly stored. Fumidil B (see 2.2.6.) is included in the syrup.

2.2.3. **Dry sugar**

Recommended by LAIDLAW (1962) against robbing, but only in warm humid climates.

2.2.4. **Sugar candy with honey**

For small nucs it is especially current to utilize a mix of honey with powdered sugar (which easily becomes hard and therefore not storeable) or granulated sugar.

Preparation : three parts of fresh warm stored powdered sugar is mixed with one part runny honey. Thick honeys can be diluted but not more than with 10% water. Otherwise a hard crust will form.

Honey : sugar syrup that has been fed to colonies and stored is suitable. This type of "honey" cannot be consumed because it is from sugar. Because of the danger of spreading disease, cheap honey of unknown origin should never be used. Nosema spores can be destroyed by a short heating of the honey. Foulbrood spores however cannot.

To *knead* the dough a bakers kneading machine can be used. Cheap cement mixers with two blades work just as well. In a 140 liter machine a load of 50 kg sugar with 15—17 kg honey can be mixed.

At the end either more sugar or honey must be added so that the dough is soft and plastic but not sticky when pulled.

To reduce the work load during the breeding season, it is best to place the warm candy in the nucs one to two months in advance. Before being utilized in summer, the surface of the candy must be checked to make certain that it hasn't been changed during storage. If a crust occurs, thinned honey should be brushed over the surface. When sticky then dry sugar is strewed on.

Small amounts of candy can be kneaded with the hand. Larger amounts from 20 to 30 kg should be placed in a low tub and mixed with a garden spade for about 20 minutes (BÖTTCHER, 1963 ; p. 103).

Candy is usually stored in containers with inclined sides from which it can be easily tipped out. If the containers shape conforms to that of the feeder, chunks that can be directly placed in the feeder can be cut off (MÜLLER OLE, 1954). Another very practical method is to store the candy in plastic sacks. Under these conditions candy doesn't change.

2.2.5. Candy made with invert sugar

Invert sugar can be used instead of honey out of economic or hygenic grounds (for instance American foul brood in stored honey).

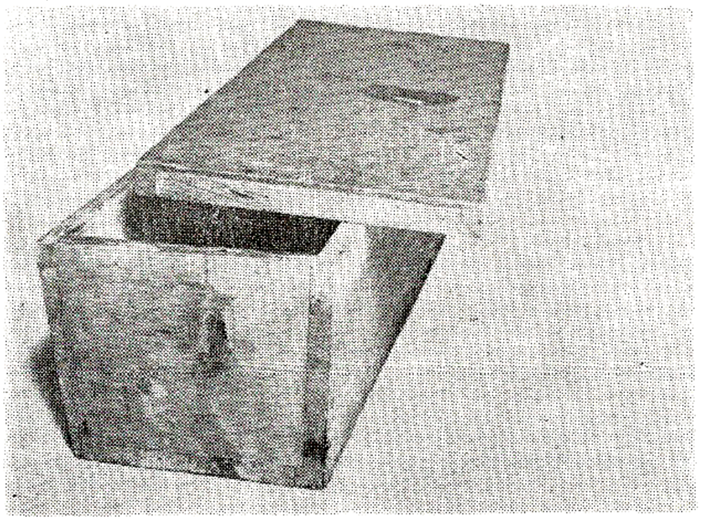


Fig. 127 — *Boxes used for storing sugar candy should have inclined sides so that the candy can be tipped out easily.*

This can be done by fermentation or by the addition of organic or inorganic acids.

a) Acid inversion

The pharmaceutical industry produces as a waste product an invert sugar which under certain conditions contains large quantities of hydroxymethylfurfural (HMF), a poison to bees (JACHIMOWICZ, 1976). This product should not be used for candy. When fed during a honey flow it is readily accepted by the bees. However if the weather turns cold or rainy and the bees have only this candy to eat, they will starve near a full food chamber. They do not construct a circle of honey on the comb and often on the first nice day will abscond as a hunger swarm (RUTTNER, H. and JACHIMOWICZ, 1974). Every honey analysis laboratory is able to determine the HMF value.

However invert sugar that is made with lactic acid contains only a slight amount of HMF and thus is a good honey substitute. WEISS (1968) recommends the following receipt : 1 kg of sugar and 2 grams of lactic acid are added to 1/2 liter water and cooked under a low heat for 30 minutes. Then 1 kg of this syrup is kneaded into 3 kg of sugar. The resulting candy remains soft enough to cut for months. If it is necessary to store the candy, the amount of lactic acid can be reduced to 1 or 0.5 grams per kilo of sugar.

b) Enzyme reaction

For years an invertase enzyme produced syrup has been used in Scandinavia (MÜLLER OLE, 1954). The preparation requires several weeks at 35°C. Now the process is much simpler and quicker. For instance, bakers use a product (Invertin) sold in 1 liter bottles by the MERCK Company (FRG). According to WEISS (1968) 1 to 2 ml of Invertin diluted in 80—100 ml cold water is kneaded into 1 kg of powdered sugar to make candy. This candy is somewhat drier than honey candy but remains plastic and does not form a crust. Opened Invertin bottles must be kept clean and stored in a refrigerator. Invertin is not harmful for either bees or man (WEISS, 1977). In practical experiments no difference was seen between honey, invertin or lactic acid syrup candies.

Several sugar companies (Frankenzucker FRG for instance) produce a feeding candy sugar that is mixed with a dry enzyme. To make the candy, only water need be added. Isoglucose syrups (such as Apireve) are also good for making candy. However not all corn starch sugars can be used.

2.2.6. **Sugar candy with Fumidil**

Mating hives without exception are menaced by Nosema. For that reason it is recommended and in some countries (Austria) required that Fumidil be mixed in the candy. The contents of a bottle of Fumidil B (25 g) are first added to about 1 kg of sugar, mixed and then this dry mixture mixed with 12 kg powdered sugar before the honey is included.

2.3. *Bees*

The bees used to fill mating hives must be healthy. Some breeders run into problems because they shake bees from colonies that are not good enough for honey production. The result is a high loss rate and short lived Nosema infected queens. The excrement of these queens infects their colonies and the vicious circle is closed.

The bees should be 1 to 21 days old such as those found on the brood frames. As a rule of thumb the quantity of bees necessary for a small mating hive is the following: the number of bees on one frame of brood will produce one small swarm. This must be taken into consideration when breeding. Bees from queenless starters are used first, afterwards bees from strong colonies with a tendency to swarm.

Large units in standard or half frames can be built in two different ways: as small nucs with brood and bees or as artificial swarms, with bees only. Both methods, depending upon the existing factors can be utilized parallel to each other, even in the same operation. The small mating hives "babynucs" in contrast, are probably exclusively made with shaken bees and a queen cell or young queen.

2.3.1. **Stocking mating hives with brood frame nucs**

When mating hives composed of standard frames are utilized, then the method used is the usual one for making new colonies at the bee yard. The main worry is to have enough frames with sealed brood at the correct time. For three frame nucs, a frame of brood thickly covered with bees, a food frame and an empty frame are used. If necessary, more bees can be added. Since these nucs usually are allowed to develop into full colonies, they can be even stronger at the beginning.

More preparation is necessary when making *half frame nucs*. If one wishes to avoid the expense sand unpleasant job of cutting up brood frames, then full drawn combs with capped brood should already be available by the time the first series of queen cells are ripe. For this reason breeders (G. PIANA, N. RICE and R. WEAVER) give such frames to strong colonies to breed in. A large part of the half frames with brood and honey can be obtained from colonies that overwintered on nuc frames (see 1.2.4.) grouped at the end of the last season. Normally however such colonies are ready to be split in an economic way only two to three weeks after the first nucs have been made. For better acceptance of the queen cell, it is best that the queen be removed one to two days before the split. To build a nuc frames with bees are removed and placed individually in each nuc. A honey frame and feeder are added. Most breeders work with two frame colonies. If the frame does not have enough bees or brood then the required amount of shaken bees is added. Thus in addition to brood frames it is necessary to have a supply of bees. The strength of nucs built with brood frames will not be so even as that of nucs built with bees only.

The amount of bees and brood must be taken into consideration when stocking as these nucs will be utilized for queen production and not for forming a hive. Thus they should only be strong enough to keep their strength through five or six mating cycles. When nucs are made stronger than necessary, bees and time are wasted. Finding and catching queens is quicker in a small hive than a strong one.

After the brood frame and honey frame are placed in the box and the feeder is filled, a queen cell is pushed in the brood frame 2—3 cm below the topbar. The frames and feeder are then pushed together in the correct position and the box closed. In a large breeding operation where several hundred nucs must be stocked every day five people are necessary for a smooth flow of work (place in brood frame, push in queen cell, place in empty comb and control of spacing, stocking with bees, filling feeder and closing hive).

The brood frames and bees are brought in from another yard to eliminate drift back to the original colonies. The entrance is opened the evening of the following day.

2.3.2. **Stocking nucs with bees only**

Shaking bees and building an artificial swarm :

It is best to shake bees for the mating hives in the forenoon when the bees are actively flying to reduce the amount of old bees. The fra-

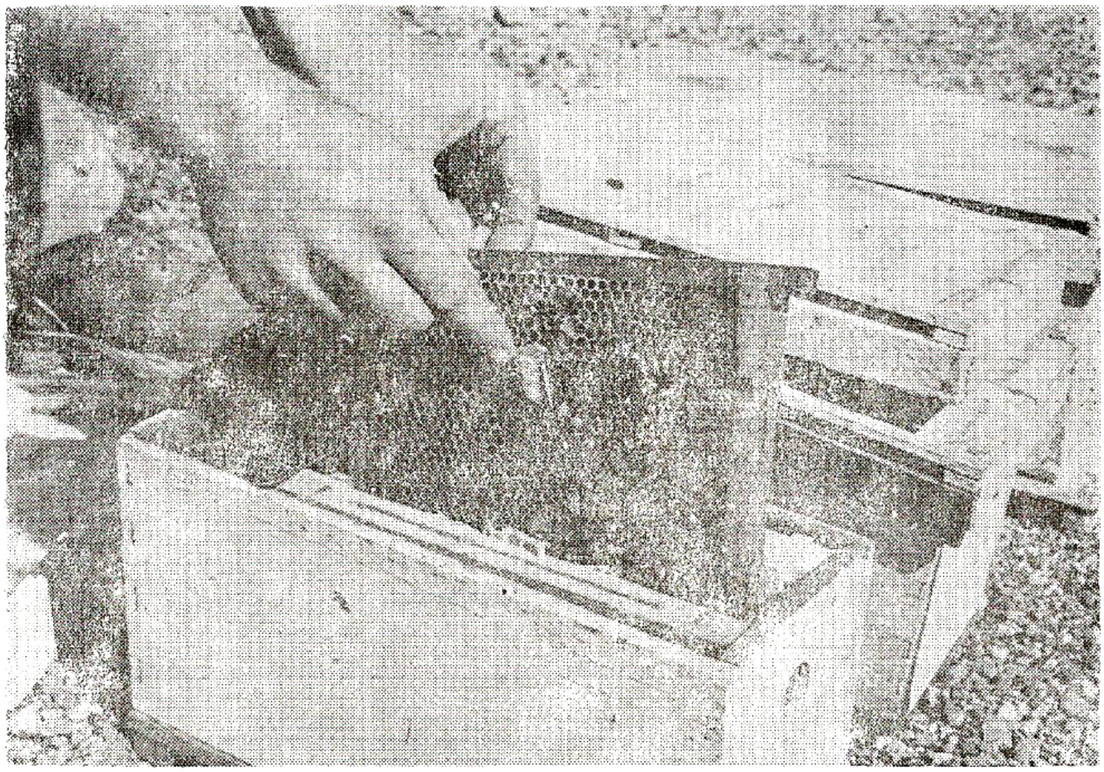


Fig. 128 — A nucleus is requeened with a queen cell especially when open brood is present. Note the double construction of the lid to prevent overheating.

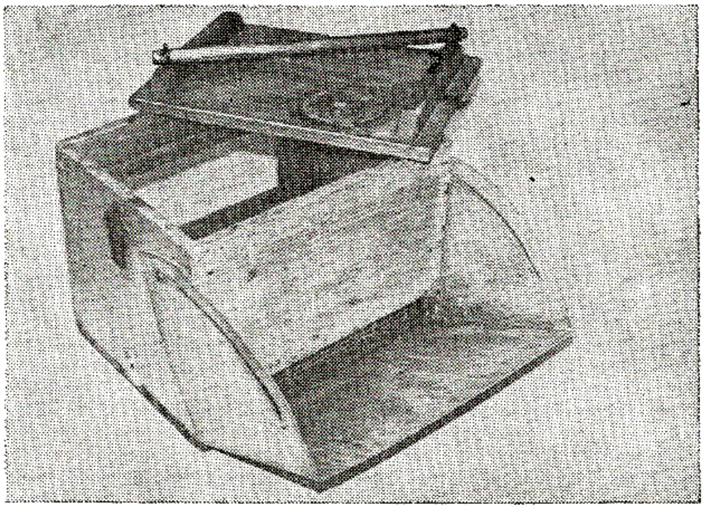


Fig. 129 — *The Marburg swarm box is utilized when small amounts of bees from several colonies are to be collected. All drones and most of the older flight bees return to their hives. Queens which are overlooked can be found on the queen excluder.*

mes that are to be shaken are placed in an empty super so that the bees can fill up on honey while the queen is being hunted. At this stage the bees are either brushed or shaken from the frame through a large funnel into a well ventilated swarm box. The work is done in such a way that most of the older bees fly away. For small shakes the "Marburg swarm box" works quite well. Incorporated into the side of this box is a queen excluder and funnel. As the bees fall into the funnel they separate. The young bees crawl through the queen excluder into the dark box while the older bees and drones fly back to the hive. Eventually the queen will be found on the queen excluder after the bees have passed through. Bees from several different colonies can be mixed this way without any danger.

The bees should not fill more than 1/3 of the box as otherwise they will suffocate. It is important that at this time the bees be fed with a thin sugar syrup and be placed in a dark room at 18°C so that they can quiet down.

Drone straining :

If the queens are to be brought to a mating yard, it is necessary that the drones be separated out in advance. When the bees are hanging quietly in the swarm box and are full of syrup, they are jarred to the bottom and a queen excluder shoved in from above (fig. 130). The bees pass through the excluder, the drones remain underneath. An empty super with a screened bottom can be used instead of the drone separating box. A queen excluder is placed on the screened super and a second super with a caged queen is placed on top to attract the bees through the excluder.

The bees are strained shortly before filling the nucs so that the drones are not imprisoned too long. Otherwise in time small drones may press through the excluder.

Fig. 130 — Up to 3 kgs of bees can be brushed through a funnel into this swarm box (300 × 300 × 300 mm). A queen excluder pushed in the top gradually forces unwanted drones to the bottom.

Filling the mating hive with bees :

In the late afternoon when the bees are full and cluster quiet after the midday heat, the required number of mating hives are placed out in the open but in the shade. A frame is removed or in the case of the EWK the glass window tipped out at an angle. If a ripe queen cell instead of an emerged queen is used, it is fastened in the center of one of the small combs or frames. B. KOEHNEN (Ordbend, California) uses a soldering iron for this purpose. At this time the lid of the swarm box or drone straining box is carefully opened and the cluster of bees heavily sprayed with water. If bees will not be fed syrup later on, then each portion of bees is sprayed. This way the bees remain quiet and drink water which they will urgently need in the next three to five days during the cellar holding period and transport. Of course if a queen cell is used, then the bees should not be sprayed too much so that they can quickly build a warm cluster around the cell (fig. 128).

A dipper containing about 200 cm^3 is used. It is convenient to use a dipper with one or two flat sides so that the bees can be easily scraped from the walls of the box (fig. 133).

When an EWK is filled, the glass plate must be immediately closed. Multiple frame nucs are more practical when filling one after the other because they can remain open until the bees have distributed themselves inside. Then the last frame is placed inside, the frames covered with a sheet of plastic and the nuc closed (fig. 132).

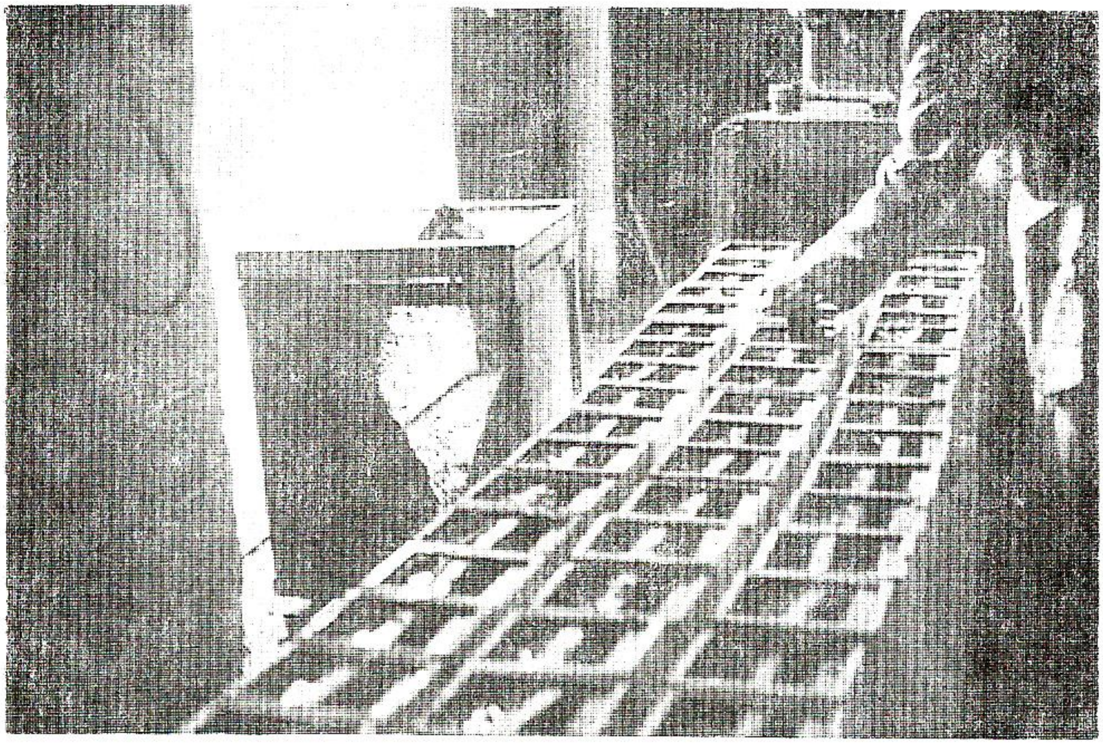


Fig. 131 — *Forming mating nuclei at the Koehnen breeding apiary at Ordbend, California.*

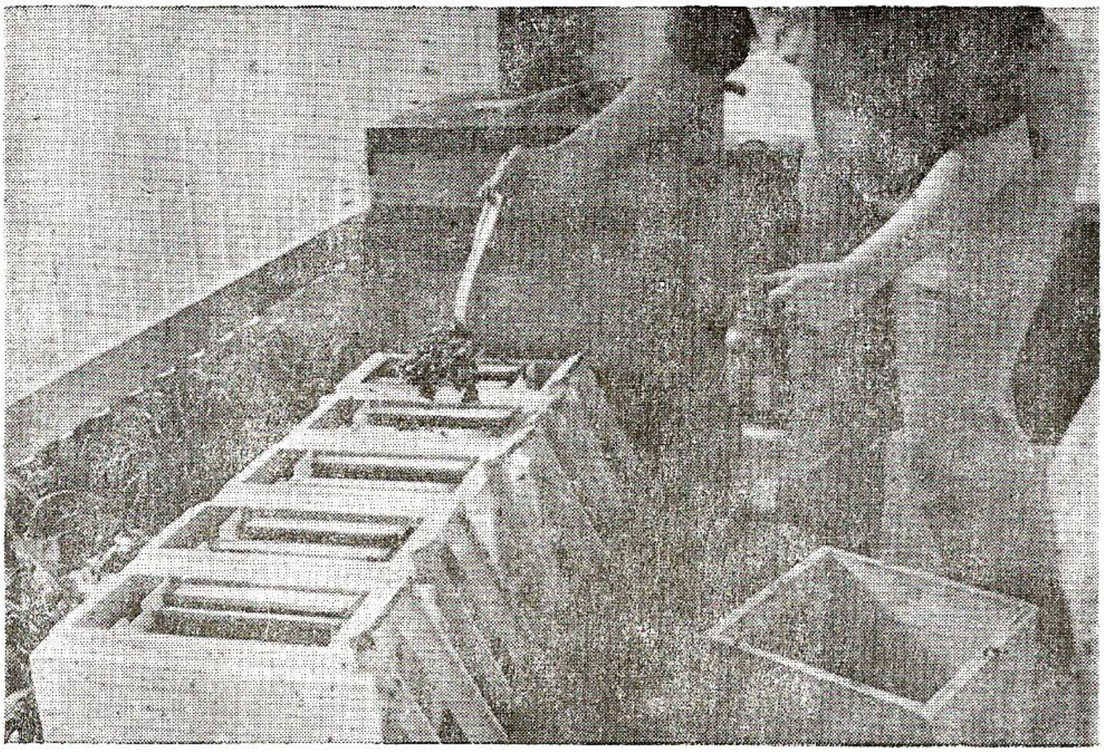


Fig. 132 — *A ladle of 120 g bees is given to every mating hive (in this case the model 1, 3.2. a). 3 frame wooden nuclei of equal size require twice as many bees. The bees are sprayed with water at the same time.*

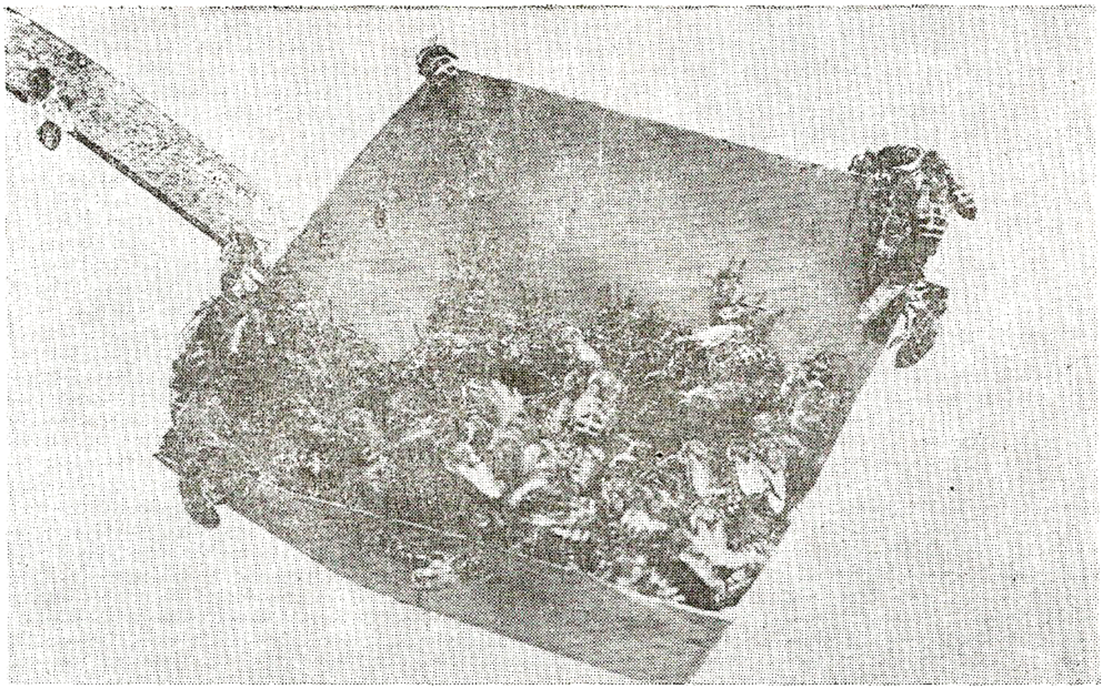


Fig. 133 — This bee ladle contains about 200 ml. The straight rim allows the bees to be easily removed from the sides of the swarm box.

2.4. *Introducing a young queen to a mating hive*

Every broodless mating hive composed of bees only can be requeened just as easily with a young virgin queen or queen cell. Because of its poor insulating capacity, the EWK can only be requeened with queens to prevent wastage. The advantages of using queens were pointed out at the beginning : control of the queens development and security of identification by marking. For certain purposes (breeding programs, research) utilization of queens that have emerged under controlled conditions is mandatory.

Care of queens during and after emergence is covered in section 3.2.1. Here we describe only the introduction of queens to mating hives. The guiding line to follow is "bees and queens should have the same behavior during introduction". When smoke is blown into the entrance at the same time that the queen is introduced, the queen will not be noticed during the first confusion.

MÜLLER OLE (1954) used his own **special starting box.** Well fed bees were shaken to the bottom of a 80 $\times$ 80 $\times$ 60 mm box with a screened bottom and the queen thrown in. This little colony was then stored in the dark until transport to its somewhat unwieldy mating nuc .(Although some of OLE MÜLLER's methods may seem cumbersome, there are many well thought through practical tips in his book).

In Lunz we work with quiet bees. One half hour after filling all is calm. The queen and her attendants are dumped into a container with water and pushed under repeatedly. The wet queen is allowed

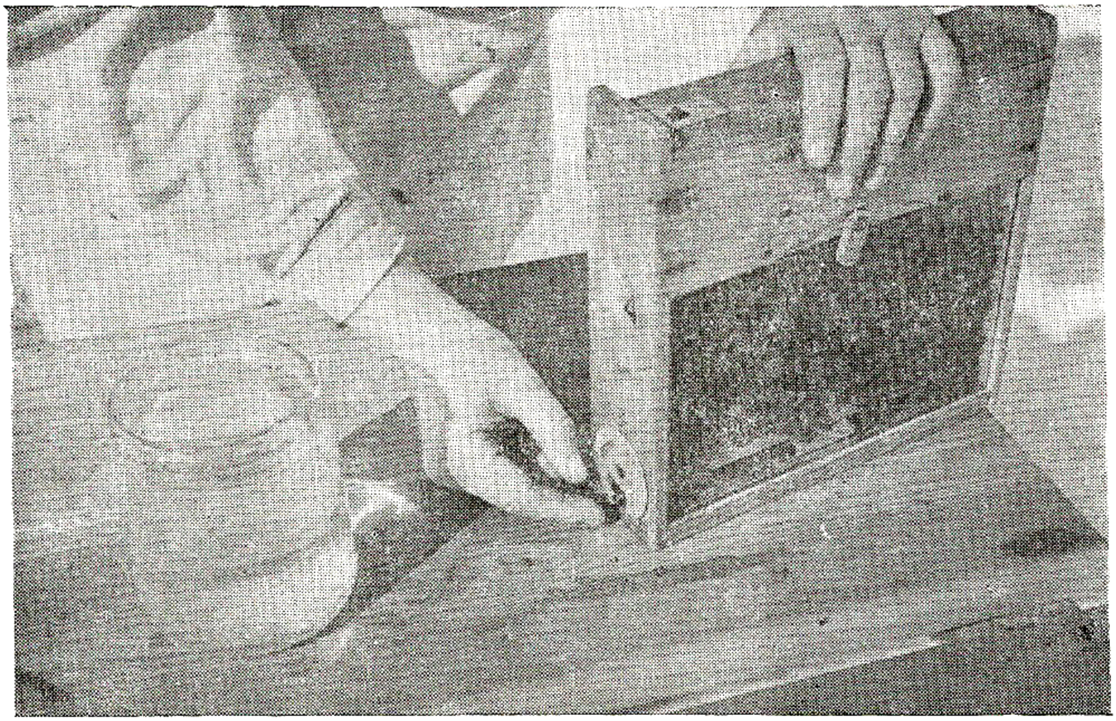


Fig. 134 — *The queen is dunked into water before introduction. The wet queen crawls slowly into the entrance, is dried by the bees and accepted.*

to walk slowly into the entrance and she crawls unnoticed into the cluster (fig. 134). This method fails however when the swarm is made during rainy weather and thus includes the foragers. In this situation it is suggested to introduce the queen with a candy release cage.

The nucs with bees are stored for three to five days in a moderately cool but dark and quiet room (cellar storage). The bees must be warm enough (16—18°C) so that even in the confinement they can begin to build comb. Comb building indicates that the queen has been accepted and that a normal colony has been formed. It makes no sense to shorten the time spent in the cellar. During the first days of her life the queen will make several dangerous flights but no matings will occur. The practician knows that nucs that are placed out too soon easily abscond. Also if the bees are placed near their origin more bees will fly back then when held for longer periods. Apparently queens must undergo a maturing process before being able to mate successfully. WOYKE and JASINSKY (1976) found that queens inseminated before they were four days old had a lower survival rate and contained substantially less semen than those that were older.

In large bee breeding operations where thousands of nucs must be stocked, the stocking of nucs at the beginning of the season is an activity that must be carefully organized. At R. WEAVER's the course of the procedure is the following :

The work on the nucs must exactly correspond with the working rhythm of the finisher colonies. Because production follows a 14 day cycle (12 working days: see chapter VII), twelve groups of nucs are required. Each days ripe queen cells are allotted to one of these groups of nucs.

Both methods, brood frames and bees only are used to stock the nucs. Stocking with bees first is necessary because on March 1st when the first ripe queen cells are ready, not enough brood frames are available. About two weeks later the colonies producing brood frames are split. Because at the beginning the number of cells grafted is only about $^1/_2$ of that grafted later on, more than two weeks are available for stocking all nucs.

The queen cell is utilized when nine (often also eight) days old. This two to three day margin helps compensate for bad weather conditions where it is not possible to work outside. In addition it is possible to delay emergence by about one day by lowering the incubator temperature from 34° to 32°C. During the seldom long bad weather periods, unavoidable cell losses do occur.

The double mating hives remain at the mating yard the whole year round. For that reason they are filled on the spot and not maintained in the usual cellar storage for three days.

One day before stocking a Langstroth deep hive body with a screened bottom containing four frames and a feeder is filled with 4.5 kg bees. A moving screen is nailed on top. Since 150 grams of bees are needed to stock a nuc, a swarm can provide for 30 nucs. Part of these swarms are used as starter hives for one time before being split.

Fig. 135 — *In Australia (at G. WHEEN), just as in the USA, the mating nuclei are placed in groups, on both sides of the road.*

The nucs are located on both sides of a driveable road and spaced about 3 meters apart. The individual steps in stocking occur in the following order :

1. Removed lid

2. Honey frame pushed against center partition (on each side of box).

3. Empty frame or foundation (wide space between honey frame).

4. Queen cell pushed in honey frame. The queen cells are carried to the mating yard on the grafting frame in an isolated box and are only removed from the frame when being pushed into the honey frame. The queen cells can withstand the short cooling without any ill infects as long as they are not shaken (compare chapter V. 4.1.3.).

5. Feeder half filled with syrup.

6. 150 grams of bees are dipped out of the swarm box and shaken into both sections of the double nuc in the space between the honey and the empty frame. The frames and feeder are pushed together towards the middle partition and the lid is placed on. The bees immediately cluster on the queen cell and keep it warm.

7. The nuc entrance is opened on the second evening 2 1/2 days after stocking.

While honey frames are being placed in the nucs, swarm boxes are prepared for dipping. The bees are jarred from the lid and then from the frames back into the swarm box. The rim only (not the bees) of the swarm box is sprayed with water to prevent the bees from crawling out. When ready they form a thick layer around the inside of the box from which they can be easily dipped. The swarm boxes are then carried to the end of nuc rows.

At the time the nucs are stocked the air temperature is that where the bees can just begin to fly or somewhat lower. When it is warmer many bees fly away and cluster on bushes where they will be collected in the evening. Nine people are required for a smooth flowing operation. With good teamwork 300 nucs can be built per hour. If two more help, this can increase to 400 or 500.

But in spite of careful planning, the unexpected can happen. Often not enough built comb is available. Then colonies are made with two frames of foundation or even in the main season with one frame of foundation and a feeder. For several weeks these nucs fulfill their purposes. What is important is that you remain flexible and correctly react to the unforseen.

3. Care of young queens

3.1. *Cage storage of queens*

After the cell is removed from the colony it is isolated in a cage. Several different types are in use and some can be easily made.

3.1.1. **The emergence or inoculating cage (after ALLEY resp. ZANDER)**

Preparation : These cages can be prepared by anyone with a small workshop by cutting 35 mm holes from a 20 × 40 mm basswood strip (fig. 136). The strip is cut between the holes so that the resulting cage is 55 mm high. A 15 mm hole for receiving the cell is bored on a cross cut of the block. A depression (6 × 6 mm) can be bored inside the hole on the bottom at the side and waterproofed with liquid wax. A drop of honey or a small ball of candy is offered there for the queen. The depression is placed on the side so that it is not covered by the cell cap which falls during emergence. Usually one side (or both) of the cage is covered with a 2.5 mm mesh screen. Through this size of mesh the queen can be well fed, but rarely hurt. Often one side is closed with a removable cellophane window (0.2 mm). Plastic sheeting does not work well because it buckels in the heat and allows the queen to slip past. The bottom of the cellophane window is nailed on with two large carpet tacks. Both of the top corners are cut off so that their flat edge can be pushed under the rim of a nail driven in each of the top corners of the cage. This way the cellophane can be swung out thus allowing access to the cage interior.

Comment : This cage is suited for artificial wax cell cups because they are usually attached to a 15 mm in diameter cell base. The cell base closes the cage.

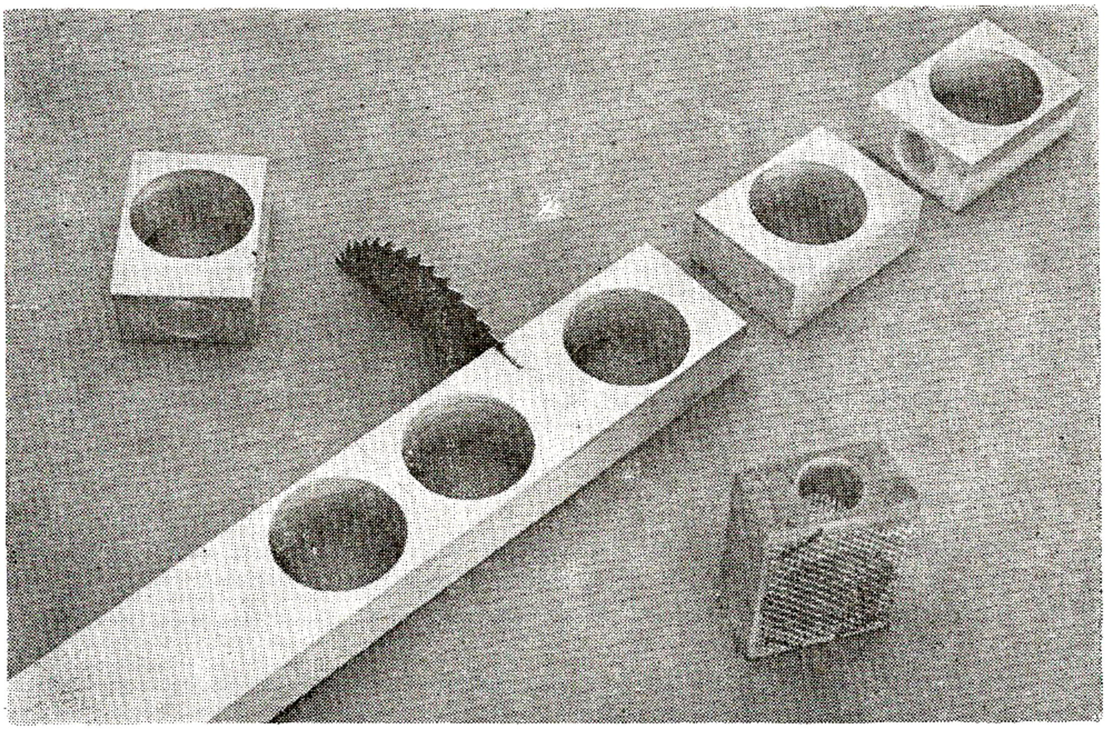


Fig. 136 — *Emergence cages are prepared from a strip of soft wood.*

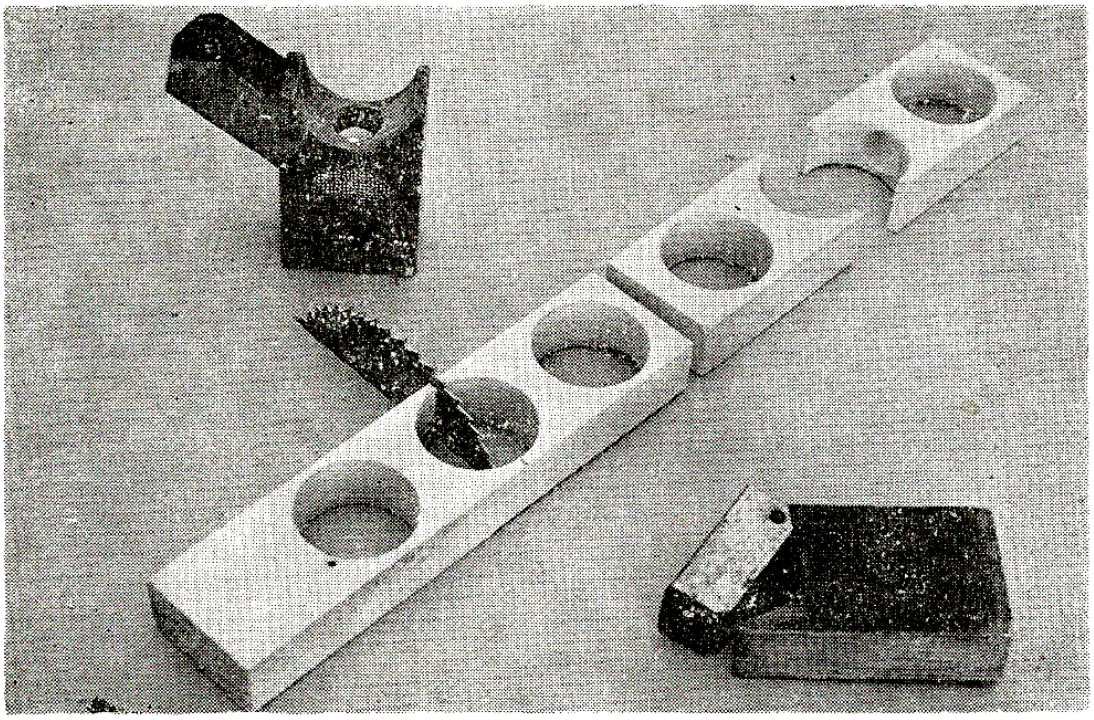


Fig. 137 — *Wankler cage. To protect the top of the queen cell that is cut from the comb, a sheet metal cap is clapped over the opening.*

3.1.2. **Wankler cage**

Cells that are not attached to a cell base or its equivalent but are reared by cutting a half circle in a brood comb (analog Miller method) or clamping strips of comb risk being destroyed. Not only the queens from inside, but also the workers from outside will try to remove the remaining royal jelly. Under certain conditions a passage to the outside will be made. For cut out cells the old Wankler cage with a tin cap has always been proven adequate. Such cages are important in breeding or research organisations when certain important cells must be utilized.

Preparation : The Wankler cage is made out of the same wood strip as the emerging cage (fig. 137). A cut is made through the middle of every third hole. The half circle is closed with a thin tin cap. The cap is nailed on with two nails so that only a small amount of resistance has to be overcome to open it.

3.1.3. **Spiral cages**

Probably the clock maker Wankler was also the originator of the simple wire spiral cage : A spring wire is wound around a finger thick tube to form a tight 6—8 cm long spiral. One side is closed with a cork, the other with a queen cell.

Comment to 3.1.1. — 3.1.3. : At adequate temperatures vigorous queens emerge problemless without bees. Bees inside the cage are more likely to try to escape than to help the queen emerge.

3.1.4. **Direct access cages**

Direct access cages have not been very popular. They have a queen exlcuder on one side instead of a screen. The grounds for this idea was that the bees could reach the cell, warm it and feed the queen as soon as she stuck her proboscis out of the first slit in the queen cell. However it occurs that queens are stung or small queens slip through the excluder while their chitin is still soft.

3.1.5. **Cup method**

The cup method is probably better though more complicated (after HEINECKE, 1951). The queen cell and the small cluster of bees on it are closed in a small cup. The disadvantage is that the rearing must be done above the frames (ZANDER — BOTTCHER 1971, p. 271).

3.1.6. **Hair curlers**

Plastic hair curlers can be obtained with a 15—20 mm diameter (fig. 138). They work very well as emergence cages and have the advantage that they are very cheap. Wood strips with corresponding holes are used as stands. The cage is set on a drop of honey placed in the bottom of the hole. The hair curler can be used for the transport and shipping of queens. The bottom end of the curler is dipped in wax to form a closed space for receiving the necessary amount of candy.

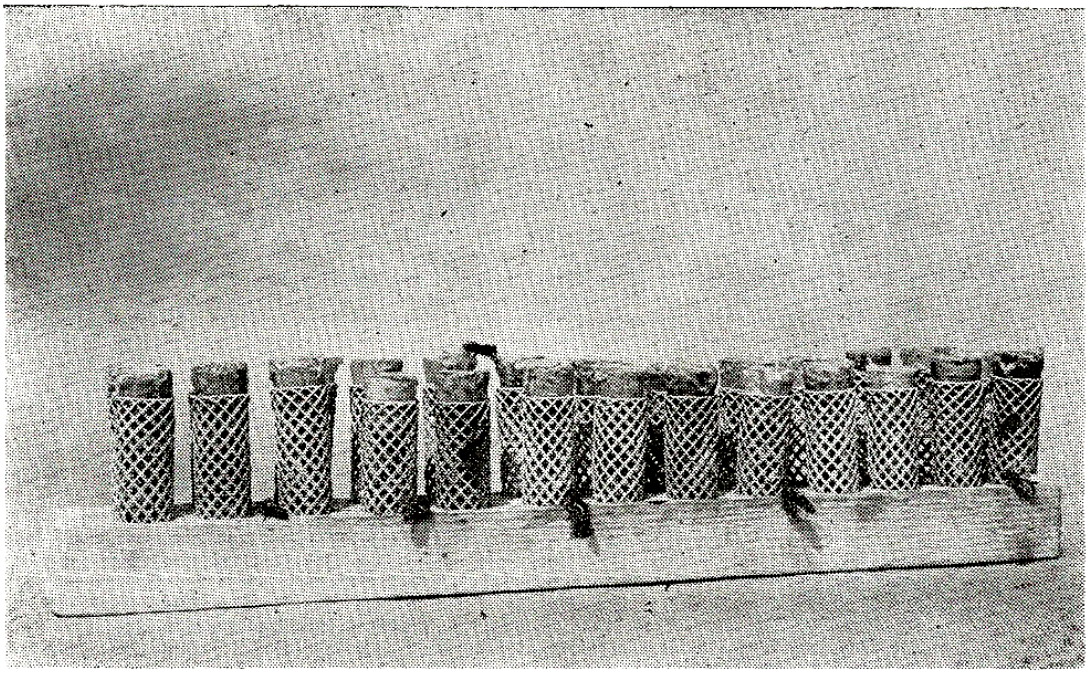


Fig. 138 — *Two rows of hair curlers in an incubator storage rack. Queen cells hang on the wooden cell cup holders.*

3.2. *Where are queens emerged ?*

3.2.1. **Emergence in the colony**

The experienced person places the emergence cages in a storage frame. This is an empty frame divided into two to three sections which can hold around 20 cages. Construction is such that the cages cannot tip out. This frame is hung in a honey super full of bees above a queen excluder where the correct temperature and humidity conditions for bees occur. These foreign cells will not cause the colony to swarm (in the case it did not already have a swarming urge) as we already know from breeding in queenright colonies (fig. 139).

Also the bees do not pay any particular attention to the newly emerged queens. Above all they are not equally fed. For that reason it is necessary twice a day to remove the already emerged queens and care for them.

3.2.2. **Incubator emergence**

When large series are often produced it is difficult to control and too much work to control the emergence in a beehive. In this situation it is worthwhile to buy an incubator. A queen cell requires a constant temperature around 34°C$\pm$ 1°. When the temperature is reduced a few degrees during the emerging period the queens will become inactive and remain "stuck" in the cell or they emerge with damaged wings.

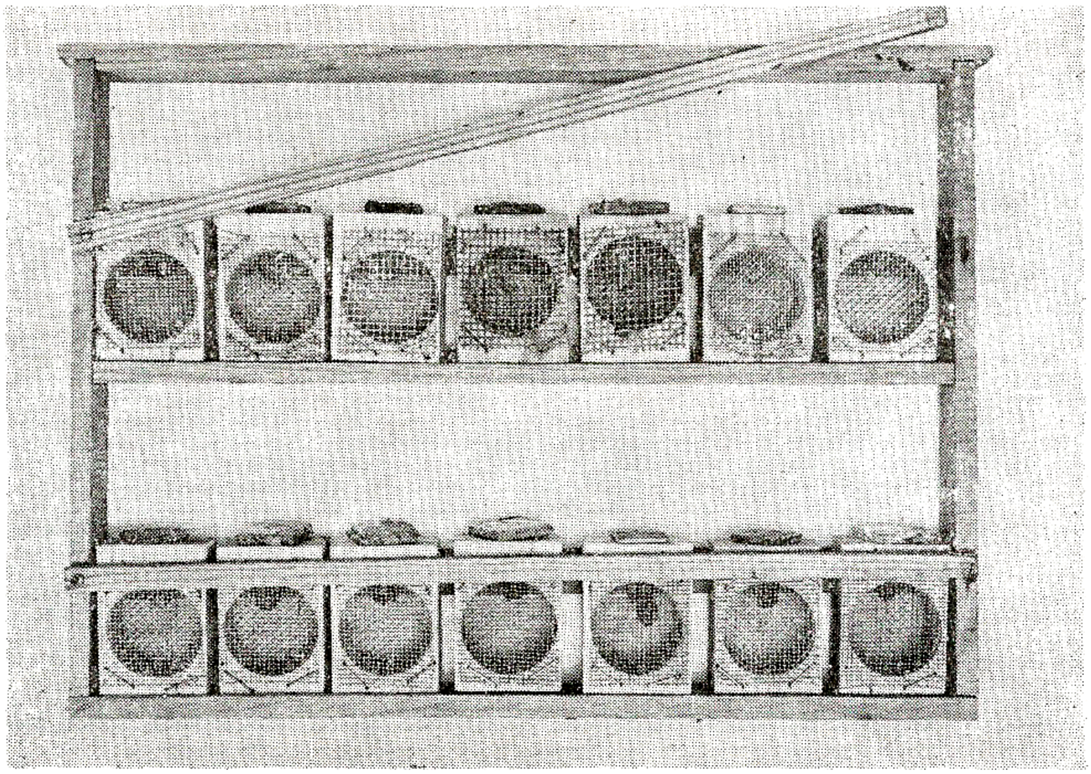
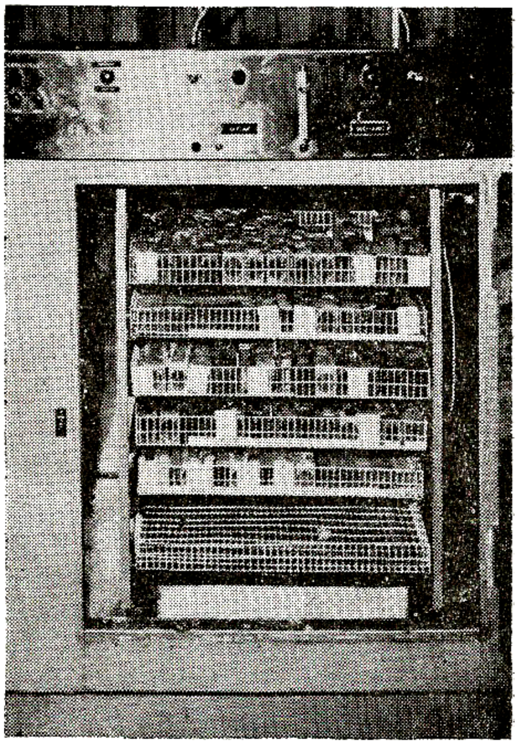


Fig. 139 —*Queen cells in emerging cages ready to be hung in a bee hive*

Fig. 140 — *Cages are placed in the storage racks of the incubator. A dish of water and a fan is located below the racks.*



A drop of only two degrees however, can be withstood without any damage (V, 1.3.). Overheating a few degrees will lead to the death of the pupae. When acquiring an incubator it must be taken into consideration that the temperature limits for emerging queens are narrower than those required for chickens.

Regulating temperature: Ether thermometers are not precise enough in most cases. We have our best results with a low volt contact thermometer (for instance Jumo, Fulda, FRG). The weak contact current turns the heating on exactly at the temperature set. Errors arise due to the residual heat in the heating element. For this reason the element should be weak. For instance a regulatable electric iron can be the source of heat in a large incubator. Presently electric timing equipment exists that not only turn on at the correct temperature but also provide the necessary amount of current for a given time (dimmer). Once the incubator is warm, this device provides only the minimal amount of current so that no problems with residual heat occur (PAUL, R. 1978).

Controlling humidity

According to BÜDEL (1960, p. 139) the relative humidity in the broodnest of a colony averages 41.5%, varying in summer from 35 to 50%. Because an incubator exerts a drying effect it is important that large water containers whose evaporation surfaces can be increased with towels, be placed inside. Too much humidity however, can also damage.

Candy can liquify and stick to the bees. The ideal is to have a humidifier with humidity controls.

The construction of the incubator case and its source of heat is of secondary importance. We have worked for many years with a refrigerator whose cooling element was replaced with a carbon filament lamp. A ventilator should be placed in larger incubators.

Comment : It is possible to maintain a queen cell from the moment of its capping to emergence in an incubator whose temperature and humidity controls function accurately. Such cells are distinguished by a thinner wax wall. When large losses occur at emergence it is very probable that either the temperature or humidity controlls are not in order.

3.3. *When and how are queen cells separated ?*

Emergence is on the twelfth day when larvae of the same age are grafted that are 1/2 to 1 day old. During hot spells queens will emerge one day earlier. Usually caging is done on the 1oth or 11th day. A small pea sized ball of candy or a drop of liquid honey in a small wax container (smaller than the cell cup to prevent the queen from getting sticky) is carefully placed in each cage. When a large cell is placed in a small cage care must be taken that the queen will have enough room to emerge from the cell.

3.3.1. **Storing emerged queens**

Whether in a hive or incubator, the emerged queens must be removed twice a day from the 12th day on. When the candy hardens another clump of candy is added. After emergence every queen is given five to ten nurse bees. In no case should field bees be removed from the windows of the workshop and caged with the young queen.

At 34°C the incubator is too warm for emerged queens. The bees become excited and do not take good care of the queen. At this point a temperature between 26 and 28°C is suitable. When a second incubator is not available a thin partition is placed on a hive and covered with a specially built hollow lid or shallow super. This restricted space is easily heated to the correct queen storage temperature by the colony below. Emerged queens should not be stored for more than 12—36 hours. Of course caged virgins can be also stored in a queen bank (compare 4.5.2.).

3.3.2. **Control of emerged queens**

a) *Body form*

When a whole series emerges late either they were cooled or poorly fed. Queen that emerge on the 14th or 15th day after grafting are an indication that the larvae were not immediately cared for as queen larvae. These queens should be quickly eliminated as they will cause problems for the breeder or later the receiver.

For general use it is not important that a queen be oversized or normally developed. In any case she should not be small. The size of the queen can be estimated according to the width of the thorax area (scutum). The length of the queen changes several times during the first three weeks (see TARANOV 4.4.).

With controlled emergence another possibility occurs to ascertain if legs and wings are intact or if any body deformation exist.

b) *Colour*

The colour of the queen depends in part on how fast and at which temperature she emerges as the final coloration occurs in the cell. Piping swarm queens that have remained longer in their cells due to fear of the rivals are usually very dark. Light queens however perform just as well. Carniolan queens can be coloured light brown gray till almost black. I know of one line where most of the queens had a milk coffee coloured ring on the second abdominal segment. However all the daughter bees were gray without any yellow colouration. In contrast it should be considered a sign of hybridization when a F1 queen originated from a cross with yellow Ligustica-drones, shows a conspicuous yellow colouration. This condition often occurs also in the workers of many queen breeders.

Institutes and small bee breeders prefer the controlled emergence method. In commercial queen breeding operations emergence is mostly uncontrolled. Culling of the queens is then done just before shipment.

3.4. *Marking queens*

Queens must be marked before mating if separation between descendents of different queens is wished or if it is wished to recognize your own queen after utilizing a mating yard used by others. For our different lines we use markers in five or more different shapes or numbers in the colour for the year. We have always found that from time to time queens enter the wrong mating hive. Never have we been able to demonstrate that more marked queens than unmarked are lost in the mating flight. Positive recognition of a queen is necessary for those breeders engaged in line breeding and honey production testing. In addition it is an agreeable help to each beekeeper to quickly locate and identify her age. For that reason many countries utilize the five colours which rotate going from light to dark every five years : white, yellow, red, green, and blue. White is used in 1981, 1986 and 1991 etc. Red stands for 1983, 1988 etc. The Swiss use only the first four colours.

3.4.1. **Marking materials**

Quick dry car lack is often used for marking. It is recommended to mark drones first to determine if the solvent is toxic. Otherwise shellac dissolved in alcohol or cellulose in aceton can be used as a carrier in which the coloured powder can be stirred. Light colours stand

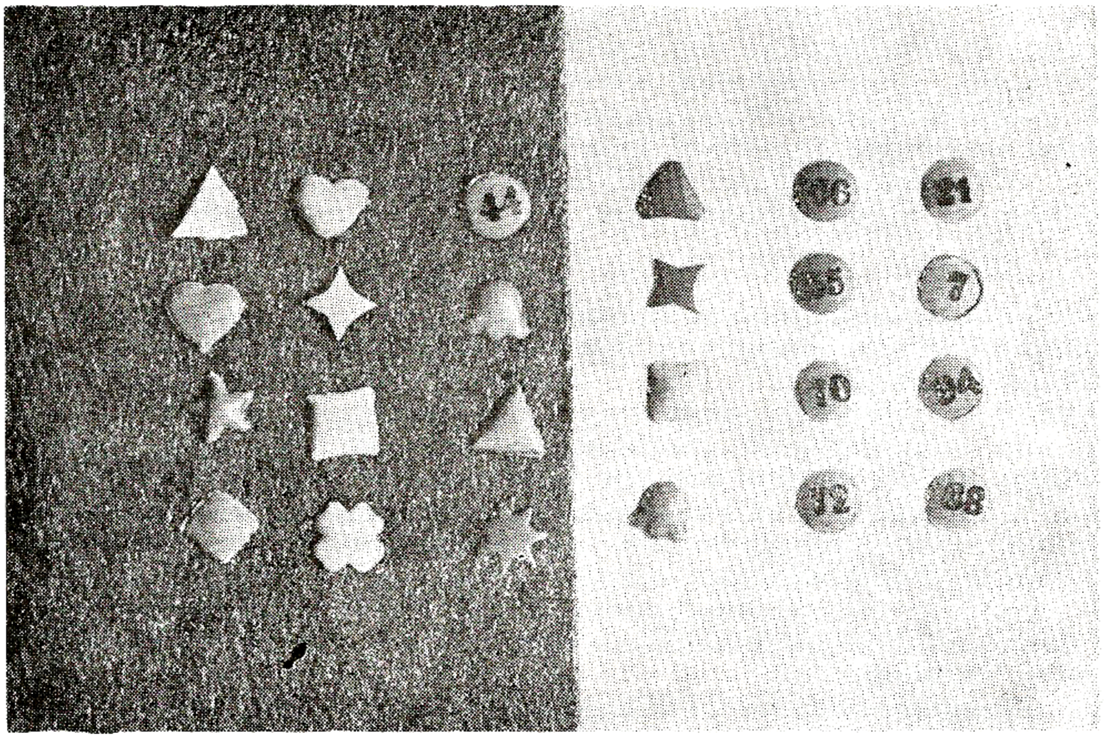


Fig. 141 — *Slightly curved marking tags composed of hard plastic exist in five colours with numbers or different shapes.*

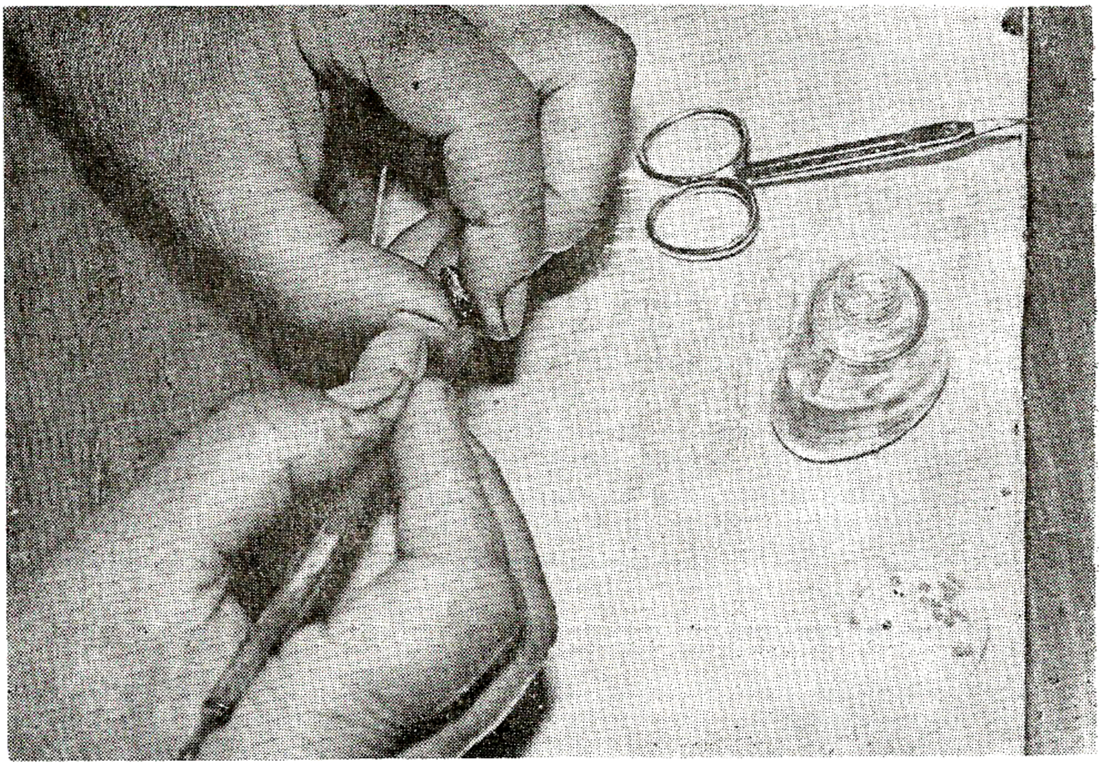


Fig. 142 — *This is how a queen is held for marking. As an additional sign, the wings of mated queens are clipped.*

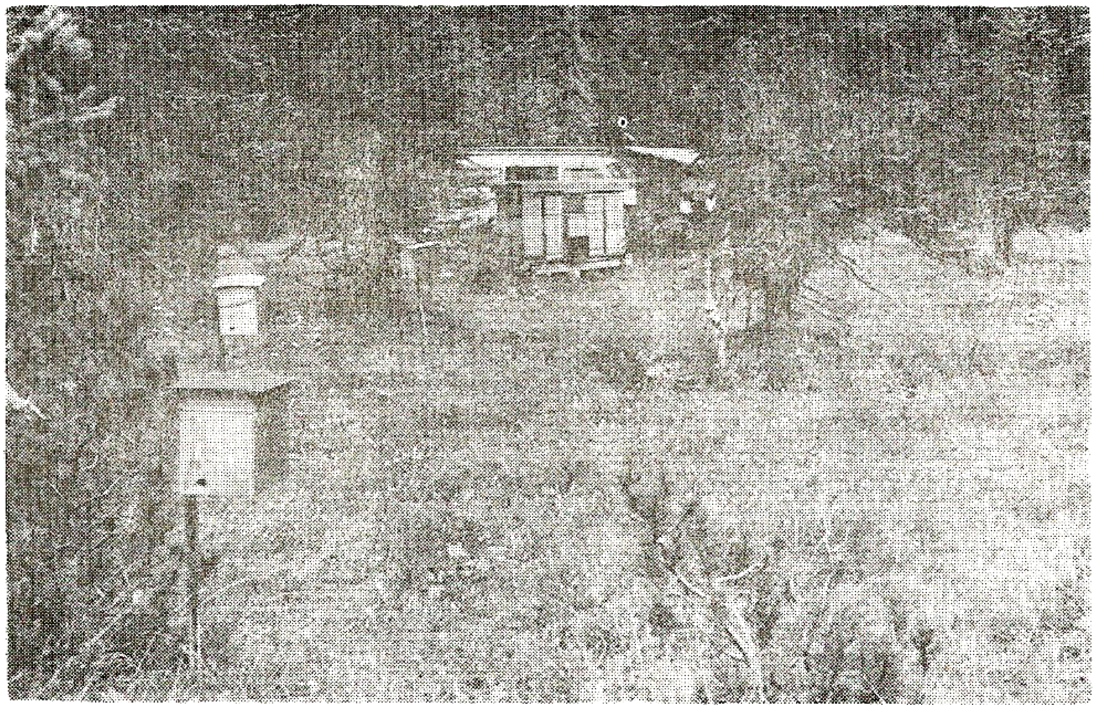


Fig. 143 — *In this mating yard the protective coverings for EWK's are hung on iron stakes which must be hammered into the rocky soil every year.*

out well. In the case of dark bee races dark colours do not stand out well from the chitin. Small disks punched from metal foil are even better. Silver and gold are metal colours that remain. Red, green or blue are usually painted foils and the colour or number does not always remain. Plastic disks are now in general acceptance. Every colour is luminous, but after a few years not every number can be read with certainty. The width of the disks is 2 mm. Larger disks are easily lost. For that reason a strong quick drying glue is used. After many different trails we have always returned to the use of a good colourless acetone finger nail polish. Queens can be marked with a sharpened match stick. But it is better to use a round piece of wood the size of a pencil that has a pin with a small round head pushed in both ends. Glass headed needles are too large. One of the needles is bent at a 45° angle. If it is out of steel and not iron, it must be annealed first.

3.4.2. **Marking process**

To mark the queen is placed between the forefinger, middle finger and thumb of the left hand. The needle is dipped into the paint and the drop which hangs on is wipped off and the thorax of the queen dabbed. Careful, no paint should fall on the wing base or on the neck of the queen. In the last case she will be immediately killed. Now the bent needle is wet with the tongue and the plastic disk picked up with the pin head and its hollow side pressed against the sticky thorax of the queen. The disk must lay on the half moon shaped scutellum.

This way the queen will never be disturbed when she sticks her head in to inspect a cell. The queen is confined in an airy cage or under a wire holder for several minutes until the glue is dry. The acetone smell must disperse before the queen is introduced.

There are many different marking devices where the queen does not need to come into contact with the hand. Holding the queen in the hand should not cause any problems for the experienced breeder.

4. Mating yards

There is not enough room here to write about the advantages and disadvantages of mating yards, pure mating areas or bee yard matings. On the contrary we will discuss the activities that are to be carried out.

4.1. *Transport*

The nucs should be carried to the mating yard in the late afternoon. The entrances are first opened at dusk. This way the first bee flight will occur the next morning. They can also be placed in position in the early morning or in rainy weather but never in the afternoon heat as they may swarm immediately. In general during the flight period all movements and disturbance at the mating yard should be avoided.

4.2. *Placement*

A partially shaded windless spot should be chosen. Very weak single frame nucs easily swarm when placed in direct sunshine. Multiple

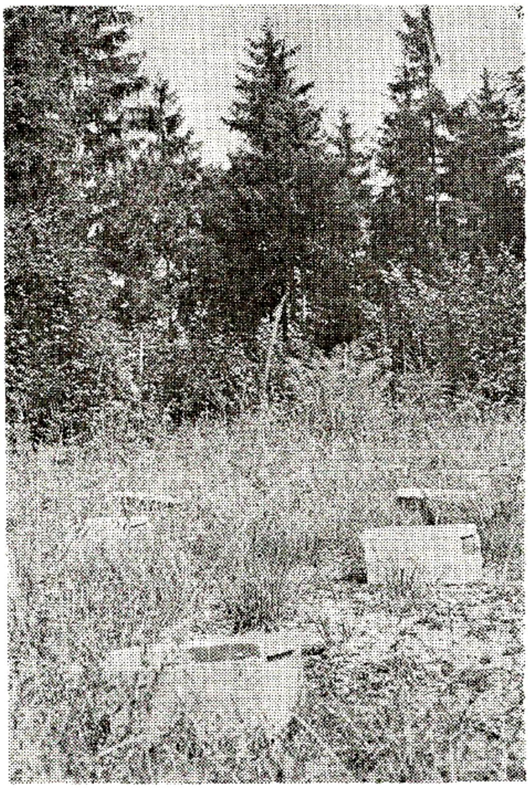


Fig. 144 — *Styrofoam nuclei can be placed on the ground even in rainy areas. Ants can be a problem however.*

Fig. 145 — *PIANA commonly uses two-nuclei mating hives placed on the ground in the shade of trees. The queens orient themselves better than when hives are hanged on poles.*

frame nucs are less sensitive in this respect but also will suffer from the summer heat (R. WEAVER, fig. 128).

The protective box for the EWK is attached to a stake. In the long run it is economical to use stakes out of 25 × 25 mm angle iron especially when the area must be cleared again in the fall. They can be quickly driven into stoney ground (F. RUTTNER, 1973). Placement at different levels and in changing surroundings (shrubs or half grown trees) makes it easier for the queen to orient. Nucs or three frame colonies out of styropore are simply placed on the ground. This also helps orientation. Attention must be paid that the entrance will not be covered by growing grass. According to Piana queen losses from boxes raised from the ground are distinctly higher, especially in hot weather. The boxes are set in a zig zag fashion instead of regular rows. Distances between the boxes should be at least two to three meters. At large mating yards a driveable road is placed between two rows.

When the ants do not find any honeydew on the trees they are sugar thieves and will chew the polystyrene insulation. Often they will chase the bees out of weak boxes. Stakes are painted with lime or clove oil to keep the ants at a distance. Often additional preventive measures are necessary against other pests (1.2.4.).

4.3. *Mating*

The first flight of the queen usually does not occur before the 6th and the first mating flight before the 7th day of life. After short orientation flights the queen must first be absent for at least 10 minutes

Fig. 146 — Although this positioning by rank and file can make it easier for taking care of the nuclei by the yard worker, the queens often miss their mating hive and are lost.

before a mating can be expected. The main flight period is between 1 and 3 p.m. at temperatures over 20°C, moderate cloudiness and reduced wind movement (F. RUTTNER, 1955). The most active flight can be observed after a bad weather period. Then flight will occur at even lower temperatures. Hardly any matings occur in the morning in spite of good weather conditions. Drones return immediately when storms approach in the afternoon.

Thus the possible mating times are very limited especially in the mountains or on the coast. But as most of the isolated mating stations are found in these areas, there must be an above average concentration of drones so that matings can occur in a short span of time. As long as on northern German mating island only one drone colony was used the results according to quantity and quality were discouraging. Once enough drone colonies were available queen losses were not so high and their lifespans were normal.

4.4. *Control and removal of queens*

The timing for the first inspection can be calculated by the weather conditions. When the queen begins to lay during her first two weeks of life, she can be transported away or utilized as soon as large areas of open brood can be seen.

A few drone cells in the first brood are not disturbing. Later solid worker brood should be expected. It is different when egg laying first begins in the third week. Here one must wait until the brood is sealed to make certain that the queen is not a drone layer. It is best to kill such late queens immediately because they will usually cause problems.

On no account should a queen be removed as soon as she is seen with the first mating sign. Perphaps she should mate another time? In general queens begin to lay two days after the last mating. Only after a long delay of mating will she sometimes begin earlier.

TARANOV reported a relationship between queen weight and the begin of egg laying. Average egg laying of queens weighing between 180—190 mg occurred on the 17th day (or in another experiment on the 15th day). Heavier queens laid already on the 10th or 11th day.

In large breeding operations queen production can only function smoothly when all phases of the process (grafting-cell building-mating) are coordinated with each other. This means that a receptive mating hive must be ready for each ripe queen cell. R. WEAVER works his queen rearing colonies in a two week cycle (2×6 days). For this reason the mating hives are divided into twelve groups. One group for each day's cells. This means that the queens are also removed at that rhythm. This system corresponds with the general experience that queens which have not yet begun to lay after 10 sunny days are of inferior quality. PIANA culls out all queens that have not begun to lay by the 16th day.

This orderly working arrangement can be followed when good mating weather occurs day for day with only a few exceptions. It is not by hazard that all large breeding operations occur in areas with a constant warm dry summer climate.

Fig. 147 — *The varied plant species, the distance between groups, different flight direction for each and every nucleus ensures the successful mating at the Koehnen breeding apiary in California. Transportation is also excellently provided for.*

Mated queens are caught by especially dexterious workers. Catching stools are particularly used in the U.S.A. and Australia that make it easier to endure the day long working in a bent position. The stool has a spot for everything used in the catching operation : beekeeping equipment, empty cages and cages with caught queens (fig. 148).

According to WEAVER an experienced person can cage 40 queens with their attendants in one hour. When queens without workers are caged (for use in packages or for shipment in a swarm box) up to 55 can be caught. Due to a lower concentration, performance drops after 5 hours.

The accompanying bees are often taken from the same colony as the queen. Because nucs are often disturbed and dequeened, they have a higher nosema infection than normal colonies. For this reason many breeders obtain queenless bees from strong healthy colonies. N. RICE uses an automatic cage filling box. The cage with the queen is placed in a compartment over a swarm box filled with bees (fig. 149). Bees are driven upwards into the cages with smoke. Bees are removed from cages that are too full.

Italian breeders who do a lot of exportation and thus must submit to severe veterinary controls use another technique to obtain disease free bees (see IX, 3.2.3.).

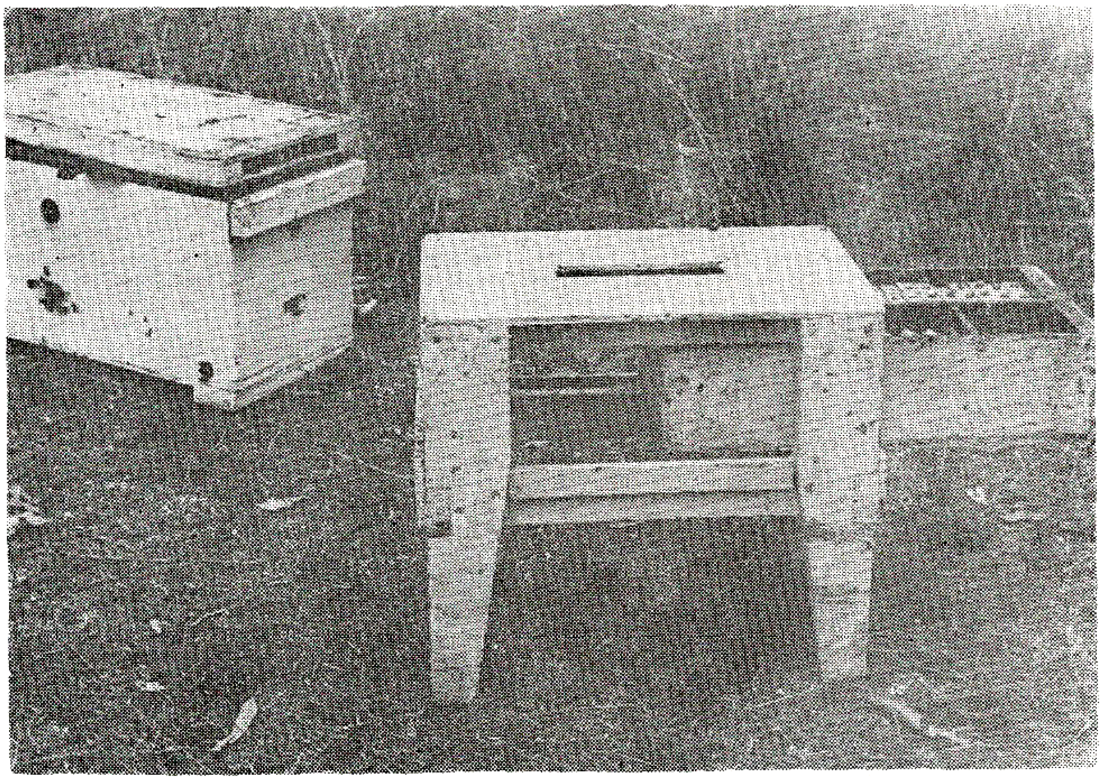
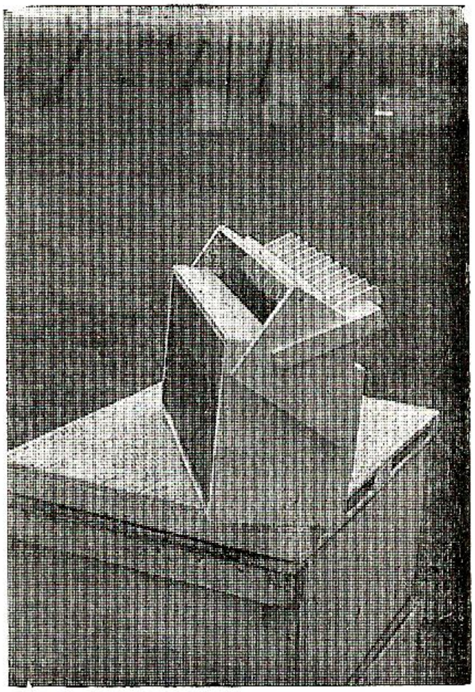


Fig. 148 — *A working stool with a place for tools helps to make the work easier at the mating yard.*

Fig. 149 — *Filling box. N. RICE leaves the bees to enter the mailing cage. The cages are introduced into the hive body, after which bees are disturbed with smoke.*



A ripe queen cell is given shortly up to 24 hours after the queen is removed. In addition the feeders are filled again at this time.

Even under good conditions 20 to 30% of the queens are lost during the mating flight. Queenless colonies weaken quickly, especially when they are broodless for a long period. Brood frames to strengthen can usually be obtained from other nucs.

It is advisable to maintain colonies especially for strengthening the smaller nucs. From two to ten queens can be mated in a small nuc in a season depending upon the demand, strength of nuc and weather conditions.

4.5. *Queen storage*

During the breeding season periods occur where more queens are produced than can be shipped or used and their mating hives are needed for the next series of cells.

4.5.1. **Storage in shipping cages**

Queens can be held for up to two weeks in shipping cages with 10 bees and candy. With 20 bees they live longer and with 50 bees can endure for three to four weeks (FRESNAYE). LAIDLAW-ECKERT recommended a temperature from 30°—34°C and under certain conditions the giving of water (one must think of the dry air conditions in California !). FRESNAYE (1965) made many different experiments and had the best results at 25°C without water. He found that at 50—60% humidity the bees could eat enough candy to live. When water was supplied they ate more than what they needed, their large intestine overfilled, they excremented, became black and didn't live as long. The main difficulty was with the bee, i.e. its digestion (compare 3.2.2.).

4.5.2. **Storage in colonies (queen bank)**

Use of queen banks in the southern States and California has been reported (LAIDLAW and ECKERT, 1962). A few frames of open brood in the uppermost super with a queen excluder underneath is placed on a very strong colony. Frames containing queens are placed between. A frame contains two to three rows of flat cages placed back to back in pairs (fig. 150). Thus there is room for 50—70 queens in a frame. Queens are caged without candy or attendants. A large mesh screen is used for the cage to facilitate food exchange. Three to four of such frames can be stored in a strong colony. It is recommended to continuously feed the colony. The same is also possible with large artificial swarms.

100 to 300 queens can be stored in a super with 3 kg of bees and copious honey reserves (WEAVER, ROBERTS and STANGER 1969; LAIDLAW and ECKERT, 1974). The amount of bees in the super is the determining factor. All passages must be completely packed with bees. Queens are usually not held for more than a month in this manner. The question as to whether or not the queens are harmed by this treatment results in different judgements. Producers personally report no harm.

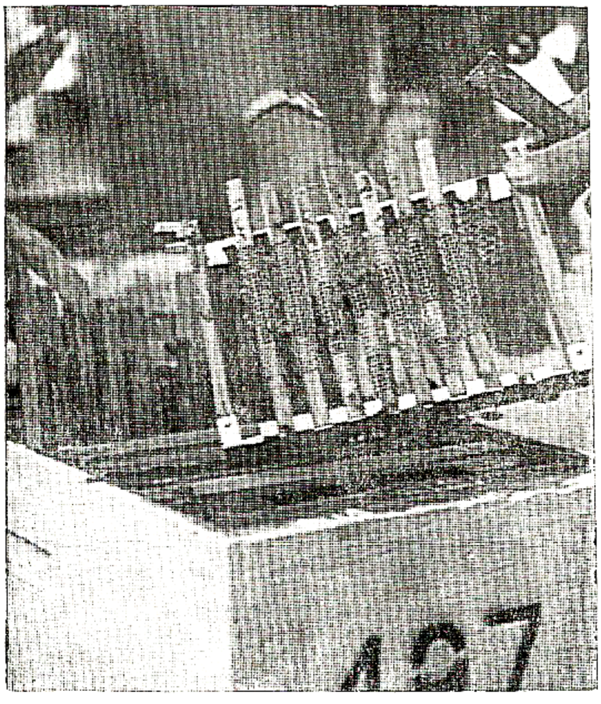


Fig. 150 — *Queen banks. In such or even larger sets of long cages mated queens are stored in California, for a period of time. They are called "queen banks".*

At the present this method has not found acceptance in Europe. However it is possible that it is used by some here.

JEVTIC (1951) allowed the bees to go to the queen. He used large cages (60 × 60 × 25 mm) with a queen excluder on one side. For security reasons the bees were prevented by a tin cap from entering the cage during the first three days.

4.5.3. **Laboratory queen storage**

GARY (1966) attempted to hold queens in the laboratory without workers. Optimal temperature was found to be 25°C and pure honey the best food. Every addition of antibiotics distinctly shortened the life of the queen. Under good conditions 75% lived after 10 days, 65% after 20 days and only 35% of the queens lived after 30 days. In the first days the highest mortality (up to 60%) was observed. However it must be realized that GARY did not use young queens but queens of unknown ages that had been stored in a queen bank. FRESNAYE found that when old queens are caged they have a shorter lifespan than younger ones. When caged with bees, two year old queens had hardly half the lifespan of a young newly mated queen. Both authors found that overwintering in cages would be hardly possible.

However FOTI *et al.* (1958) did just that in Romania. They maintained the queens in 30 × 40 × 60 mm large cages in an incubator at 25°C and 50—70% relative humidity and fed honey. From time to time the bees were changed. At the beginning they gave 50, at the end of winter about 90 bees. The labor costs were covered by the high productivity of the young queens in the following year. In other places (my own experiments for instance) due to the large queen losses the results were less favorable.

4.5.4. **Small colony queen storage in temperate rooms**

Maintaining small colonies in the open is a problem in inclement climates. At the instigation of W. GOTZ (Oberursel) we wintered nucs with 1 to 3 frames in a cool room at 10—12°C. The colonies were connected to the outside by a flight passage about 30 cm long and 40 × 40 cm wide and thus could make cleansing flights. The length of the passage hindered the bees from flying out in the cold even when the room occasionnally became warmer. Since several years we have overwintered small colonies without great losses (H. RUTTNER, 1978).

CHAPTER IX

Transport and introduction

H. RUTTNER

1. Transport of eggs

The experiments on the time of survival of eggs outside the bee colony were discussed in chapter VI, 3.1.

It was shown that freshly laid eggs survive for a short time only. However, eggs removed from the colony 1 1/2—2 1/2 days after deposition hatched to 100 per cent after transport of 24 hours; to 50 per cent after 48 hours. From these results it can be seen that mailing of eggs is feasible without difficulty. The mailing of eggs abroad or even overseas is also possible provided prior individual arrangement with the air freight service has been made.

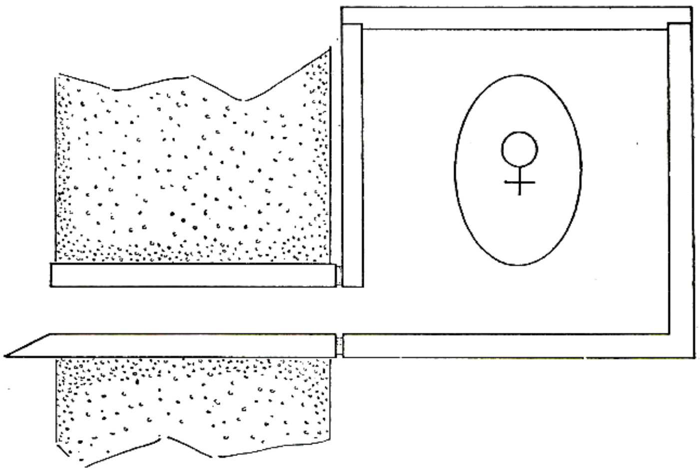


Fig. 151 — In northern latitudes, small nuclei can be overwintered in tempered rooms, if they are connected with the external atmosphere by a long, narrow flight channel.

2. Transport of queen cells

As shown in detail in chap. V (1.2.2., 4.1.3.) there are also other relatively insensitive phases during the development of queen larvae and pupae until emergence. During these periods different manipulations can be made. The larvae are insensitive during the two first days of larval life as food requirements are still very low. Another period occurs arround the 5th and the 6th day of larval development during the spinning activity of the larva. Subsequently, however the cell has to be left absolutely undisturbed. Only during the last two days before emergence may the cells be manipulated carefully again without danger of damage. They may be placed horizontally or may be kept and transported at room temperature for several hours.

Yet for the process of emergence itself they certainly need the temperature of the brood nest again.

These favourable periods must be considered for the manipulations during the work of raising queen cells and during transportation of the various stages of development.

2.1. *Transport of unsealed queen cells*

Several breeding centers supply unsealed queen cells in order to distribute precious breeder strains in a cheap and rational way for practical purpose. This is more economical than the use of pieces of comb with eggs or larvae.

2.1.1. **Transport without bees**

TIESLER (personal communication) reports, that testing stations for queens in northern Germany distribute about 3000 grafted queen cups annuaaly. These are started in a swarm box for 3 hours and are afterwards transported by car to the nurse colonies for up to 3 hours.

M. SCHÖNUNG (1972, 1973) reported good success with transport of freshly dry-grafted larvae for several hours. He drills holes, 15 × 15 mm in a block of styrofoam (Roofmate) using a metal tube. The grafted cup with its wooden base is inserted into this cavity thus being protected against drying out (fig. 152).

At Lunz, on the other hand, we get the grafted cups nursed in the swarm box for several hours. The accepted larvae are transported over a distance of 150 km in the way described above. Nearly all of them are further nursed in the cell building colonies at the place of destination. Similar experiences on a much larger scale are reported by Roy WEAVER (VII, 3.2.4.).

2.1.2. **Transport in the swarm box**

Some of the queen rearers transport the swarm box with bees (VII, 3.2.3.) to the breeding station to graft there the larvae of a certain strain. If however the journey back is started immediately after grafting the major part of the larvae will disappear ; this will not be the case if several hours are allowed to pass between grafting and transport.

This method is advisable if the cells can only be given to the nurse colonies on the day following the grafting. Otherwise it is better to practise according to 2.1.1.

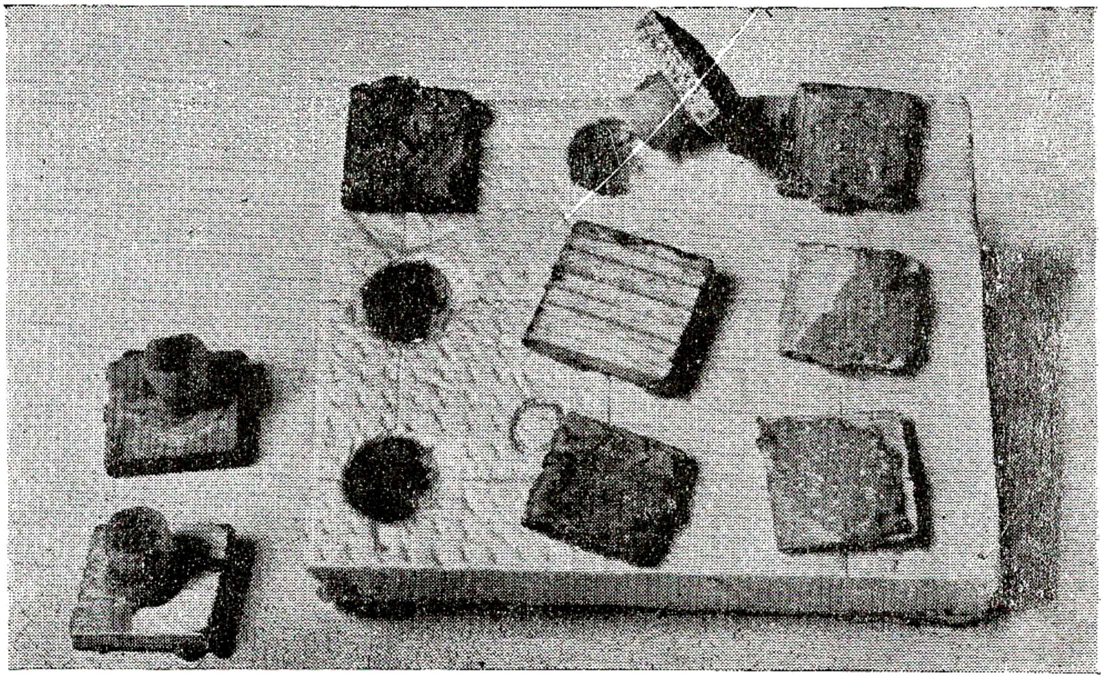


Fig. 152 — *Transportation of open queen cells. Larvae, freshly grafted or nursed for several hours can be transported for hours if they are protected from drying out and fluctuations of temperature by insertion into holes in styrofoam block.*

2.2. *Transport of sealed queen cells*

During his work in the mating yard Guido SKLENAR always had under his shirt — using his body heat as incubator — a cigarette box full of mature queen cells, softly packed, in order to requeen de-queened nuclei.

In Israel the queen producers sell queen cell which are then transported by the beekeepers over long distances. REINPRECHT (unpublished) made transportation boxes for queen cells. Holes, 15 mm wide and 50 mm deep were melted into a block of polystyrene foam using a hot metal rod to take the queen cells. The depth of the holes is sufficient to permit queens to leave their cells if emerging during transport.

In our queen shipping programme we preheated the transportation blocks with the queen cells in an incubator to 35°C before transporting them by car for nearly three hours or by train for five hours ; this was frequently done during cool weather. During the last years more than 3000 queen cells were exposed annually to transport conditions by train for five hours. In this way the losses never exceeded 10% even in unfavourable conditions (fig. 153).

For these larger consignments the nursing cages with the queen cells were packed in commercial insulated cooling bags or boxes (without cooling batteries). On one occasion the transfer of cells was delayed after 300 km transport by car, and the 400 cells had to stay in the insulated box at room temperature for altogether 24 hours. Afterwards the queens emerged in an incubator quite normally. The age of the pupae had been

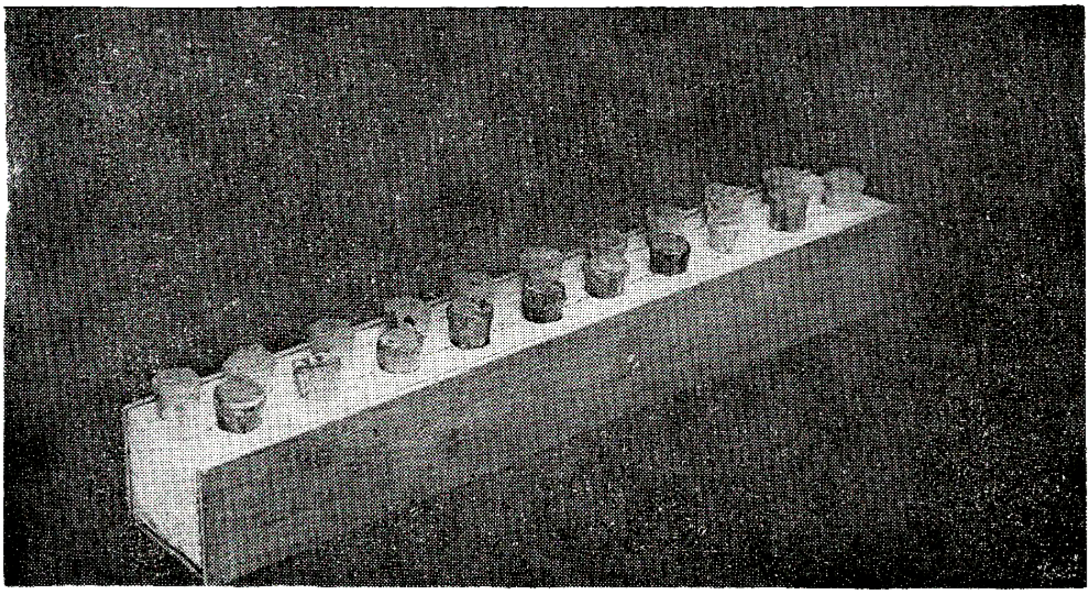


Fig. 153 — *Mature queen cells are placed into holes, 50 mm deep, in a styrofoam block. In this way the queen producer transports cells to the mating yard or for sale.*

calculated so that virgins were due to emerge on the day of transport, on the next day or the one after that. These dates were frequently delayed by one day (fig. 154).

3. **Transport of queens**

3.1. *Transport of virgin queens*

Emerged young queens must be sent if the distance is too great for transportion of queen cells. The technique of transporting virgins does not differ from the transport of mated queens (3.2.). It has to be considered however, that the introduction of virgin queens into mating

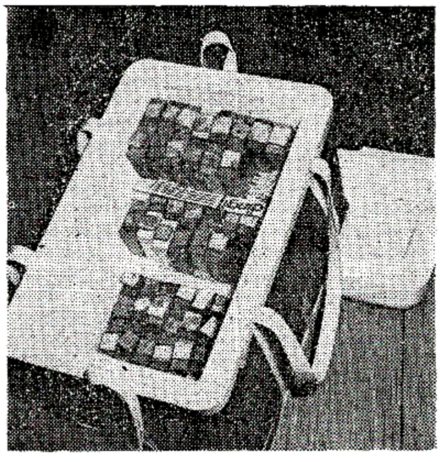


Fig. 154 — *For transportation of queen cells over a whole day a preheated cooling box is used. Additional heating units are not necessary, they could damage by local overheating.*

nucs creates more difficulties for the receiver. In general only shaken swarm specially made for a virgin queen can guarantee success, but even with this method the losses are the higher the older the queen had become before introduction, according to our experiences (and FRESNAYE 1965). On the other hand, TARANOV describes a method of introducing virgin queens even to mating nuclei with open brood (see 4.2.).

3.2. *Transport of mated queens*

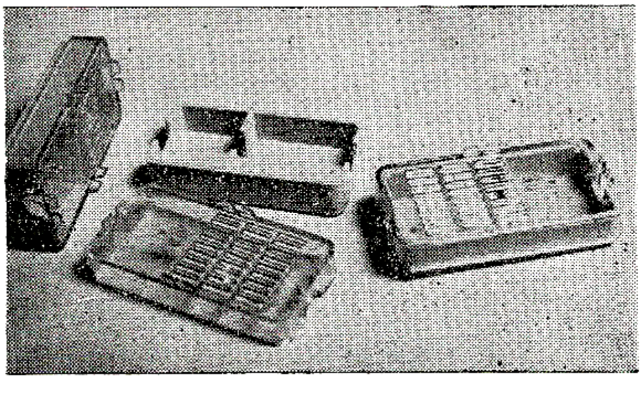
3.2.1. **The mailing cage**

Mailing cages have a compartment for bees and another one for about 10 g candy. The passage between these two compartments has to be large enough to avoid blocking by a dead bee. The upper surface is covered by a fine-meshed wire gauze (mesh size 10 = 4 wiers/1 cm, wire diameter 0.4 mm). Mailing cages have to resist pressure; this is why they are usually made from wood or from plastic material such as a type from Poland (fig. 155). Hair curlers, to be closed at both ends are also suitable, one end is immersed in liquid bees wax to make a reservoir for the candy (fig. 156); VIII, 3.1.5.).

3.2.2. **The candy**

The loss of a queen may be the consequence of desiccation (hardening) as well as of liquefaction of the candy. Thus the quality of the candy is of major importance for the success of shipment — especially in regions with hot climate (either dry or humid).

Fig. 155 — *Mailing cages for queens can also be made of plastics. They can be connected to piles.*



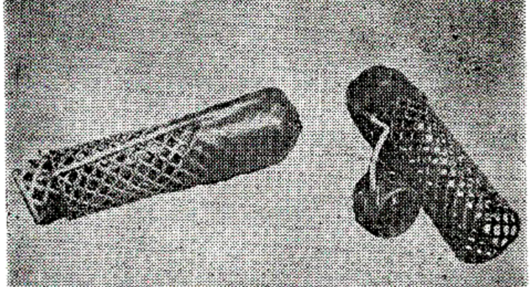


Fig. 156 — *Hair curlers are used for shorter queen transportations. A food chamber is formed at one end by dipping in liquid wax. The candy should be solid to prevent sticking of the bees.*

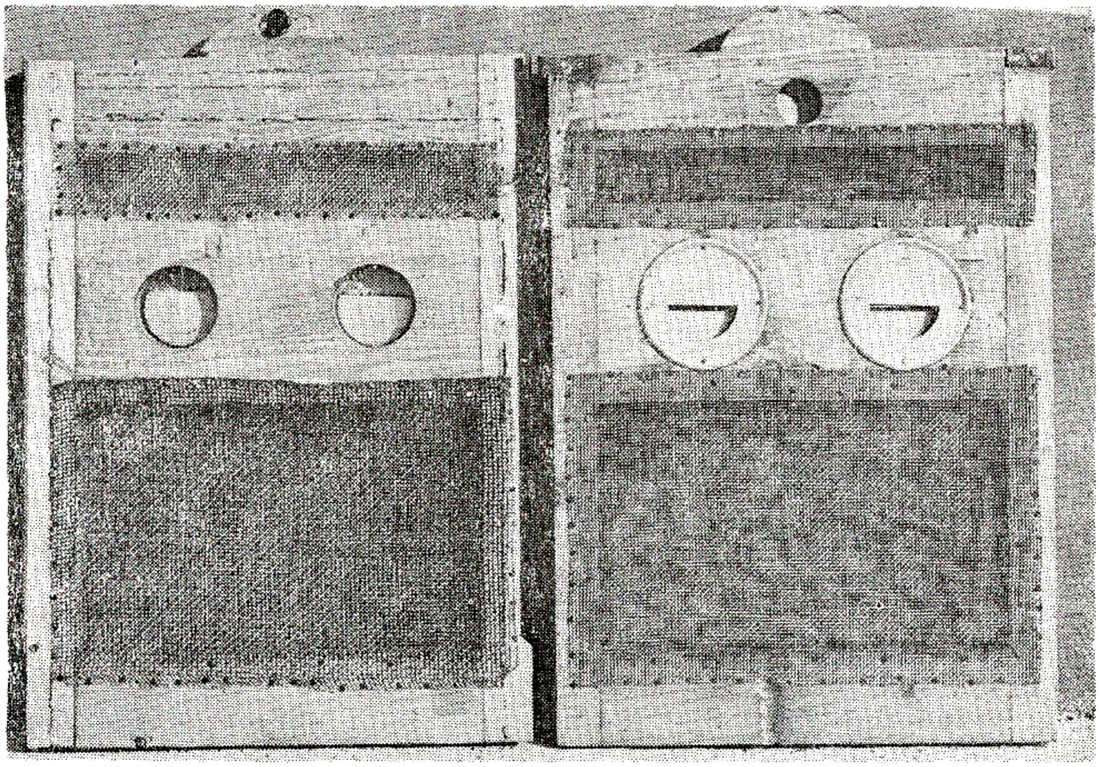


Fig. 157 — *Two brood chambers are separated by a double screened board to obtain young bees hatched without contact with the mother colony. The elder bees return to the mother colony through two bee escapes. A separate entrance without bee escape does not accomplish this purpose. Right : View from top, Left : view from bottom.*

The same candy as described in VIII, 2.2.4. is used. The right consistency, similar to marzipan, is obtained however, only after storage in a container for at least two months. It should be dry and kneadable, and not sticky. SKLENAR (1948) claimed to increase the vitality of the queen by adding some pollen to the candy.

The candy should be filled into the food compartment only a few days before shipment as the wood absorbs a great deal of the moisture from the candy. To prevent this it is recommended to coat the food chamber with liquid wax or paraffin. The surface of the candy under the wire gauze is covered by a piece of grease-proof paper to prevent desiccation (fig. 159).

3.2.3. **The bees**

10—15 bees are added as attendants to each queen. They are taken from an orphaned nurse colony or from the mating nuc. Old bees from other bee colonies should never be used as they would attack the queen.

When no other bees are available any colony may furnish 10—15 bees. When these had been kept in a matchbox for 15—20 minutes they will gladly accept any queen without aggressive behaviour towards her.

For the exportation of queens any prevailing special veterinary regulations must be observed. Frequently the accompanying bees are examined in the country of destination.

For the Istituto Nazionale di Apicoltura Bologna (Italy) the following method is recommended, and has also been adopted in Austria: A screen board, covered on both sides with wire gauze, is placed on top of a bee colony. A bee escape is incorporated who the design of the frame. Now a brood chamber is placed on the top of the hive and is furnished with combs of emerging brood and with food. All brood combs are without bees. The chamber is well insulated and the brood will emerge as the right temperature is supplied through the wire gauze by the colony below. With increasing age the young bees will leave the super by the bee escape and will join the colony below. They cannot return to the super. Only young bees, up to 10 days, remain on these combs ; they will never have had any contact with the mother colony on account of the double screen. If combs which have been used for brood rearing once only are used, there is no danger of an infection with nosema or a brood disease. In no way can *Acarapis woodi* be transmitted. Against transmission of *Varroa jacobsonii*, however, this method is inefficient. It is of course taken for granted that a queen raising apiary will be free of these three diseases ; Nosema however will be stimulated continuously by the stresses caused inevitably by the manipulations during queen raising.

Queens with nurse bees 3—10 days old survive for about two weeks in the cage; very young bees of 1—2 days age must not be used; they survive in the cage for only a few days and they are not capable of nourishing the queen.

3.2.4. **Filling the cage**

More often than not the bees are pushed individually into the mailing cage through the opening. To avoid stings — inevitable when working by hand — an aspirator may be used to blow the bees gently into the cage (fig. 158).

Bigger firms (as Norman RICE, Australia) have developed special equipment to fill the cages. They put a special cover on top of a swarm box filled with bees, which holds in a slit a row of shipping cages

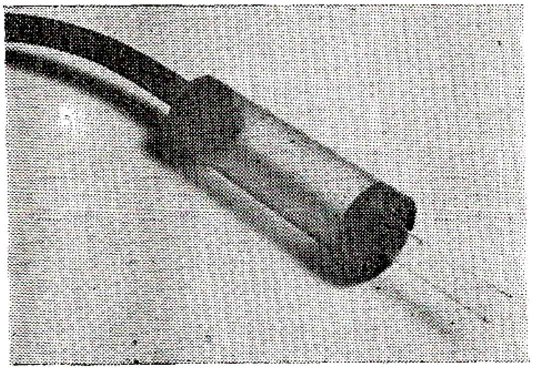


Fig. 153 — *The aspirator to catch bees is made of a lucite tube of about 30 mm diameter. On both ends tubes of 8 mm diameter are attached. The one connected with the flexible mouth tube is protected by a fine screen (tissue = ladies stocking) to avoid aspiration of bees.*

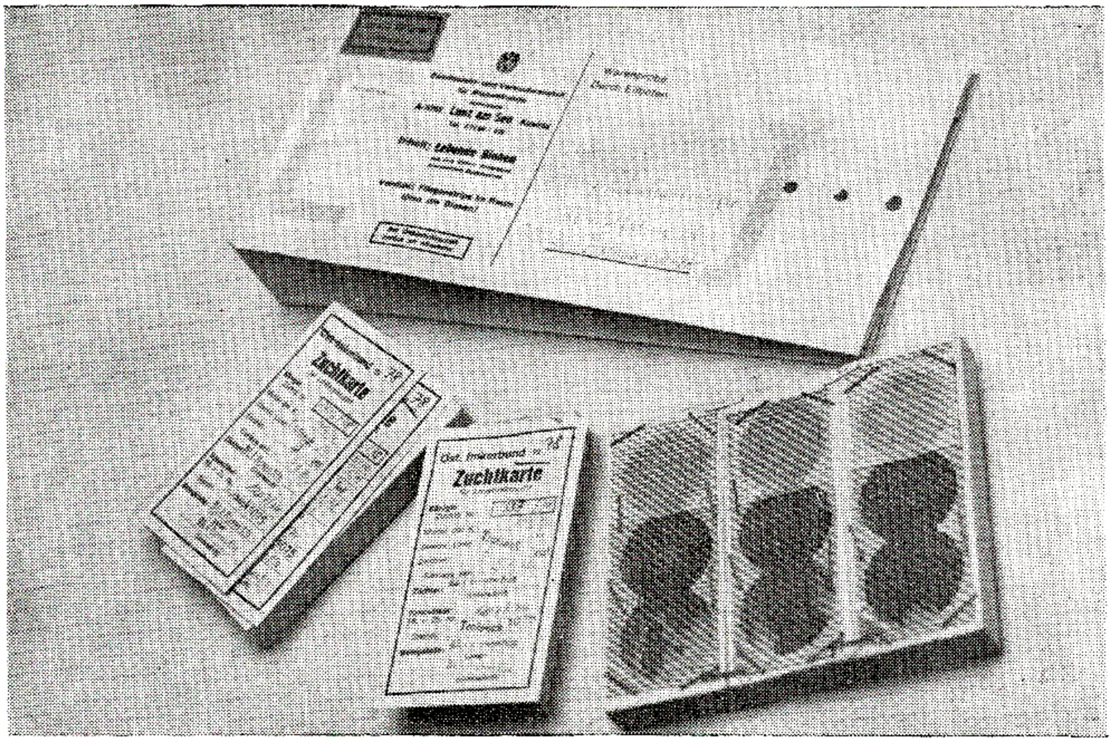


Fig. 159 — *Several cages are attached one to the other by a stapler for mailing. A label should be visible on the bag saying : "Living bees ! Attention, fly strips in the room will kill the bees !" This shallow type of Benton cage is especially suited for shipping by mail.*

(fig. 149). The bees are urged to run up into the cages by gentle use of smoke. Finally a queen is added and the entrance of the cage is closed by a fastener.

3.2.5. Packing

Small shipments are delivered by mail. As the post office accepts only consignments of certain dimensions, the cages are best placed in a robust envelope or — better — in a string paper bag. Several cages are stapled together to plates with a fastener in order to obtain a stable parcel. Ventilation holes are necessary only if more than 5 cages are in the bag. Not much air is needed by the bees — there is rather a danger of poisoning by insecticides entering the bag through the holes.

If however 20 to 100 queens are packed together in the same box, ventilation by free air currents must be provided. If shipping is done by air, precautions have to be taken that the box remains within the climatised passenger compartment of the plane and that it is not treated with insecticides.

Consignments suffer mainly by heat ; especially if the cages are stored in the sun behind a window or within a car. On the other hand, queens can be maintained in full vitality for weeks if transported personally and supplied with fresh water from time to time. Either drops of water are placed hanging in the meshes of the wire, or a piece of moist cotton is given for a drink (see VIII, 4.5.1.).

3.2.6. The arrival of a shipment of queens

The receiver should make his preparations carefully to ensure optimum acceptance of the queens. As soon as the queens are provisioned with water and stored in a well ventilated room (without vapour strips or other insecticides) they may remain in the cages for another few days without danger.

4. Introduction of the queen

A special book would be necessary to review in a thorough way the work done on queen introduction. SNELGROVE (1943) and JOHANSSON (1971) describe in a concise way 65 different methods and some beekeepers, to be sure, will practise still further methods being convinced by their superiority. It is astonishing that nearly all the principles of introduction — also those of the most recent "inventions" — were mentioned in the beekeeping literature already 100 years ago.

What is the reason for this variety ?

Evidently because no method is absolutely safe under all conditions. The success of queen introduction depends on a multiplicity of factors :

1. Condition of the resident queen (age, laying activity etc.).

2. Condition of the queen to be introduced (mating, damage during transport, egg laying activity, production of pheromones etc.).

3. Size and weight of the queens. TARANOV found a high correlation between weight and acceptance of the queen (queens below 180 mg were accepted to 47%, queens heavier than 200 mg however to 96%).

4. Condition of the colony to receive the young queen : Race, aggressiveness, seasonal development, ratio between young bees and old bees ; did it have two queens or already laying workers ?

5. External conditions (nectar supply, robbing, weather, season).

In spring during a good honey flow a young queen may be introduced by simply marking her walk through the entrance ; later the situation becomes less easy and the beekeeper has to consider the most suitable method. Instructions are found in every good book on beekeeping.

An important factor is the expenditure of time needed. If it is feasible to observe the behaviour of the bees towards the queen, the beekeeper has a safe basis for his decision. If possible it is best to wait for the "buzz of queenlessness" after removal of the old queen before introducing the new one. In practice however both actions will have to be done at the same time and this involves some risks.

Even if the introduced queen has started to lay eggs she is not out of danger. This is why the first inspection should not take place earlier than after one week. To prevent balling of the queen nothing but the presence of eggs need be verified in a very careful and quick way without any other disturbance of the colony. The danger of balling of the queen increases until the 21th day, especially if there are genetic differences between the queen and the workers.

4.1. *Changing the queen of unsatisfactory colonies*

A young breeder queen is by no means a miraculous remedy to save weakend colonies — frequently the queens will not even be accepted by colonies of this kind. If for instance a colony had been queenless for a long time, it is better to add a comb of open brood so that it can raise its own queen, rather than to risk a mated queen. Or an open or capped queen cell from a selected strain may be added. At any rate, the young queen should emerge within the colony and start her mating flights from there (VIII, 1.1.). Whether the colony will recover again depends on its success in developing a strong population in time for wintering.

4.2. *Replacing the queen in mating nuclei with brood*

If the laying queens is removed from a nucleus, requeening is generally done by adding a queen cell. With this method however the beekeeper loses control in respect to the quality of the queen, sometimes also in respect to her origin. Moreover, TARANOV found that these queens hatched from cells started to lay eggs after 12—13 days (maximum 15 days) in contrast to introduced virgins which started to lay already after 8—9 (maximum 14) days.

In consequence of these experiences a new method was tested in the USSR of introducing young virgin queen into a nucleus after the removal of the laying queen : A small case was made from thin waxed card-board. About 40 young bees were placed in this box, together with the young queen. The bees had been taken from the nurse colony or from the incubator ; they had emerged from brood combs only 3—5 days ago. The opening of the box had been closed by a thin sheet of wax, perforated with 4 small holes with a diameter of 1—2 mm (nothing is said about feeding the bees, but evidently the bees should be hungry and beg for food). When placed in the colony the bees will enlarge the holes of the box to 4—5 mm and an exchange of bees occurs. Only after 12, 24 or 48 hours the diameter of the hole will permit the queen to pass.

The results are shown in the following table (TARANOV).

Method of introduction	No. introduced	No. accepted	%	mated
Queen cells	50	35	70.0	30
Queens presented in				
a) Titov cages	56	38	67.8	34
b) card-board box with bees	52	48	92.3	46

According to TARANOV, in practical experience the same results (success or failure) were obtained during introduction of thousands of queens when introduction was made either by the card-board box with bees or by adding a queen cell.

We did not test this Soviet method yet but it opens new ways.

4.3. *Requeening of normal colonies*

4.3.1. **Introduction cages**

Under favourable conditions they may be introduced within a simple wire cage, closed with candy, without accompanying bees.

There exist manyfold variations beginning with the shipping cage (BENTON, fig. 159) and hair curlers (fig. 156) to the technically perfect Wohlgemuth cage which is placed with in a comb-building cluster. Recently a cage is recommended with two entrance tubes 8 mm wide, both closed by candy. One tube is shorter (ca 25 mm) and closed by a queen excluder at the inner opening (fig. 160). This short tube is cleared first and single bees will make contact with the queen without becoming aggressive in their semi-isolation. The queen is released only when the longer tube (about 35 mm) is free of candy somewhat later. In the meantime her pheromones had been distributed within the colony. This method was described as early as 1902 by Alley CHANTRY and 1904 by MILLER (see JOHANSSON 1971) and later modified by WOYKE and WENNER.

Other authors (BUTLER and SIMPSON 1956) recommend to let the queen become hungry. The introduction cage is a tube of wire gauze of wide mesh covered at the open end with a single layer of newsprint.

4.3.2. **Push-in cages**

With this system the queen is confined on her own in a cage of wire gauze over a comb area with emerging brood. The grid is pressed into the comb and fastened. If new comb is used the queen will be released by the bees while they remove the dead pupae. With dark comb the queen has to be released after 4 days ; she will have started

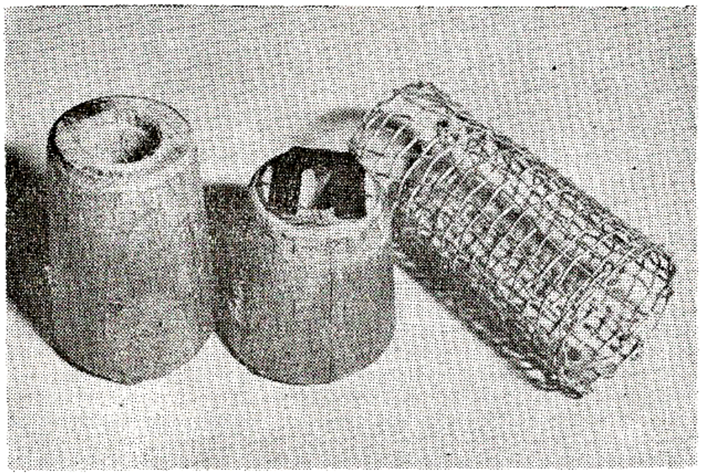


Fig. 160 — *Introduction cage with two entrances of different length, both closed by candy. The shorter tube is supplied with a queen excluder for early access of bees to the queen. The longer tube is to release the queen later on. (Miller cage)*

to lay eggs already at this time. This is best done by piercing a hole through the comb from the other side.

To avoid this manipulation on the 4th day, a tube to release the queen can be inserted into the cage. This is a tube 40—50 mm long and

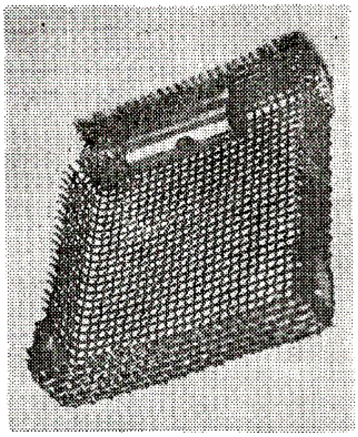


Fig. 161 — *Push-in cage with a tube closed by candy, by which the queen can escape later on, if she was not released through the comb. If a small additional opening of the tube is provided several bees can enter precociously and thus improve the acceptance additionally.*

8 mm wide, totally filled with candy (fig. 161). In my opinion this device could be modified — similar to the cage of Alley CHANTRY — in order to let some older nurse bees enter the cage after a short delay, while the queen is released into the colony somewhat later only.

An additional opening in the sidewall of the tube, 4.5 mm wide, is made 25 mm from the entrance. As soon as this part of the tube is cleared of the candy, the workers of the colony are able to enter the cage. The queen however is released when the other half of the tube is free.

We agree with CALE (1966) that the push-in cage is one of the best tools to requeen old colonies.

4.3.3. **Queen introduction with alcohol**

According to ÖRÖSI PÁL (1957) the Hungarian CSATIS observed already in 1932 that honeybee queens were readily accepted when introduced with the aid of the vapour of whisky. HÜSING (1969) used ethanol 95%, we had the same results with spirit or with a heavy brandy: 10 ml of the liquid for a colony of normal strength (5 ml for a nucleus) are used to moisten absorptive material (such as a paper handkerchief) which is placed on top of the frames. The cage with the queen is closed by a light plug of candy to release the queen quickly while the alcoholic vapours are effective. The cage is introduced before the alcohol is placed a little to one side, not immediately below the pad.

The alcoholic vapours conceal the odour of the old queen (HIRSCHFELDER 1972, H. RUTTNER 1972). The main advantages of the method are good acceptance and the fact that the queen immediately starts to lay eggs without a brood stop being imposed upon the colony.

4.4. *Queen introduction by establishing a new colony*

The methods of queen introduction described so far were mainly devised to reactivate queenless or failing colonies by giving a new queen.

Now however we intend to describe how to bring a precious breeder queen into a colony with the least risk possible.

The only reasonable use of a precious queen is in the building-up of a young colony. In general it will become stronger, will be of better health and higher productivity than an old, requeened colony !

Moreover, a queen is in a bad shape after egglaying has been interrupted for several days. Her queen substance has diminished and thus she is frequently killed or severely damaged for the rest of her life if introduced by a simple requeening method. If however a young colony is created, the risk is only low. Uniting the young colony in autumn (or next spring) with an old colony means a welcome reinforcement ; on the other hand direct requeening by introduction is frequently connected with a brood interruption and in consequence with a weakening of the colony. There are further reasons of hygiene and economy which favour the formation of young colonies with young queens.

A precious queen should be introduced only to a young, developing colony !

What possibilities are there to choose from ?

4.4.1. The shaken swarm

About 1 kg of young bees are shaken into a swarm box off 6 brood combs or off 8 combs out of the super (Attention ! A virgin queen may be present in the super !). The bees may be taken from different colonies. In this case especially the "Marburg" swarm box has proved to be of great advantage.

The bees accompanying the queen in her travelling cage are released (in a closed room only !) and killed, and the closed shipping cage with the queen on her own is placed into the swarm cluster. After filling the feeder the swarm is kept in the dark for 1—3 days.

A hive body is equipped with two combs of food and 4 of foundation. In the evening the swarm is shaken on a large sheet of cardboard and is made to run through the entrance into the hive. The queen is released among the running bees. Feeding is continued until all foundation has been drawn out.

Time : Usually May — June.

Advantage : Hygienic, simple.

Disadvantage : Expenditure of bees during the time of honey production ; emergence of young bees only after 3 weeks have passed.

4.4.2. Shaken swarm in the open (Sklenar)

In the evening an empty frame with the caged queen is fixed in an open position away from the bee yard. Bees are shaken off a number of combs on the cage. The flying bees return to their hive, the young bees stay with the queen. The swarm remains in the open over night, it is hived in the morning and the queen is released.

Advantage: A very safe method, it is especially recommended when the bees of a number of mating nuclei can be united to form a colony.

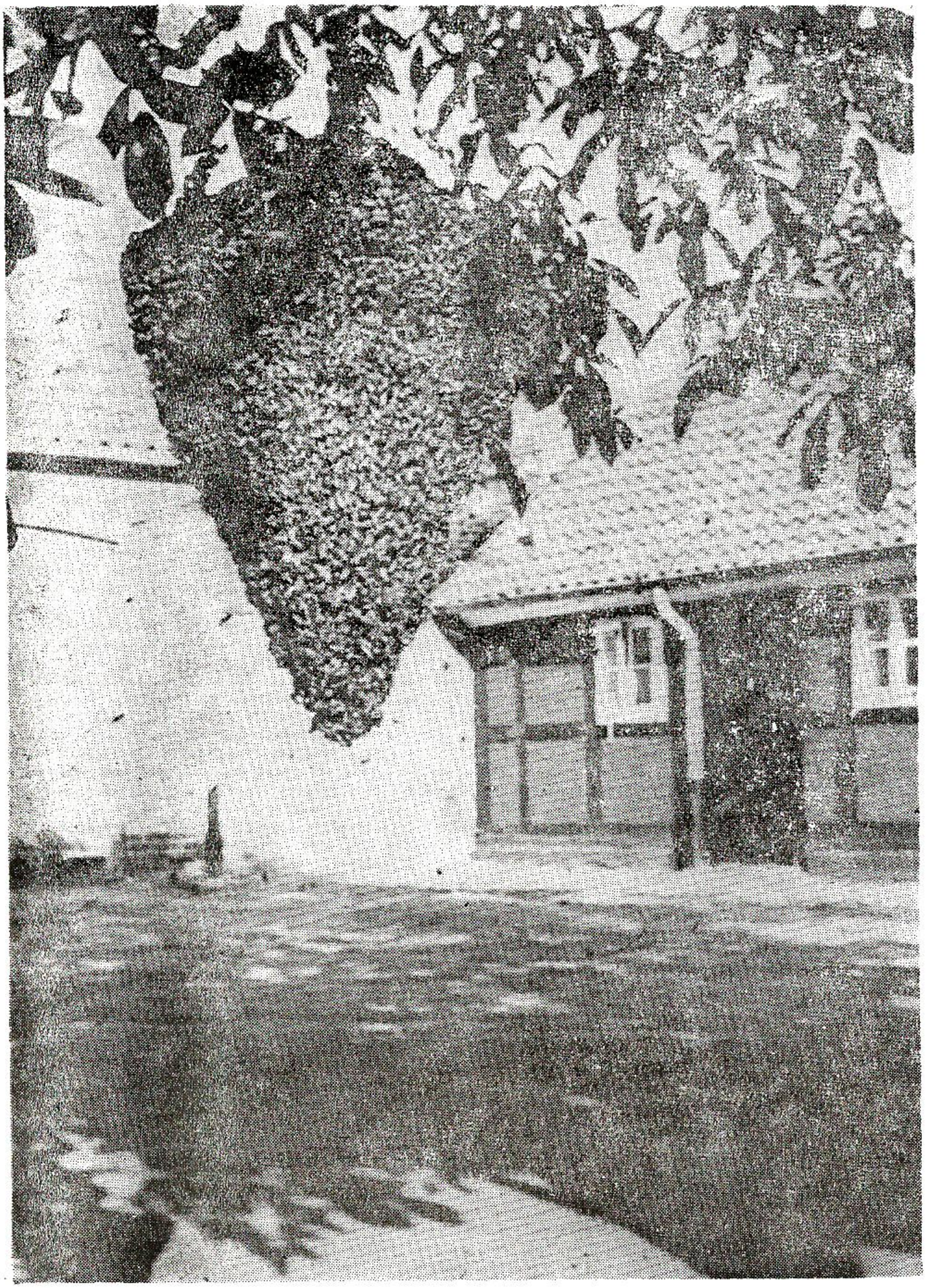


Fig. 162 — *Shaken swarm in the open. The caged queen, fixed to a frame, attracts the shaken bees. The following morning the swarm is hived (photo Englert).*

4.4.3. **Brood division**

1—4 combs of **sealed** brood, depending on the season, and 2 combs of provisions together with the adhering bees are placed in an empty hive body or nucleus hive. The cage with the queen, closed by a plug of candy is inserted in the middle of the brood area. Application of alcohol may promote acceptance (4.3.3.).

When the division can be taken to a bee yard at least 3 km away it can be put on its own place with an open entrance the same evening. This dislocation is of advantage in different aspects : No drifting, no danger of robbing, no disturbance, a new flight area.

If however the division has to stay at the original apiary the bee of 2—3 additional brood combs are shaken into the division to compensate for any bees returning to the mother colony. Further 3 days of captivity in a cool room help to consolidate the new unit. This procedure is recommended if an especially cautious introduction is intended under difficult conditions : The queen is kept in the cage during the 3 days of confinement of the colony and access is permitted only after free flight is given : All old bees will immediately return to the mother hive and the queen is among young bees only. This method is nearly as safe as introduction to an artificial swarm.

Time : June, July.

Advantages : Low expenditure of bees during the period of honey production (a division made with only one brood frame in June may develop into a colony of full strength before the summer flow of the next year). Young bees emerge from the brood comb for about 10 days, thus a nearly continuous supply of young bees is guaranteed.

Disadvantages : In general not quite as safe as the other methods described.

4.4.4. **Division with emerging brood only, without bees**

No loss will occur, if the young queen has the first contacts with very young bees only. This division is made on top of the colony which is to be requeened later on : A hive body is furnished with two combs of emerging brood, with combs with provisions and an empty comb filled with water — all without adult bees. The bee hive which is to "nurse" the division, receives a crown board with a double screen and a closed entrance. The hive body with the brood is placed over this screen board ; the colony below raises the temperature sufficiently for the emergence of the brood. As soon as several hundred bees have hatched the next day, the queen is simply released on one of the brood combs.

Important : The flight entrance of the division remains closed for a whole week ! Only after this period is the entrance cautiously opened so that at first only one single bee can pass. At the beginning the division has no guard bees for its own defense and robbing is the only risk of this method. Do not feed ! Once established the division receives a brood comb without bees from the mother colony every week. Finally the young colony will be stronger than its parent.

The method can also be adapted for hives which have to be opened from the back provided the upper chamber has its own entrance.

Time: Any time of the year, as long as brood is present.

Advantage: This method may be regarded as 100% safe. As more labour and care is involved, it is especially recommended for "difficult cases": e.g. Quens after a long transport or of another race, introduction at an unfavourable period.

In the chapters VII to IX the life history of the young royal larva has been described to her emergence as queen and her mating, and finally also the creation of a new colony. The great number of methods described may appear confusing; however each of them has its place under special conditions of geography, climate, biology, season and management.

CHAPTER X

Rearing and care of drones

F. RUTTNER

1. Introduction

The bibliography on queen rearing is immense. On the contrary only a relatively small number of publications deal with the rearing of drones and with the conditions to keep vital drones. This reflects the lack of interest by beekeepers in drones — even to a certain rejection of these "useless, buzzy and stupid" insects. As far as possible their production was forestalled, so as not to waste honey which could be profit. The statement by LEVENETS (1956a) that for rearing 1000 drones, 750 g of honey and 450 g of pollen are needed and that these same drones consume another 6.32 kg of honey during their lifetime, expresses the opinion of most beekeepers of the past. For the practical beekeeper the counter calculation seems evident, 1000 drones less = 7 kg honey more.

Today, however, we know that this data on drone food consumption is far too high (WEISS 1969) and that drone rearing is dynamically integrated into the biological system "bee colony". This biological system is not merely the simple sum of single factors as in a mechanical structure, but the result of sometimes astonishing interactions, not yet fully understood, even today. Thus it is not surprising that reality is quite different from that guessed at by the most sophisticated calculations. There is no reason why a reducion in honey yield should be expected from the rearing of drones (see later).

No discussion is needed regarding the important influence of the genetic quality of the drones on the quality of the offspring in a breeding programme. It is, however, not yet fully recognized that the quality of the queen bee herself depends to a large exent on the number and quality of the drones available for mating. In this context the term "full mating" (F .RUTTNER, 1956) is of importance. Only those queens which were able to fill their spermatheca with 5—7 million spermatozoa during the short mating flight, will have a full life span of egg production. If this is not achieved as a result of a low number of drones or insufficient flight conditions the queens will frequently be prematurely superseded by the bees.

The lack of interest by beekeepers in drone rearing may perhaps be based to some extent on the experience, that, during the main breeding season sufficient drones are normally present, even without special management methods. On the other hand it is more difficult to influence the rearing of drones than it is queens.

It will be shown in this chapter however that there indeed exist practicable methods of drone rearing. Stimulation of drone production is of particular importance in the following circumstances.

1. Prolongation of the rearing season

2. Guarantee of mating with selected drones for breeding purposes, e.g. during installation of mating yards, isolated mating stations or for instrumental insemination.

2. Drone brood and drones as part of the annual cycle of the bee colony

The appearance of drone brood in the bee colony is the first sign that the instinct for reproduction is beginning to operate. According to D. ALLEN (1958) on average, three weeks (16—41 days) after the first drone brood appears, the first queen cells are found. It is not without reason that in Chapter VII it is stated on several occasions that with the presence of drones (or at least of ripe drone brood) successful queen rearing can be started. Later, in midsummer after the expulsion of drones the time is over for raising queens with simple standard methods and at will. No precise date can be given for the appearance of the first drones ; neither in relation to the date of the calendar or to the start of the flowering of certain plants (phenologically). The differences are too great between years and between colonies. Without doubt however, it has something to do with the relative amount of brood: number of bees.

The first brood in spring is reared by the overwintered old bees. During the normal course the gain of young bees is in equilibrium with the loss of old bees for a period. As the area of brood is continually increasing at the same time this is a difficult and dangerous period for the bee colony. The major proportion of the bees is concentrated on the brood, but nevertheless, the covering is frequently poor even there. In this situation the colony will not be ready to rear drone brood. Only as soon as the supply of bees increases and the ratio shifts in their favour, does the situation ease out with drone brood being accepted for rearing. In colonies which have wintered very strong, sufficient nurse bees are present all the time. In this case drone brood is cared for by older bees also and frequently at a very early date (e.g. during the flowering of the first willows).

Stimultaneously with the tendency to raise drones comes the tendency to construct drone comb. Strong colonies build 90—100% drone cells in May/June (FREE 1975).

This tendency however, changes very quickly as soon as ample drone comb and drone brood is present. The same author was able to show that colonies without drone comb construct more drone cells, and that they nurse five times the amount of drone brood as do those which already have 1—2 drone combs.

By removal respectively addition of drone brood FREE was able to control the amount of drone brood at will.

It is to be expected that strong colonies rear more drones (per 1000 bees) than weak ones. In nuclei with less than 2000 bees no drones at all were reared during FREE's (1976) experiments. However beginning with a colony strength of 4000 bees the results were far from uniform. Sometimes the fluctuations between colonies of the same strength were greater than the differences between different classes of size.

How many drones will a colony raise without any restriction in construction ?

This question can only be answered by experiments, as it is the beekeeper who decides whether and how much drone brood a colony is allowed to start. K. WEISS (1962) observed several colonies which were absolutely free as regards comb construction, since they received only empty frames with a strip of wax foundation. No restriction of the brood (queen excluder) was practised and no honey was taken. Thus the colonies were completely free to develop and to produce as much drone brood as they wanted.

The greatest expansion of drone brood was observed between the end of May and the middle of June. At this time on average, 5100 cells with drone brood were found (range 2900—8700) that is 14% of the total brood. Calculated on the amount of brood throughout the whole year the proportion of drone brood was 4.6%.

D. ALLEN (1964) found similar values : 16%. J. FREE (1973) also counted an average of 5500 cells in 14 colonies with sufficient strength to be included in the experiment. However these colonies were of overall lesser strength and the proportion of drone brood to the total brood was greater (about 29%). 2500 drones cells with brood were counted in June and in July 3400 cells were still occupied.

These considerable figures seem to confirm the optimistic opinion frequently found among beekeeoers concerning the production of drones to be expected by one colony. However, if the number of drones is to be ascertained not by the amount of brood, but by the number of adult drones actually present the picture is changed rapidly in a most confusing way. K. WEISS observed in his experimental colonies with free comb building, that during the first third of July (that is the time of maximum adult drones) on the average, only 1400 males. In one colony only, the number exceeded 2000. This is not more than just a quarter of the expected figure as calculated from the number of brood cells. In the experiments of J. FREE (1976) the differences are still more impressive (see table below).

COMPARISON OF MALE BROOD CELLS AND ADULT DRONES AT THREE DIFFERENT DATES. ONLY COLONIES WITH MORE THAN 10.000 BEES WERE EVALUATED (FREE 1975)

	26.V.	9.VI.	12.VII.
Drone brood cells (without eggs)	5 492	2 555	3 400
Hatched drones	230	1 010	252

Even if the amount of brood counted for the period before is compared (only this gives corresponding values), the difference between the expected and the observed drones is astonishingly high. This rapid decrease is to be explained only in this way; that very many drones perish during the first days of their lives, never obtaining sexual maturity. FREE 1975, observed as a maximum number of drones 514 in May, 1757 in June and 486 in July.

Thus the number of drones actually nursed in a bee colony remains within very modest limits (3.4% of the total bees during the first third of July according to WEISS). The number of drones finally present in a colony is evidently determined only to a small extent by the amount of brood in the previous period .

The calculations presented at the beginning of this chapter on the food consumption of drones are becoming questionable as a result of the above observations. Nevertheless the statement by D. ALLEN (1958) is surprising, that colonies with a high proportion of drone brood do not produce considerably less worker brood and yield the same honey crop as "restrictively" kept colonies with a minimum of drone brood. However, as drone larvae do consume food and from this a higher consumption is to be expected compared to colonies with only a few drones, there remains only the conclusion that colonies with high drone rearing activity work harder and more efficiently. At any rate there

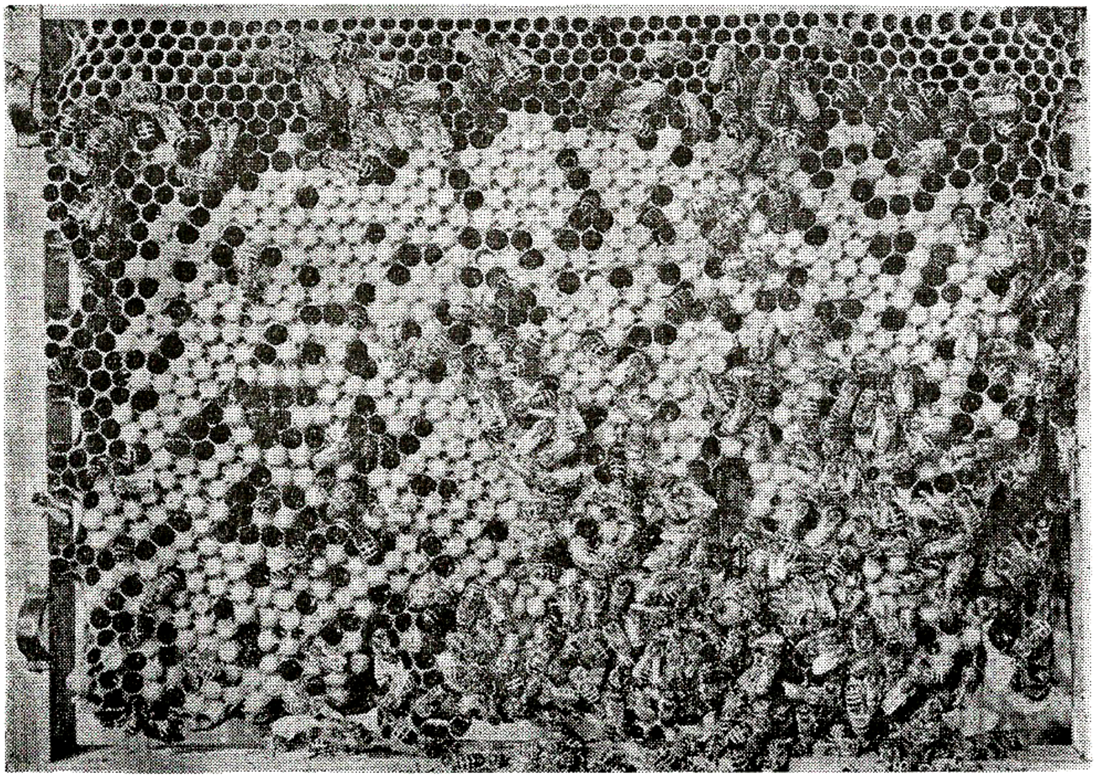


Fig. 163 — *Capped drone brood. Only a proportion of drones hatching from the cells will live to sexual maturity*

is no reason to prohibit the production of drones fearing that the honey crop is diminished. Evidently the drones belong to the picture of a "bee colony working in full harmony" as described in Chapter I.

The state of expelling the drones in midsummer depends to a large extent on the local nectar flow, being therefore rather different in different areas. FREE (1979) was able to prove these connections experimentally by confining bee colonies in flight cages. As long as the colonies were fed they kept the drones fairly well. As soon as feeding stopped all the drones vanished within a few days. At Lunz am See which has high brood rearing activity during summer as a consequence of a good supply of pollen (see p. 183) the drones are kept more than a month longer than at Oberursel, in spite of lower temperatures. In areas with an autumn flow (e.g. in the Mediterranean) a new period of drone rearing may occur, though the amount will be less than in early summer.

It is easy to understand that the capacity to hold drones is dependent on a continuous supply of food coming into the colony (not the provision from stores !), when we remember that drones do not take food themselves but that they are fed by nurse bees (LEVENETS 1956a ; FREE 1957). The drones are provided with a mixed food of high quality, composed of honey, gland secretions and pollen (B. MINDT 1962). Therefore a decrease in the readiness to share food may result rapidly and quite imperceptibly in a reduction in the number of drones.

3. Effect of external and internal factors on rearing and maintaining drones

In the following all factors with a known influence on drones are listed briefly.

3.1. *Strength of the colony*

A strong colony will rear drones earlier and in greater numbers than a weak one.

3.2. *Availability of food*

The provision with pollen is of importance. As was stated by FREE (1925), colonies of bees collect more pollen the more they rear brood. According to TABER (1973) the place of pollen storage is important too. Only pollen storage in close proximity to the brood showed a positive influence on the rearing of drones (see chapter VII).

3.3. *Season*

It is a truism, that a colony of bees will be more ready to rear drones and to produce a greater number during the expansionary stage of colony development in the spring than later in the year, regardless of the factors of colony strength and nectar flow.

3.4. *Influence of the queen*

a) **Age of the queen**

Before their first overwintering queens generally (but by no means always !) will not lay drone eggs. The readiness to lay drone eggs increases with age.

b) **Missing queens**

Queenless colonies maintain drones for a longer period and in better condition than queenright ones. They are ready to construct drone comb (even in conditions where queenright colonies would not do so) but only if there is brood in the colony (FREE 1977).

3.5. *The genetic background*

Inbred colonies are stimulated only with difficulty to rear drones. On the other hand races or hybrids of races with a high swarming tendency will rear and maintain a particularly large number of drones; according to LEVENETS (1956b) ligustica colonies expel drones a month and a half later than do caucasica colonies.

3.6. *Amount of drones and drone brood already present*

The tendency to nurse a surplus of drone brood or drone response is determined by the number of drones already present.

4. Measures to increase the number and quality of drones and to prolong the drone season

To provide a sufficient number of mature drones at the "high season" of the bees — that is during midsummer with a good pollen flow — will hardly meet with difficulty. It is sufficient to provide the colonies at the mating yard in time with drone comb or an empty frame, to have permanently during this period 1000—2000 drones in the colonies. This is the number which may be well fed by one colony. For early queen rearing it has to be clearly understood what is meant by the term "in time". We may take as a rule of thumb that a queen bee needs three weeks from the beginning of rearing (grafting) to the mating flight. The corresponding period for the drone is about six weeks. There are 24 days from oviposition to hatching and then still 16 days to full maturity. Thus to provide plenty of drones for the mating flight of the queen, drone rearing has to start three weeks before queen rearing. On our time table (p. 193) this is day "—20".

Problems start however if queen rearing differs in some respect from normal.

1. Rearing beyond the optimal period (prior or after).

2. Mating at places unfavorable in respect to climate or yield (mating stations in the mountains or on islands or dry plains as in Australia).

3. Need for many drones of specified origin on a nominated date.

4. Need for drones from colonies with diminished vitality (inbreeding, mutations, exotic races).

4.1. *General measures*

All that has been said in VII/1.3. on the preparation of nurse colonies applies. In the previous year strong colonies were selected and cared for generously. It is most advantageous to choose a location for overwintering with good climatic conditions and a good supply of pollen. Colonies with old queens are to be preferred if only the number and quality of drones are concerned. The earliest drones are produced if a drone comb is placed in the middle of the winter cluster in autumn. According to TABER (Chapt. VII/4.2.) it is best to select a "mean" comb with patches of drone cells amongst the worker cells. Later as soon as the tendency to build new combs starts it is best to present wired empty frames. A freshly built drone comb is usually well accepted for brood rearing.

Besides optimal colony strength and the presence of drone comb, the third basic factor for the production of drones is the provision of surplus pollen. If this provision is not guaranteed by a permanent pollen flow, starting sometime before the beginning of drone rearing, pollen cakes have to be fed regularly (for recipe see VII/4.2.). The pollen can be replaced in part or totally by other protein products (commercially available in various mixtures of yeast, milk powder and soy bean flour). This is adjusted to the supply of fresh pollen.

4.2. *Measures for special conditions*

4.2.1. **Prolongation of the breeding time**

For early drone rearing the measures as ennumerated in 4.1., made with particular care, are best suited. Permanent feeding of the drones and nurse colonies is more important than any other measure for rearing late in the season. Further to this a well proven method is dequeening of the nurse colonies. Queenless colonies with good provision keep the drones until the winter (in the autumn of 1977 in our laboratory we succeeded in inseminating queens with sperm of selected breeder drones at the beginning of November). WOYKE (personal communication) maintains the drones needed for insemination on a comb with open brood in a box inserted between the combs and separated from the colony by a queen excluder.

Queenless colonies of course need to be reinforced from time to time with bees and brood. Moreover, an ample supply of pollen must be available. At any rate it is quite obvious that it is easier to rear queens during other than the normal breeding period than it is to raise the drones needed for these queens.

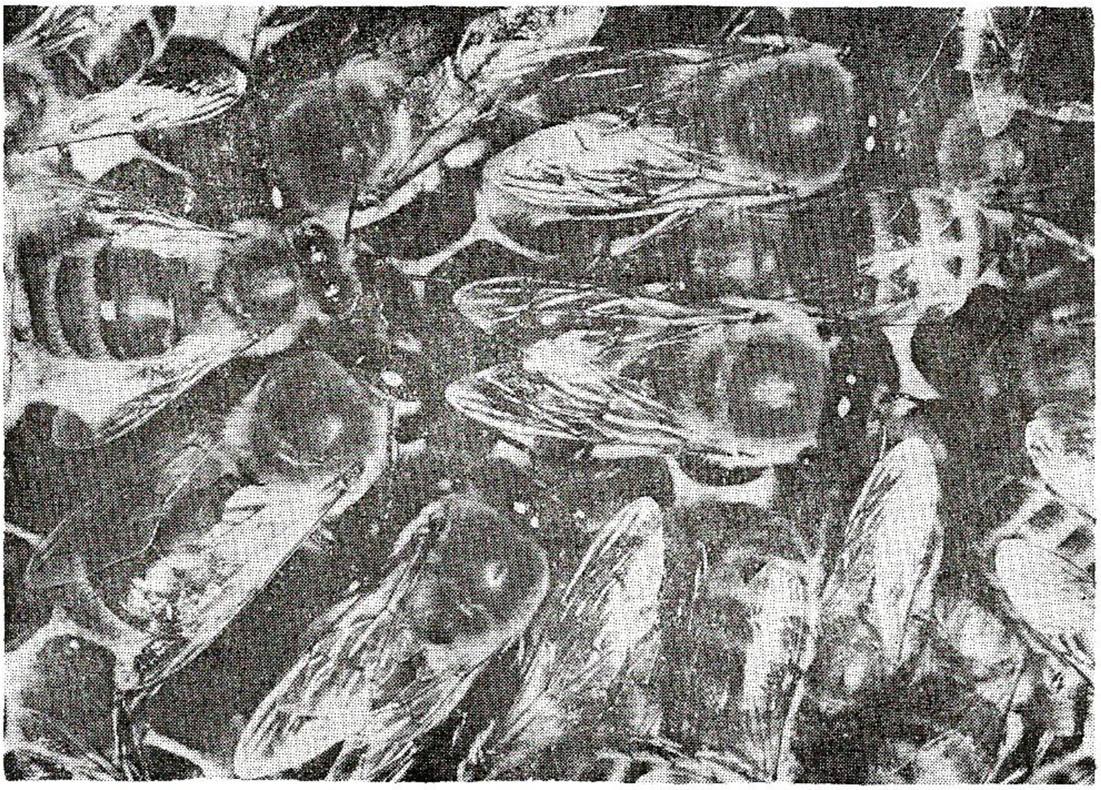


Fig. 164 — *On the peak of development the drones are an integrated part of a normal colony without the yield being diminshed by their rearing or maintaining.*

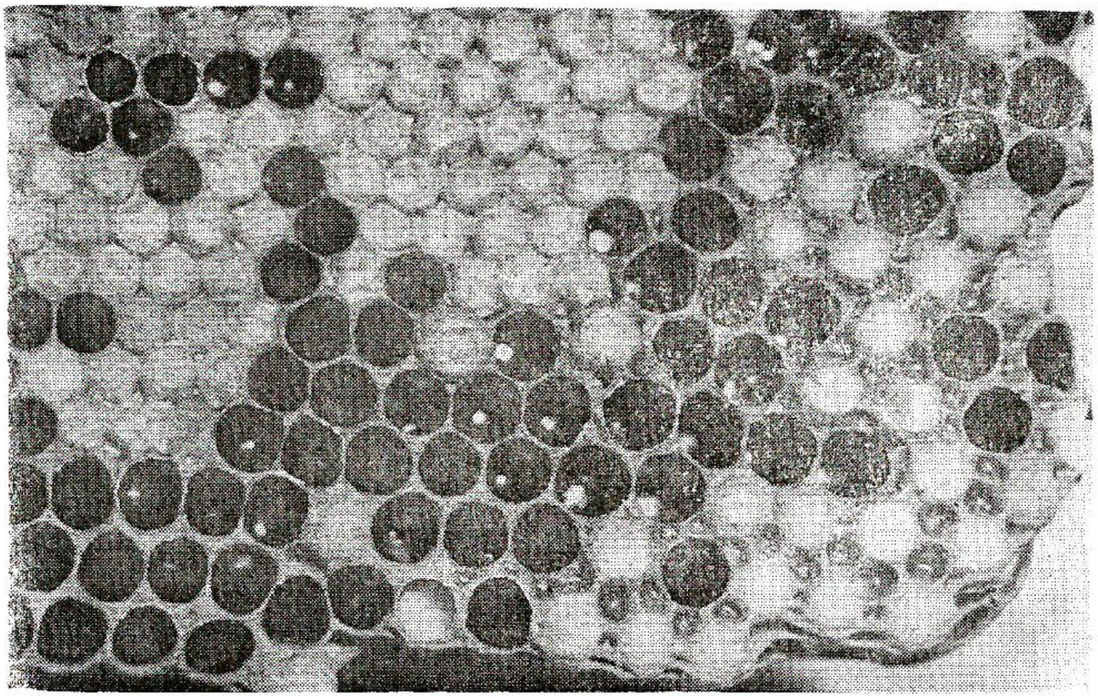


Fig. 165 — *In spring the first drone brood is found on combs with "edges of drone cells".*

4.2.2. Keeping the drone colonies at locations unfavourable to bees

In this context all that was said in 4.2.1. is valid. Permanent feeding is of particular importance. "Unfavourable conditions" may arise abruptly everywhere, not only at certain places, for instance during a protracted period of bad weather. It is no uncommon observation — but nevertheless stated with surprise — that the many drones present in the colony before the change completely disappear. If this event is likely to occur, immediate prophylactic feeding is indispensible.

4.2.3. Rearing of a large number of drones of controlled origin by a selected date

The presence of drone brood and of drones in a colony inhibits the rearing and maintaining of further drones. Thus only a limited number of drones can de raised (and nursed) simultaneously in one and the same colony. If a great number of drones, originating from only a few queens, for a mating station or instrumental insemination are needed, drone nurse colonies have to be used. The breeder queens, mothers of the drones, are continuously supplied with empty drone combs. As soon as the cells are filled with eggs the combs are distributed to other colonies (between combs of brood and separated from the queen by a queen excluder) for brood rearing. These colonies, of course, should not have their own drone brood or drones. After adding the drone comb the tendency to rear their own drones will be small any way. The drone mothers will lay plenty of eggs as no drone brood is reared in their colonies.

4.2.4. Drone rearing from colonies with diminished vitality

Sometimes it is impossible to obtain drones of inbred colonies or of colonies of a different race, in spite of the greatest care and even after reinforcement with other bees. Sometimes many eggs and open drone brood are found, but this situation remains for weeks without any change, older larvae never develop.

There is no other way in this case but to take the young brood and have it nursed to the imago stage in nurse colonies.

Young queens, born in the current year are frequently difficult to induce to lay eggs in drone combs. But if this happens it is better to be cautious and to have the brood nursed in a colony with an older queen.

5. Rearing drones from virgin queen and from worker bees

By for the most reliable method of obtaining drones from young queens of the current year consists in making them drone layers by narcosis with CO_2. An artificial swarm is made with about 750 g of bees and placed in a box with three drone combs. The entrance is protected with a queen excluder, and moreover it is advisable to clip the wings of the queen. At the age of 6—10 days the queen is briefly treated with CO_2 on two consecutive days. About 10 days later she will start oviposition. In this case also, if many drones are needed, the brood should be transferred into a nurse colony.

A method of producing drones used several times in breeding programmes, consists of inducing worker bees to produce eggs (DRESCHER 1975). Young bees are shaken off brood combs after separating them from flight bees (e.g. by the use of the Marburger Swarmbox p. 254). A strong nucleus with only drone comb is placed in an isolated location (to prevent disintegration of the swarm) ; according to FREE (1977) worker bees prefer drone cells to worker cells for oviposition. The nucleus is fed with pollen cake. About 10 days later the queenless worker bees start to lay eggs, but at first many of these eggs are removed by the worker bees. This is why the drone combs with the eggs are transferred into a nurse colony or young nurse bees from a queenright colony are added about 10 days after the start of oviposition. The production of brood food inhibits the development of the ovaries and therefore egg laying in these new nurse bees. The drones reared are on top quality, in respect to size and production of spermatozoa.

CHAPTER XI

Diseases and abnormalities of queen bees

W. FYG

1. **Introduction**

From experience it should be clear to every beekeeper that the good growth and survival of a colony depends mainly on the queen. This is understandable when one realizes that the queen is the only female in the hive with fully developed sexual organs which after successful mating can lay fertilized eggs from which female descendants, i.e., workers and daughter queens develop (Fig. 166).

Only she is in position during the brood period to produce the large number of young worker bees necessary for the natural develop-

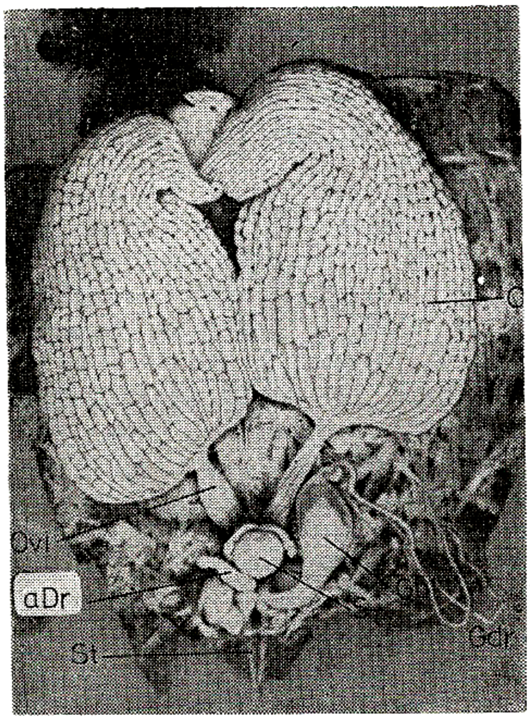


Fig. 166 — Reproductive organs of the queen (photo) : AG = alkaline gland ; PS = poison sack ; O = ovary ; OVI = oviduct ; S = spermatheca

ment of the colony. Because the queen transmits to her descendants the genetic potential of the drone and herself, she determines at the same time the good and bad qualities of her colony. Under these circumstances it is understandable that the whole colony suffers and can even die out when the queen cannot completely fulfill her role due to genetic or body deficiencies or to sickness. Today we know that not only inferior but also queens of good stock reared under favorable conditions can be subjected to numerous diseases and abnormalities. In this case we are concerned with very different infective diseases and physiological disturbances or deformities including those inherited that first appear only in the descendants. What many have in common is that they reduce or prohibit the queen from laying eggs. Knowledge of these is not only desired but is necessary from both the scientific and practical standpoint. Only then when the diseases and abnormalities of queens are well known will it be possible to determine whether the queen or other causes are responsible for poorly developing or dying colonies. The queen breeder should have a special interest in this special area of bee pathology and support research in this area. In the following a few of the more important diseases and abnormalities will be described, which I became aquainted with during my long years of work at the Bee Laboratory of the Dairy Institute in Liebefeld (near Bern Switzerland).

2. **Drone laying**

Drone laying is the most common disturbance affecting laying queens. This is the partial or complete inability to produce female descendants. It can be caused by completely different conditions (FYG 1947, 1963, 1968).

2.1. *Absence of insemination*

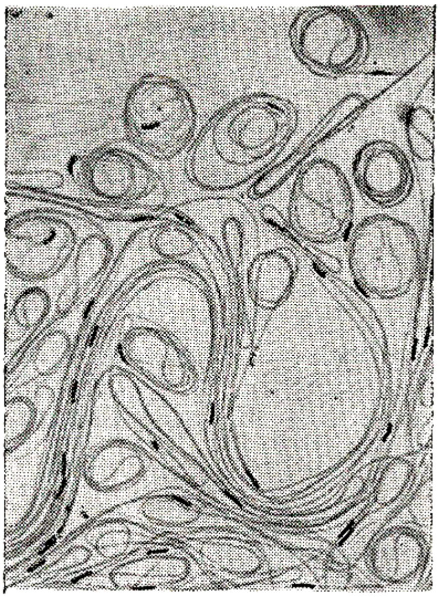
Young queens that for some reason have not mated cannot fertilize their eggs and thus, so far as they can lay, produce only drones. Such queens reveal themselves in many cases in that they begin to lay eggs only after 3—5 weeks, i.e., they begin laying late. This is connected with the delayed and often poorly developed ovaries. This is understandable when it is realized that in many insects copulation stimulates female sex gland development and egg production. My personal observations indicate that more than 1/3 of the unmated queens have no ovariole development at all. Consequently they do not become drone layers as they are sterile. In beekeeping circles it is usually thought that non-mating is due to bad weather or lack of suitable drones for mating. However one must realize that for successful mating, other factors also can play a determining role. The first condition in any case is that newly emerged queens become sexually mature at the correct time. This maturing process whose external characteristics have been described in detail by F. RUTTNER (1964), normally occurs during the first two weeks. According to BIEDERMANN (1964) this process depends upon certain hormone glands, especially the neurosecretional glands in the brain of the queen. Under these conditions a disturbance in the functioning of one of these hormone producing organs is enough to delay or inhibit the sexual maturity process. The workers which attend the young queen are also partially responsible for the successful mating process. HAMMANN (1957) found that increasing aggressive behavior on their part towards the emerged queen during the first days has the important function of stimulating the queen to make the necessary orientation and mating flights. It is interesting to note that it is not the young, but mainly the older bees who do this. When the workers are not aggressive, the young queens do not fly out with the result that they are not mated (HAMMANN, 1957 ; RUTTNER, 1964).

2.2. *Insufficient insemination*

It is common knowledge that during the copulation with drones, the queen receives enough sperm (5—6 million) in her spermatheca that she can lay fertilized eggs for up to 4—5 years. However the situation can arise where the queen does not obtain enough sperm and thus prematurely depletes her reserve of sperm. The technique of counting sperm was described by MACKENSEN and F. RUTTNER (1975). Such inferior or poorly mated queens are not only known by their delayed and irregular egg laying but also by their small brood nest with its scattered brood. After a short period of time mainly drone eggs are laid in the worker cells. Often egg laying is completely stopped. As in the case of unmated queens, these queens must be replaced as soon as possible.

2.3. *Brood of senile queens*

A simular condition occurs in correctly mated queens of advanced age. After a drop in egg production often beginning in the third or fourth year of life, increasing amounts of drone brood laid in worker cells, gradually begins to be mixed with the normally solid patches of worker brood. Bee breeders generally attribute the decreasing productivity and increased amount of drone brood to the progressive exhaustion of the ovarioles and stored semen. This however is not so. After an examination of a large number of 4 and 5 years old queens I could ascertain that although egg building in the ovarioles was slower it was not inhibited. In so far as the queens were healthy, their spermatheca still contained large quantities of semen. But most of the sperm were unable to move and many were rolled up into the "ring sperm" position (Fig. 167). They were probably damaged. A queen with such sperm in her spermatheca can fertilize only a part or no eggs at all and for that reason they become partial or complete drone producers. This peculiar sperm damage is probably the result of a degeneration of the wall of the spermatheca consisting of a single layered epithelial



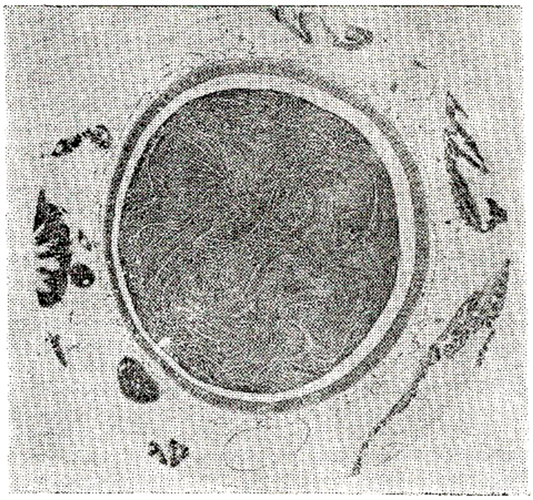
Fg. 167 — *Ring sperm (microphoto)*

sheat and a very dense network of tracheae (Fig. 168 A and B). Although the sperm in the spermatheca are under anabiotic conditions in a state of dormancy and thus probably have only a minimal metabolism, recent electronmicroscope finds of F. RUTTNER, ENBERGS and KRIESTEN (1971) speak for an active transport of elements through the spermathecal wall. According to the experimental results of G. KOENIGER (1970) the function of the tracheae in the spermathecal wall is to supply the sperm with oxygen. Both are certainly necessary to maintain the inactive sperm in the spermatheca alive and potent for several years. According to my observations (FYG, 1960), amyloid is deposited in the sperm pump, in cells of the spermathecal epithelium and in other organs of ageing queens. Amyloids are carbohydrate protein complexes in the form of small often agglomerated particles. This is a typical ageing process that begins in the second year and continues afterwards. These amyloid deposits degenerate the epithelial wall of the spermatheca and probably have a negative or degenerating influence on the spermatozoa.

2.4. *Pathological drone laying*

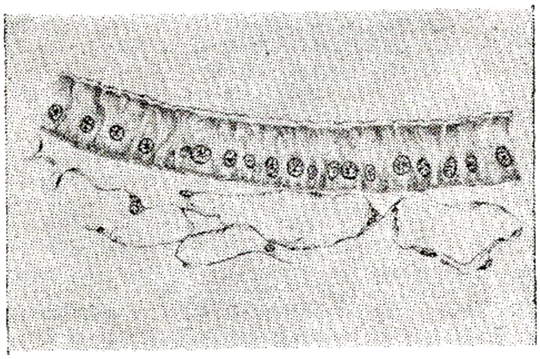
This subject deserves special attention because it concerns a sickness which is specific to queen bees and independant of the mating process (FYG 1963, 1964, 1968). As the following statistics point out, this sickness is very common. From 1261 drone laying queens that I examined from 1947 to 1963, 443 (35%) were not mated, 57 (4.5%) incompletely mated, 82 (6.5%) senile drone laying and 591 (47%) drone laying because of sickness. The remaining 88 queens laid drones for unknown reasons. Pathological drone laying is indicated when a properly mated queen begins to become drone broody already in the first or second year of life long before her supply of stored sperm is exhausted. One day she begins to randomly lay unfertilized eggs in worker cells with the result that there is a mix of worker and drone brood. Eventually her drone brood production equals that of a senile or unmated queen. At this stage many queens stop egg laying. When the spermatheca is examined many sperm are found. However instead of being typically bundled as in a healthy queen (Fig. 168 A) many are rolled into a "ring sperm" position (Fig. 167). ARNHART (1929) who first described this abnormality was of the opinion that it was due to cold damage in the late fall or early spring during sudden cold weather spells. But this causual explanation is not satisfactory because this sickness often occurs during summer months.

In the fall of 1947 after a histological search I found that in reality we were dealing with a sickness special to queen bees that not only attacked the spermatheca but many other organs and which was probably dueê to a virus.*) Even unmated queens soon after emergence can



A

B



C

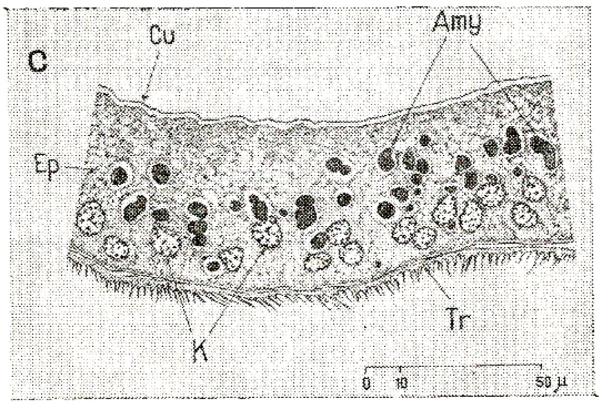


Fig. 168 — *A : Cross section of spermatheca containing sperm (microphoto).*
B : Section of normal spermatheca wall (drawing)
C : Amyloid deposits in the spermathecal wall (drawing); AMY = amyloid bodies ; CU = cuticula ; EP = epithel ; N = cell nucleus ; TR = trachea

*) Viruses are the smallest living units composed of nucleoprotein and lipids that live and propogate in living cells only.

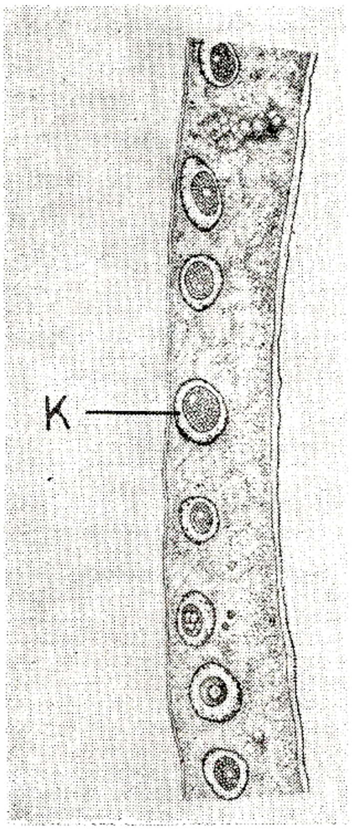


Fig. 169 — Pathological drone broodiness : spermatheca wall with inclusions in the nuclei (drawing) ; K = inclusions

become so infected that mating is probably hindered. The small disease causing organism produces characteristic nuclei inclusions in the organs affected which are easily recognized (Fig. 169). For that reason it is now possible in every case to determine whether or not pathological drone laying is present. A secondary characteristic of this disease is the degeneration of the sperm. This is probably due to the lower oxygen transport of the infected spermathecal wall. The infective nature of this disease is not only indicated by the results of microscopic examinations, but also by practical experience. The disease occurs especially often in certain bee locations and can infect several often neighbouring colonies almost at the same time or shortly one after the other. Several beekeepers who replaced the sick queen with a healthy one had to replace the second queen after a time because she also became sick. It is not known in what manner this disease is transmitted. Above all we don't know if workers are involved. It is certain however that race does not play a role because at least in Switzerland this disease has been observed in the local race, Italian, Carniolan and crosses.

3. Mating disturbances

During natural mating the sperm from the copulating drone does not enter the spermatheca directly but arrives first in her vagina and lateral oviducts, the latter swelling (Fig. 166). From here the sperm is transferred through the fine spermathecal canal into the spermatheca. This very complex process has been experimentally studied and described in detail by RUTTNER and KOENIGER (1971). The amount of sperm received is so great that only a small amount can be stored in the spermatheca. The rest must be eliminated before egg laying. From time to time the excess sperm is not eliminated but remains lodged in the female reproductive tract developing into ropy plugs (Fig. 170) that hinder oviposition. These obstructions can develop to different degrees (FYG 1963, 1968). Such queens are usually recognized by their bloated abdomens and open yawning sting chamber which often after many days still has part of a mating sign stuck inside. When the sexual organs of these queens are checked, spermatozoa in the spermatheca are normal and active. But in addition to the irregular masses of mucus from the disease, the sperm in the oviducts and vagina are visibly damaged and mainly rolled up. It is possible that these mucus masses which do not occur in correctly mated queens damage the sperm and thereby are responsible for the mating disturbance. For beekeepers it is worthwhile to know that such mating disturbances occur more often at certain bee locations and mating yards and often in sister queens at the same time. We must ask ourselves whether or not in such cases a physiological disharmony exists between the mating partners. Only futher experiments will answer this question.

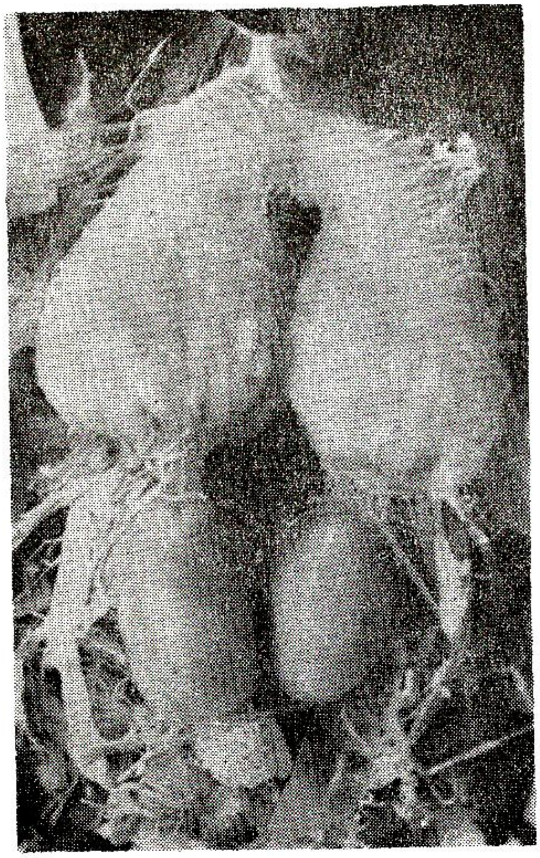


Fig. 170 — *Mating disturbance : Oviducts filled with clumps of semen*

4. **Diseases of the reproductive organs**

It is clear that all diseases that affect the queen's reproductive organs exert a very negative influence on egg laying. This is true not only for different infective diseases but also for certain metabolic disorders that cause a degeneration of the ovaries. To the first group belongs for example, the parasitic or *M-Melanosis* (FYG 1934, 1963) which is caused by a microorganism similar to yeast. The causative organism is probably introduced from outside into the sexual organs. In the oviducts and ovarioles it causes a very typical lumpy infection brownish black or black in color (Fig. 171, n1, n2). Young and old queens which are infected stop egg laying within a few days and become sterile. The same parasite occasionally also infects the poison sack and poison gland. The infective lumps in these organs can become so large and hard that their pressure on the oviducts may make egg laying more difficult or even inhibit it.

A similar and just as often occurring infective disease of the ovarioles is *B-Melanosis* (FYG 1963, 1968) which mainly occurs in young queens. It is caused by a coli related bacteria with flagella. The infection in the ovary also is black colored but of a different type. The disease often appears shortly after mating or soon after the begin of egg laying. Melanosis can occur occasionally in large numbers after queens are inseminated when strict sterile conditions are not maintained (F. RUTTNER 1975).

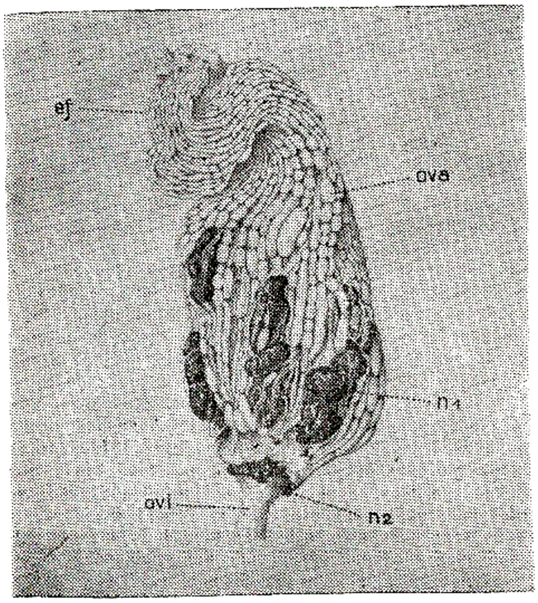


Fig. 171 — *H-melanosis : Ovary with seats of infection (drawing) ; EF = end filaments of the ovaries ; OVA = ovarioles ; OVI — oviduct ; n1, n2 = melanotic seats of infection*

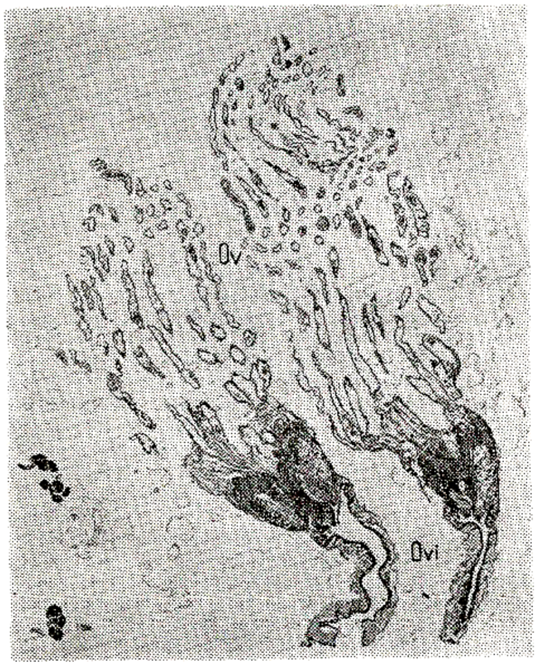


Fig. 172 — *Ovary atrophy : section (photo)*

Ovarian atrophy (FYG 1963, 1968) is another disease of the reproductive organs occurring more often than realized attacking young and old but especially egg laying queens. The characteristic for this disappearance of the ovary is the deterioration of the germ, egg and food cells in the ovarioles and the reabsorption somehow of the breakdown products. In the terminal stage of this disease the ovarioles contain neither eggs nor egg developmental stages and for that reason appear completely barren. Excepting for the shriveling of the ovarioles, two other symptoms are the thick swelling or hypertrophy of the fat body tissue and the conspicuous increase in the amount of blood. Both are possibly related to the fact that the breakdown products of the egg and food cells of the ovary are reabsorbed into the blood and fat body cells. The cause for this peculiar disease of queens is still unknown. All examinations up to now indicate that disease is not caused by bacteria because no visible microbes have been found in the blood and degenerated ovarioles. Futher research of this disease should take into consideration the possibility of a viral infection or a metabolic disturbance caused by an internal secretion.

5. Intestinal diseases

5.1. *Nosema*

The most frequently occurring intestinal disease of the queen is nosema which is caused by the spore forming animal *Nosema apis* Zander. When the spores of this parasite are ingested along with the food into the alimentary tract, they germinate in the lumen of the midgut which functions as a stomach. The amoeboid vegetative form penetrates the epithelial cells of the midgut. Within a few days large quantities of new parasites are produced and again spores are formed (Fig. 173). The epithelial cells crammed with nosema spores are shed into the lumen

Fig. 173 — Nosema *infected gut (microphoto)*

of the gut during the continual renewal of the midgut mucus cells. Along with the undigested food they pass from the midgut into the hindgut and are eliminated with the excrement into the hive. For that reason every nosema infested queen is a source of infection for her colony until the disease causes her death. Although the nosema parasite attacks only the epithelial cells of the midgut, the infection has a negative influence on other organs because of the metabolic disturbances it causes. This is especially true above all for the ovarioles that degenerate within a short time thus rendering the queen infertile (FYG 1948, HASSANEIN 1951).

Although the queen is just as sensitive as the worker bee to a nosema infection, it does not mean that in every hive with nosema infection that the queen is sick. From 310 queens out of infected hives which the author has studied over the years, only 127 or 41% had nosema. The remaining 183 or 59% in contrast were healthy. Queens from colonies beset with both nosema parasites and malpighian tubule amoebae have a greater risk. From 164 queens out of such colonies, only 38% were healthy while 62% had nosema. The higher risk of infection is probably due to the resulting diarrhea caused by the malpighian tubule amoebae which enhances the spread of nosema in the colony.

5.2. *Enteroliths (intestinal stones)*

Additional intestinal disorders can also negatively influence egg laying. This is the case for the formation of enteroliths or stones in the hindgut (FYG 1960, 1963, 1968). These hard round or egg shaped formations (Fig. 174 E) range from yellow ocher to brownish black in colour. They occur in varying numbers in the hindgut epithelium and often reach an imposing size. The enteroliths show concentric layering

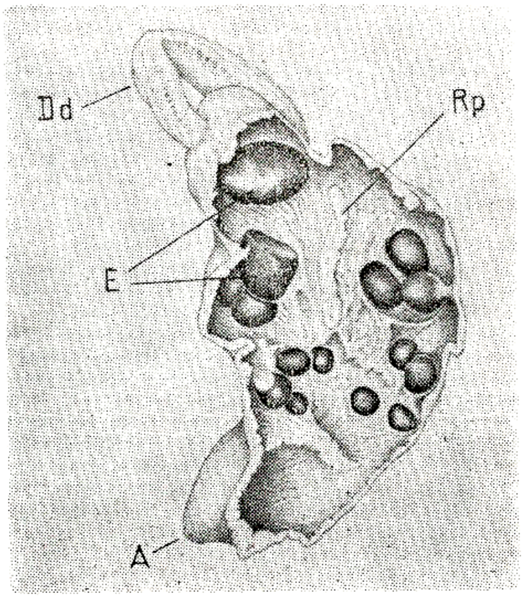


Fig. 174 — *Stone formation in hindgut (drawing)*
A = anus ; Dd = small intestine ; E = stones ; R = rectal glands

and a radial structure similar to many human gall and bladder stones. Chemical analysis indicate that the hindgut stones are mainly composed of uric acid. Their existance is probably due to a metabolic disorder. The enteroliths almost always slow the passage of excrement which in turn causes the hindgut to swell. This in turn can make egg laying more difficult. In addition large stones in the hindgut which lays under the reproductive tract probably can exert so much pressure that a queen will not be able to lay eggs.

6. Acarine disease

One of the most well known infective diseases is acarine disease which is caused by the mite *Acarapis woodi*. This mite also attacks queens. Infestation occurs when fertile and reproductive female mites pass through the spiracles into the large prothoracic tracheae of the host. Here they subsist on blood from the bee and reproduce. According to the results of MORGENTHALER (1933, 1968) both the queen and workers can only be infested during their first days of life. Later they are largely resistant to mite infestation. This age resistance is probably the reason why older queens in highly infested colonies can remain healthy. Queens which are infested shortly after emergence do not die from the disease and for this reason are a dangerous source of infestation for their colony.

7. Abnormalities and malformations

As in all living forms it is possible for the queen and her workers to deviate from the norm. Depending upon the smaller or larger degree of deviation they are called either abnormalities or malformations. These irregularties can be the result of either genetic or environmental factors. Only systematic breeding experiments or thorough anatomical examinations can produce reliable information. Although many abnormalities and malformations are of no importance to the beekeeper, their research increases our knowledge about the external and internal conditions necessary for normal development. At the same time it can help reveal important genetic processes of the honeybee. This should not only interest scientists specialized in this area but also bee breeders. For this reason a few of these abnormalities will be described.

To begin with the so called dwarf queens should be mentioned. They are sometimes produced under poor honey flow conditions and are about the size of a worker bee. In no case should they be confused with an egg laying worker because excepting for their small size, their anatomy does not visibly differ from that of a normal queen. Their reproductive organs are so small however, that usually they do not mate and thus remain infertile. Although stunted growth in many animals can be due to heredity or disturbances of internal secretions, in the case of the queen it is probably due to insufficient feeding during the larval period. These dwarf queens are often not only tolerated but also treated as a normal queen by the colony. They resemble the primitive or transitional forms between the queen and worker as described in the papers of BECKER (1925), v. RHEIN (1933), KOMAROV (1935) GONTARSKI (1936, 1941) and VAGT (1955) (see chapter 4.3). All transitional female forms between a typical queen with fully developed reproductive organs and a normal worker specialized for foraging without reproductive organs can be produced depending upon the age of the larvae used for grafting. Anatomically complete queens are only produced from freshly emerged or at the most one day old larvae that from the beginning or very early are fed with royal jelly. Dwarf queens are sometimes produced from older larvae in the honey super. Their presence, when not realized, can be the reason why a colony will stubbornly refuse to accept a queen.

Crippled wings

It would be false to assume that the normal development of the queen depends upon food only. Other environmental factors also have a large influence. This is especially true for temperature, humidity and supply of oxygen (FYG 1958, 1959). Queens with crippled wings can be produced when the queen cell is temporary chilled during the pupal stage (Fig. 175). A similar wing deformity of queens, workers and drones according to HACHINOHE and ONISHI (1959, 1954) can occur which is due to a change in the genes, the mutation rudimental wings. Since such queens cannot fly and tbus are unable to mate under natural conditions, it is necessary to perform artificial insemination to determine whether the malformation is due to a genetic or environmental factor.

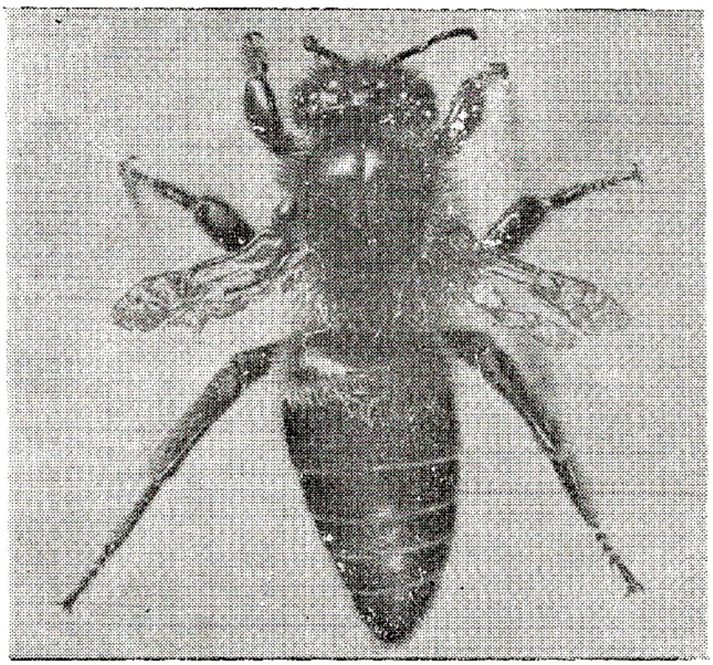


Fig. 175 — *Queen bee with crippled wings (photo)*

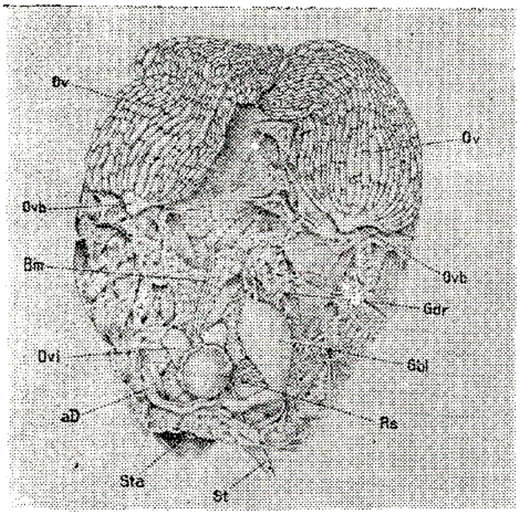


Fig. 176 — *Developmental inhibition of the oviducts (drawing): aD = alkaline gland ; Bm = ventral nerve cord ; Gbl = poison sac ; Gdr = poison gland ; Ov = ovary ; Ovb = calyx of ovary ; Ovi = oviduct ; Rs = spermatheca ; St = sting ; Sta = sting apparatus*

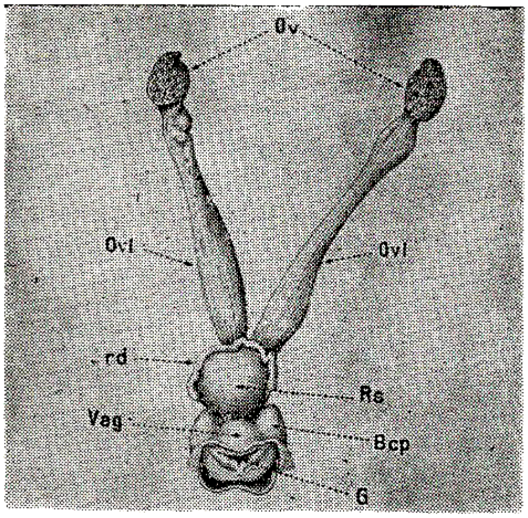


Fig. 177 — *Ovarian hypoplasia (drawing) : Bcp : bursa copulatrix ; G = orifice of the vagina ; Ov = ovary ; Ovi = oviduct ; rd = spermathecal gland ; Rs = spermatheca ; Vag = vagina*

Not only the wings and other body appendanges, but also different organs can exhibit developmental disturbances. Two examples concerning the reproductive organs will illustrate this (FYG 1963, 1964, 1968). In the larval and early pupal stages the ovarioles and reproductive tract develop independently of each other. During the period that the small sausage shaped ovaries lay under the dorsal region of the 8th abdominal segment, the vagina and oviducts grow inside from a pair of swellings located ventrally on the 10th abdominal segment. They usually connect with the ovarioles on the third pupal day. For some unknown reason it can occur that the oviducts stop to grow before they reach the ovaries (Fig. 176). In this case there is no connection between the closed off ovarioles (Ov, Ovb) and the two oviduct (Ovi) stumps on the sides. Egg laying under these conditions is of course not possible. As I have found in many cases, this oviduct defect will not inhibit a successful mating. Lack of ovariole development occurs less often. Fig. 177 illustrates such a case. It concerns a young externally normal but sterile breeder queen. Both her ovaries were rudiments (Ov), but the oviduct (Ovi) and the vagina (Vag) and spermatheca with its glands, were in contrast, very well developed. The congenital atrophy or hypoplasy of the ovarioles was due to the early degeneration of the germ cells in the ovary structure. That the queen was naturally mated in spite of this is interesting from the scientific standpoint, because it supports the long known independence in insects of the sex organs and sexual instinct from the functioning of the germ cells.

Another malformation which can occur in queens and their descendents is gynandromorphism or hermaphroditism. In this situation internal and external male and female anatomical features can occur side by side or in a moisac mixture. These gynandromorphs which develop from a fertilized egg have stimulated the curiosity of scientists for a long time and for that reason there are many theories about what causes their formation. However here we will not go into specific details as that would lead us too far away from the present subject. Here it is enough to say that Miss Betts was the first to describe a queen gynandromorph in 1923. The right side of this queen was male and in contrast the left side female shaped. In July 1941 the bee laboratory at Liebefeld received a queen from the Swiss canton of Tessin that had produced numerous and many varied forms of worker bee gynandromorphs over a two year period in an observation hive. In one graft from this queen, a gynandromorph queen almost ready to emerge which developed probably from a larva with a gynandromorphic predisposition was found. This queen (Fig. 178) had a drone head and an abdomen with well formed female sexual organs. A thorough anatomical investigation indicated that in reality, it was a moisac and not a transversal gynandromorph. If this abnormal queen had emerged and remained alive it would have provided the rare in the honeybee occurring opportunity to study the sexual behavior of a queen gynandromorph.

Another abnormality to be mentioned is "cyclops" (Fig. 179). It is characterized by the approachment and in typical cases dorsal fusion of the two side occurring compound eyes to a single, sickle or half moon shaped eye. This developmental disturbance occurs predominantly in workers and drones but has only been observed very seldom in queens (LOTMAR 1936, HOFMANN and KÖHLER 1953, F. RUTTNER 1968). Examinations by Lotmar indicate that not only the eyes but also the brain, ventral nerve cord and other internal organs are deformed. Al-

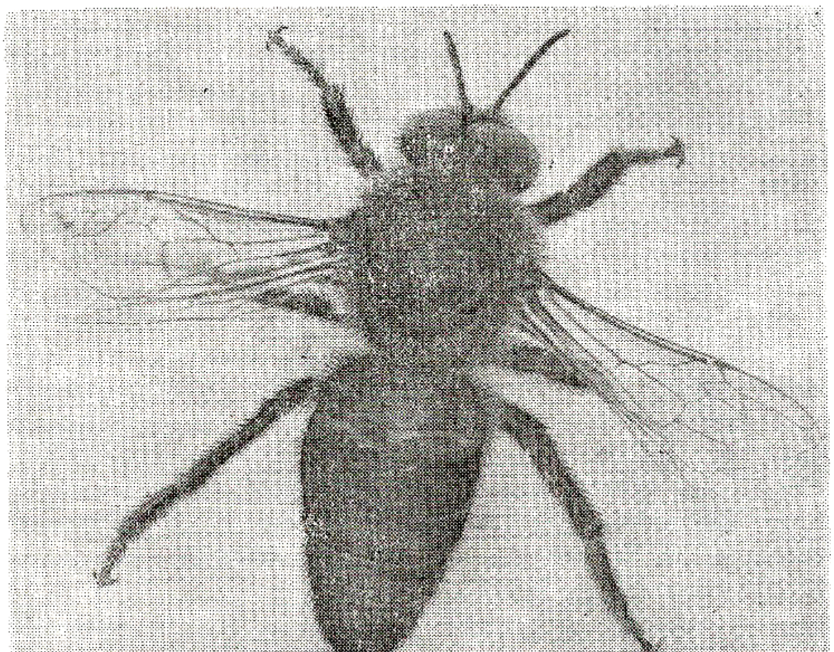


Fig. 178 — *Queen gynandromorph (Photo)*

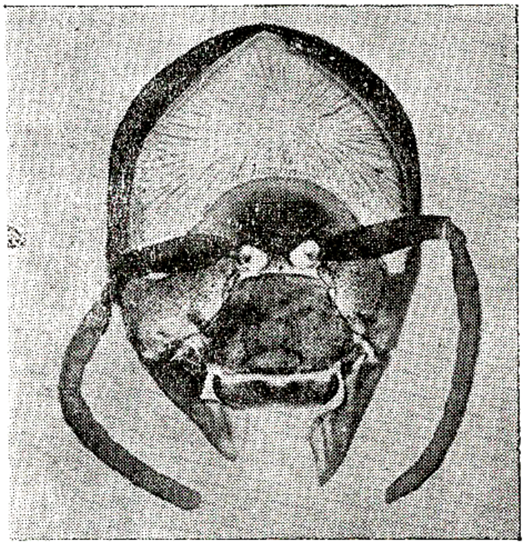


Fig. 179 — *Head of a cyclop bee (photo Leuenberger)*

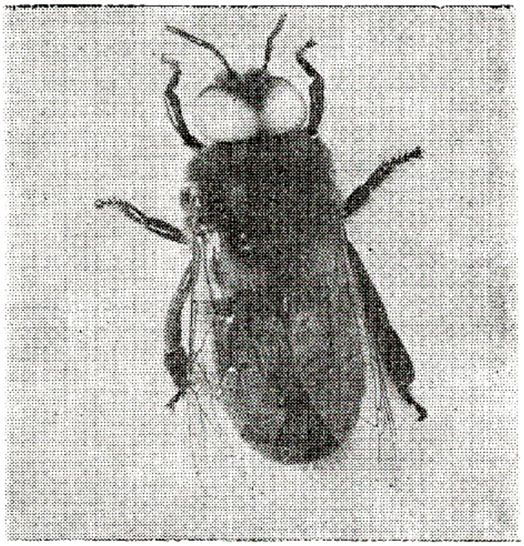


Fig. 180 — *Drone with white eyes (photo Leuenberger)*

though there are indications that cyclopism is of genetic origin, it must be taken into account that this abnormality in higher animals can be caused by other factors such as lack of oxygen during the developmental period (MANGOLD and WAECHTER 1953).

In beekeeping circles another abnormality, drones with white eyes (Fig. 180) is probably better known. In this case a mutation inhibits the normal coloration of the ocelli and compound eyes. Because the pigment building in these organs depends on several genes (KÜHN 1965) it is possible for very different eye mutations to occur. As in other insects in addition to white eyes, honeybees may have cream colored, yellow green, red or brown eyes. In the last 10 years other mutations have been found which influence other anatomical characteristics. A summary of these genetic caused abnormalities can be found in a publication by F. RUTTNER (1971).

In this connection it should at last be mentioned that young mated queens exist that mainly or only lay sterile eggs from which no or only a few larvae hatch. More recent investigations (FYG 1972) have demonstrated that the embyro begins to develop but sooner or later development stops. The cause for this incomplete egg development is very probably genetic and not due to nurse bees. The same possibly is true for another brood abnormality which ANDERSON (1924) and TARR (1937) called "addled brood". Here the brood dies in the prepupa or pupal stages.

8. Frequency of the different abnormalities and diseases of the queen bee

At this point the reader is probably curious to know in what frequencies the various malformations and diseases occur. The following table gives a summary explanation of the 3921 observations from the

3415 abnormal queens that I examined anatomically and microscopically. These queens were sent over the years to the bee laboratory at Liebefeld from Swiss and a few foreign beekeepers.

Abnormalities and diseases	number of cases	percent
Drone broodiness	2213	56.5%
Mating disturbance	138	3.5%
Diseases of the reproductive organs	329	8.4%
Intestional diseases	495	12.6%
Acarine disease	27	0.7%
External malformations	24	0.6%
Internal malformations	326	8.3%
Hereditary abnormalities	96	2.4%
Other diseases and abnormalities	97	2.4%
Unknown disease factors	176	4.5%
	3921	99.9%

The findings in this table are greater than the number of queens examined because some had two or even more abnormalities or diseases. As this survey points out, drone breeding is the most important disturbance in the queens normal ability to reproduce.

Diseases of the alimentary tract and reproductive organs are also proportionally important. In any case they play a more important role then the numerous developmental abnormalities which are mostly of scientific but of no real economic importance. It would be false however to pay no attention to these nor to the remaining diseases and exceptions to the rule. Only with a complete and thorough knowledge of all diseases and malformations will we be able to diagnose with certainty. The beekeeper can help a lot by not destroying, but sending alive if possible, any sick or abnormal queens to specialized scientists for study.

9. **Examination methods**

A few technical hints may be useful for those laboratories wishing to examine queen bees.

9.1. *When sending in living queens* it is best to use the normal shipping cage with 10—20 accompanying bees. A candy made with honey and sugar works well for provisions. Liquid honey should not be used because the bees often become so smeared during the transport that the bees and queen die. Dead queens can usually only be examined for mating, nosema and acarine disease. During the warm times of the year decomposition of the internal organs is so fast that it is not worthwhile to examine futher.

9.2. *Supplies for anatomical examinations*

Before dissection living queens are deeply narcotized or killed with ether vapor. A mall glass bottle with a cotton wad can be used as a narcotizing container. The cotton is covered with a fine wire screen and absorbs the ether that is dropped on it.

For the dissection, the following are necessary or desired :

Binocular microscope enlarging 10 to 20 times with an appropiate preparation platform and a strong source of light whose position can be varied (for example direct lighting with a low voltage lamp and transformer).

Preparation dish : Petri dish about 9 cm in diameter half filled with a mixture of paraffine and beeswax.

Dissecting tools : fine tweezer scissors, scaple, lances and surgeon's iris knife such as those used in eye operations ; fine pointed watchmaker tweezers (for instance Dumont and Fils, Nr. 5) ; preparation needles with straight and bent tips ; insect pins of various lengths and thicknesses.

Dissecting solutions: 0.65% physiological NaCl or ringer solution for insects (composition : NaCl 0.75 g, KCl 0.35 g, $CaCl_2$ 0.0021 g, 100 ml distilled water).

9.3. *Anatomical dissections*

The queen is first examined under low magnification dorsally and ventrally to determine if there are any external malformations. Only then is she dissected. To dissect the queen is pinned with the dorsal side up onto the dissecting dish with two insect needles. The first needle is pinned through the thorax (Fig. 181, N_1). The second needle is introduced into the sting chamber from behind and pinned thorough the last abdominal sternite with a light stretching of the abdomen onto the dish.

The abdomen is opened with two scissor cuts. The first cut (S_1) begins at the sting chamber and continues on the left side of the body between the tergites and sternites until the first abdominal segment is reached. The tergie of this segment is cut through from left to right (S_2). Then the dorsal abdominal covering is folded back to the right with a pair of tweezers and pinned with insect needles to the paraffine of the dish. Using this simple procedure the abdominal organs remain in their natural position much better then when the dissection begins from the ventral position. Subsequent preparation is facilitated when physiological NaCl or ringer solution is added.

To expose the head organs and especially the brain, a cross cut is made at the top of the head behind the ocelli, then continued in front of the compound eyes down to the clypeus. Here the tentorium of the internal head skeleton must be carefully severed.

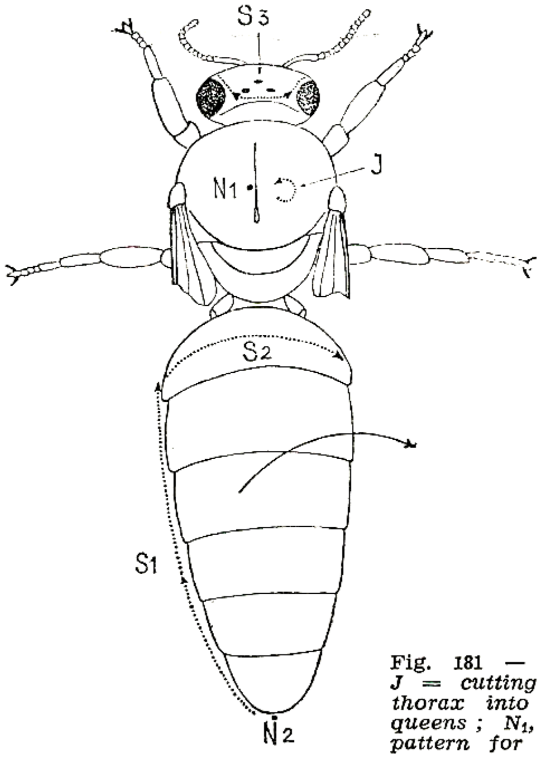


Fig. 181 — *Cutting directions for dissecting the queen : J = cutting pattern for opening a closeable hole in the thorax into which innoculations can be made in living queens ; N_1, N_2 = preparation needles ; S_1, S_2, S_3 = cutting pattern for opening the abdomen and the head capsule*

In the thorax the large tracheae from the first pair of spiracles are examined first, especially where queens are suspected of or have acarine disease. Once the head and the episternum are removed these tracheae are accessible and can be removed for microscopic examination.

9.4. *Histological examination*

When histological slides are to be made, the queen's internal organs must be fixed while still fresh. It is recommended to fix these organs directly in the preparation dish in their natural position *(in situ)* after the dissecting solution is poured off. After about 30 minutes the objects are removed from the preparation dish and placed in a glass bottle with the same fixing solution. The bettom of each glass bottle has a filter paper disk placed there before hand. The rest of the preparation, especially the removal of chitin is done with advantage when fixing is finished after the objects are thoroughly washed out with 70—95% alcohol. Fixing solutions which contain water penetrate less well than those containing alcohol when organs are richly served with air filled tracheae. This disadvantage can be eliminated by fixing in an exsicator with a side tube and faucet. The air is carefully evacuated.

According to the author's experience the following fixing solutions have proven to be reliable :

Heidenhain's Susa mixture

Composition : 4.5 g sublimate, 0.5 g NaCl, 80 ml distilled H_2O, 2.0 g trichloracetic acid, 4.0 ml glacial acetic acid, 20 ml formalin. Fixing time 1 to several hours. Then direct transfer to 90% ethyl alcohol. Leaching of sublimate in alcoholic solution of iodine-iodine potassium 2 : 3 : 100.

Bouin's mixture

Composition : 15 ml saturated watery picric acid solution, 5 ml 10% formol, 1 ml glacial acetic acid. Fixing time 2—3 hours and thorough washing in 70% ethyl alcohol.

Carnoy's mixture

Composition : 60 ml absolute ethyl alcohol, 30 ml chloroform, 10 ml glacial acetic acid. Fixing time 1—3 hours. Then direct transfer to 95% or absolute ethyl alcohol. When objects are fixed too long they easily become too hard and brittle.

Van Leeuwen's mixture

Composition : 1% picric acid in 12 parts aboslute ethyl alcohol, 2 parts 40% formalin, 2 parts chloroform, 1 part glacial acetic acid. Fixing time 6—12 hours. Then washing in 70—90% alcohol.

The mixtures of Carnoy and Van Leeuwen are especially suited for glycogen testing.

The embedding of the fixed and dehydrated (by using increasing concentrations of alcohol) object is done best in a mixture of methylbenzoate and benzol in paraffine (melting point about 55—58°C). The choice of the staining method depends upon what is to be demonstrated or found out. The double coloration with Weigerts Ironhematoxylin and Eosin or phloxin as well as the Azocarmin method from Heidenhain are useful for general slide surveys. Mann's methylblue-Eosin-Stain is suited for selective staining of the characteristic nucleus inclusions of queens with pathological drone laying sickness. The paraffine in the sections are removed with xylol and then rinsed in decreasing concentrations of alcohol and finally in distilled water. Then they are stained for one hour with the following preparations :

1% water solution of methylene blue	35 ml
1% water solution of Eosin	35 ml
Distilled water	100 ml

The sections are then thoroughly rinsed in distilled water and then placed for a short time in 70—95% alcohol. Then they are enclosed in Canadian balsam in the usual way over rinses in alcohol and xylol. The specific nucleus inclusions are bright red, the tissue is stained blue.

The modified Claudius stain is used in smear preparations or tissue sections when it is necessary to make bacterial or fungal pathogenic agents distinct and contrasty so that they can be seen. It is based on the Gram method. It is done as follows, after the smear is air dried and fixed with a flame or the tissue slide has its paraffine removed and has been passed through a series of decreasing concentrations of alcohol :

1. Stain for 2—5 minutes in a filtered 1% solution of methyl violet 6 B

2. Short rinse with distilled water and careful drying with a fine filter paper.

3. Stain in a mixture of 8 parts of a half saturated water solution of picric acid and two parts of a 1% water solution of Duro-red : 2—3 minutes.

4. Quick rinse in distilled water and dry again with filter paper.

5. Differentiation in chloroform, anilin oil or in one of the following formulations : absolute ethyl alcohol-chloroform 1 : 1 ; absolute ethyl alcohol — Anilin oil 2 : 1 or 3 : 1; absolute ethyl alcohol-acetone 2 : 1 Differentiation is continued until the preparations has an even red color when held against the light.

6. Slide placed in 2—3 series of xylol and then enclosed in Canadian balsam.

Gram positive microbes are colored bright blue to blue black. Tissue stains in various shades of red. Carbolfuchsin can be used instead of methylviolet. In this case a stain is composed of a mixture of 8 parts half saturated water picric acid solution and 2 parts of a 1% water solution of Wollblue or water soluble anilin blue. Such preparations are superior for microphotographs and are characterized by a long durability.

9.5. *Blood sampling*

Two places on the queen are suited for taking blood samples with fine drawn out glass capillaries. Namely, the top of the head (vertex) behind the ocelli and the intersegmental membrane between the 3rd and 4th sternites of the abdomen. The head capsule is opened with a transverse scissor or small scaple cut after scraping the hair and swabbing with alcohol. For preparations of blood smears the blood does not need to be sucked out of the wound because it will enter the tube by capillary action. Then it can be blown as it is onto a glass slide that has been thoroughly washed with alcohol to remove fat. With the edge of a cover glass it is spread out into a thin layer. Care should be taken to pierce through the intersegmental membrane into the perineural sinus only, not into the intestinal tract, when the abdominal plates are slightly raised with a pair of tweezers. Methyl alcohol is suited for fixing air dried blood smears (fixing time 2—3 minutes). The smears can be stained using either the Giemsa or Mann's methylblue-eosin stain. The modified Claudius stain works well for demonstrating the presence of bacteria or fungi in the blood.

9.6. *Innoculation method*

When researching the infective diseases of queen bees it is sometimes desired or necessary to inoculate the hemolymph of healthy queens with the pathogenic agent isolated from the infected organ or culture substrate. Because bees usually do not tolerate injections very well the author recommends using his method which has proven to work well. The queen is anesthetized with either fumes or carbon dioxide and placed on a dissecting dish with her ventral side down. A pair of crossed pins between the head and thorax and thorax and abdomen are used to hold the queen in position. The top of the thorax (mesoscutum) is a suitable place to inject (Fig. 181 J). The hair is removed from this spot with a scraper and the area is carefully swabbed with alcohol. Using the binocular microscope a half circle cut about 3 mm long is made in the mesothorax with an eye scaple. The chitin plate is slightly raised with a fine pointed tweezers and the pathogenic agent is placed into the hole of the wound directly into the blood. After the chitin plate is closed back in place again it is held in position with a good sticking glue such as rubber cement ("Dartex"). Collodion and mastic are not suited for this purpose because once they are dry the closed wound can easily spring open again. After the innoculated queens awakes from the anesthesia she is given back to her colony in a small introduction cage.

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Subject Index

Author Index

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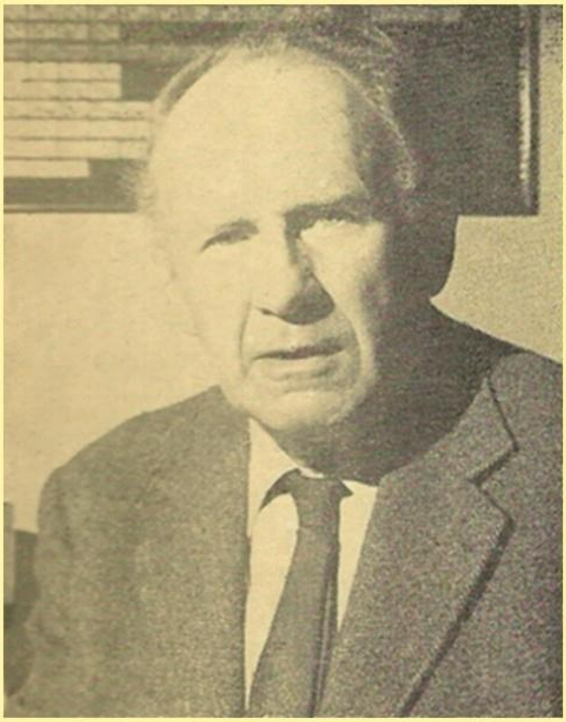

Prof. Dr. Friedrich RUTTNER, known to beekeepers the world over, has devoted his entire life to beekeeping. He is Chairman of the Bee Biology Standing Commission of APIMONDIA, and is working with devotion and love for the development of world beekeeping. He began his activity in 1948 at Lunz am See where he worked together with his brother Eng. Hans RUTTNER, the founder of the Genetics and Breeding section of the Institute there. Since 1964 he has been a Professor at the University in Frankfurt, and also the Director of the Bee Research Institute at Oberursel. The more than 80 papers published by Prof. RUTTNER are known to specialists in all parts of the world, and are of outstanding value in the domain of genetics, queen breeding, bee taxonomy and systematics, and of bee behaviour.

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He has supported the APIMONDIA Publishing House from its establishment, by many publications of which most prominent is the "Instrumental Insemination of the Queen Bee", and this essential book "Queen Rearing".

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