BAY OF PLENTY
COMMUNITY COLLEGE
Private Bag
RD 3 Tauranga
NEW ZEALAND
Telephone
440 920

HANDOUTS FOR QUEEN REARING COURSE

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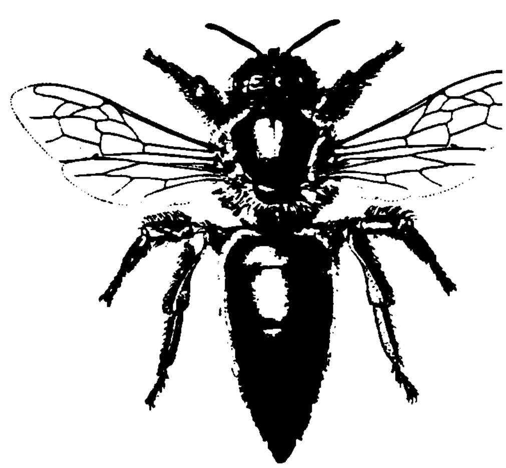


Helping our queen bees reach their full potential

Murray Reid, Apicultural Advisory Officer in Hamilton, defines the essence of good bee management in this article which is adapted from a paper presented to the MAF seminar in Tauranga in late July.

Beekeeping is big business these days, but it is a business that tends to be complicated. What with finance, taxation, machinery, marketing, exporting and so on. The production side can be complicated too, but does it really need to be so?

After all, bees have survived by themselves for millions of years and still survive in spite of what we do to them.

TO ME, successful and profitable beekeeping boils down to two very simple aspects; plenty of feed and young queens.

This implies, of course, that we also must have a good population of healthy worker bees and good brood combs so that the egg laying potential of the queen is not limited and that the bees are in a good nectar and pollen producing area.

We all appreciate the value of young queens from selected stock, in theory, if not in practice. Obviously the best re-queening programme is one that uses carefully selected and tested queens, and I would suggest that to be sure this is done to your satisfaction, you should be selecting and breeding from your own stock. However, I also believe that any young queen is better than an old selected queen and this year in the Waikato and Bay of Plenty, at least, the value of young queens was so obvious. They were the only hives you took any honey off.

I would love to go on about the proven value of autumn and spring nucs, but this is outside the scope of my topic. Rather let me concentrate on some of the background to what should happen in the hive being prepared for the flow. Some people would call this theory, but nothing could be further from the truth. It is the very heart of the practical side of successful commercial beekeeping.

What I have been asked to do is to discuss how we can assist our selected queens to show their true genetic potential. Some of the things we should do are so basic I feel silly mentioning them.

It stands to reason a starving colony will not be worth much, yet in the autumn of 1979 a commercial beekeeper purchased over 50 expensive queens, made up nucs, got his queens laying nicely and fed them well and wintered them down. Despite reminders from me that these nucs would need feeding again in early August, he did not get around to checking them until the end of September. The result – disaster. They were all dead or so far gone they were beyond repair.

This brings me back to my first prerequisite for commercial beekeeping – plenty of honey stores. It seems a little strange to me that in the Waikato we have people moving more and more to single brood nest wintering. Whereas in Southland the trend is to wintering hives three high.

In most of the Waikato we can get away with this system because of plentiful supplies of pollen. However, this season caught many beekeepers on the wrong foot. Pollen shortages showed up for the first time in many areas. I did not hear of one beekeeper who was prepared for this and had stored pollen on hand to feed either as a patty or in sugar syrup. Many beekeepers did not even recognise the effects of the shortage when it was staring them in the face.

Bees need a huge amount of good quality pollen with all the essential amino acids present: Pollen is essential for royal jelly production; royal jelly in one form or another is fed to the larvae and is also the main food source of the queen.

A good hive in one year will rear over 200 000 bees. On average, 125 mg of pollen is eaten by nurse bee's for every larva reared. This means our strong hive will need more than 25 kg of pollen a year.

Now, a full comb of pollen will be enough to rear 7 000 bees. As it takes 10 bee loads to provide enough pollen to rear one bee, our hive will need over 2 million bee loads to rear 200 000 bees. Remember this amount of pollen is for brood production only. Young adult bees need a lot of pollen themselves in the first three to four days of life and pollen is also used by bees producing bees wax.

So our ideal hive now has plenty of honey; two to three frames (or equivalent) of pollen and the young queen. What else do we need to consider?

We tend to think of honey production in terms of the flowers only, especially in poor seasons. A poor season is always blamed on the weather, soil temperatures or neighbouring apiaries. This is partly right, but I would suggest that even in a poor year a strong hive will gather some nectar – certainly more than a weak hive.

If we assume the flowers are producing nectar, the amount of honey a hive will produce is determined by two things: The population of adult bees and the efficiency of each individual bee.

American scientists have studied these two factors and have found that production is higher in the strongest colonies since they have more bees available to forage for nectar. This increase in production is not a simple mathematical relationship, for a colony with 60 000 bees may produce 2.28 times as much honey as a colony with 30 000 bees. Also, the production per bee increases as the population increases and thus a colony with 60 000 adult bees may produce 1.15 times as much honey per bee as may bees in a colony with 30 000 population.

The strain of bees also has a marked influence on the rate of production of adult bees and this may affect the production too. Let's look at what things affect the total number of bees in a hive.

Obviously the population at any time is related to the birth rate and to the death rate. The birth rate is determined by the egg laying capacity of the queen. Well-reared queens of good genetic stock have produced up to 3 000 eggs per day. However, rates of 1 500 to 2 000 would be better averages. The limiting factor now becomes the physical restriction on egg laying due to the lack of suitable comb.

The queen laying 2 000 eggs a day will fill a full depth comb every three days and will produce brood occupying seven full depth combs. In practice, up to four combs in a single brood nest system are not available to the queen.

In these cases, the full potential of the queen when it is needed most, that is in the spring, is not being realised.

The solution to this problem is obvious, we can reverse brood boxes, we can add the second brood box to single storey hives early in the season, we can add empty combs to the centre of the brood nest. We can be careful how we use queen excluders or we can use follower boards to allow the queen to lay in the outside combs.

Maintaining bees on pallets helps to keep the inner sides of the hive warmer. The queen can now lay right to the outside comb on the warmer side. All these things help the hive to reach its theoretical maximum adult population before the honey flow.

The life span of the adult bee is also very important. Adult summer bees tend to live from 28 to 35 days with an average of 31 days.

Nosema disease will markedly affect the length of life of adult bees and will reduce it to about half that of healthy bees. The following table gives some idea of the affect egg laying rates and death rates of the adults can have on total hive numbers. These figures have included a deduction of 10 per cent for larval mortality.

THE EFFECT OF EGG LAYING AND ADULT DEATH RATES ON COLONY STRENGTH

Oviposition Rate (Eggs/Day)	500	1 000	1 500	2 000
	Maximum populations of adult bees			
Length of life (days):				
35	15 750	31 500	47 500	63 000
31	13 950	27 900	41 850	55 800
28	12 600	25 200	37 800	50 400
20	9 000	18 000	27 000	36 000

Productivity/bee

We have seen what factors affect the total hive population, now what about productivity/bee?

Foraging for nectar and pollen is the final activity of honey bees. So if worker bees live longer they will produce more, all other things being equal. Researchers have found that bees that begin foraging at an average age of 28 days only forage for eight to nine days. In contrast bees that begin foraging at an average age of 15 to 16 days do so for 14 to 15 days, nearly twice as long.

Now what makes the bee begin foraging earlier than could be expected?

The larval stage of the honey bee lasts five days whereas the nurse bee stage of the young adults lasts about 10 days. One nurse bee can provide food for more than one larva, so even at the rate of one nurse bee to one larva there will be a surplus of nurse bees.

In small colonies the excess of nurse bees will not be very significant, but in the stronger colonies in which the

COLONY PREPARATION FOR THE HONEYFLOW

A CALENDAR OF EVENTS

AUGUST				SEPTEMBER					OCTOBER				NOVEMBER				DECEMBER					JANUARY			
4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12	19	26
						A B	C	D		E F	G		H	I	J	K									

Drone egg production (August 4 – 18)

Queen rearing period (September 1 – 15)

Virgin queen intro (September 15 – 29)

Mated queen intro (September 29 – October 13)

Critical 7–9 week colony build-up period (October 13 – December 8)

Honey flow (December 8 – ?)

Eggs laid during. . . . . weeks of work during honey flow

A	0
B	0
C	0
D	0–1
E	1–2
F	2–3
G	2–3
H	2–3
I	2–3
J	2–3
K	1–2

9th December has been assumed to be the start of the major honeyflow; however variations occur about New Zealand.

queen is laying 2 000 eggs a day there could be a surplus of 10 000 or more nurse bees. What happens to these nurse bees? Basically they're weaned early.

Because they cannot dispose of their royal jelly, their hypopharyngeal glands degenerate early and they become foragers. Feeding larvae is very exhausting work and this is why winter bees with no larvae to feed can live for months instead of weeks. This also explains why these young bees that begin foraging early live longer than foragers that start out later in life. This is in spite of the fact that foraging is such a risky business with high mortalities in the field.

This is the secret of why strong hives have a greater field population than weak hives and why they produce so much more. They simply have a surplus of nurse bees which become foragers earlier in life and they live much longer too. This is the basis of our recommendation that any colonies that do not have a population of 20 000 bees (a very full single box) by the time of the honey flow should be united.

Now let us see what we have. We ideally have a young queen of superior strain, we have plenty of honey stores and pollen, an excess of good, clean worker comb for the queen to lay in and an excess of foragers. What else is there? Just good timing to bring all these together.

Here we need to refer to a calendar and plot on it the estimated dates for various nectar flows, especially the main clover flow.

The calendar of events included with this article tells us that to get maximum effort from our field bees for a nectar flow lasting from mid-December to near the end of January, we need to begin stimulating intensive egg laying around the middle of September.

I realise that in many areas flows may begin after January. This chart is based on the fact that it takes 21 days from the time the egg is laid until the adult worker emerges. The worker may spend another 21 days on hive duties before becoming a serious forager for a further nine to 10 days.

As we have seen, strong hives will release a greater number of nurse bees into the field up to a week earlier than "normal". These bees can also be expected to forage longer for 14 to 15 days. The critical egg laying period for our queens is from the middle of October to the end of November. October is often a death period so heavy feeding may be required.

Mated queens should ideally be introduced into colonies in October. Queen cells should go out from mid to late September. The queens usually take four weeks to start laying which brings us well into October again. This means queen cell production should begin early in September or as soon as there are plenty of drones in the hives.

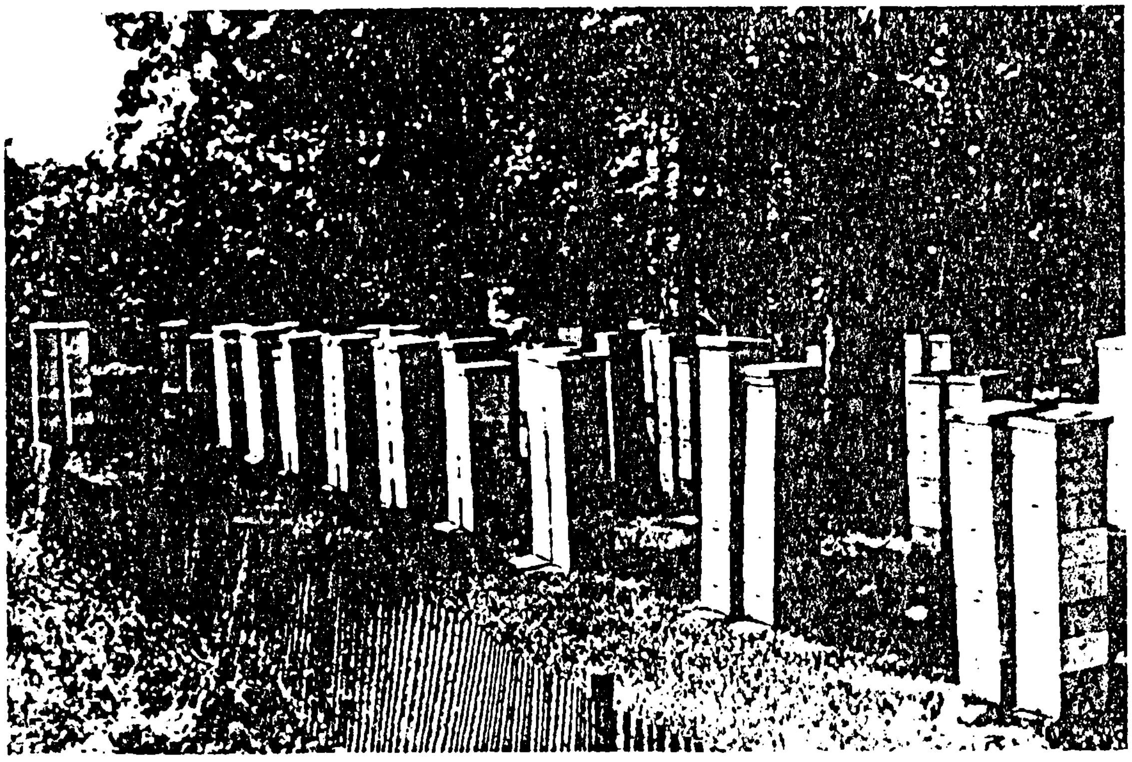
Two other management techniques come to mind to help our queens: One is to reduce the problem of drifting, the other is site the apiaries in areas where they can get some shelter and easy access to a cross selection of nectar and pollen sources.

* * *

All this is not theory, it is practice. It happens by itself in certain hives every year, with or without our help. What we need to do is to appreciate what is happening and why. Then try and get as many hives as possible peaking at the right time.

However, having said all that, a man called Murphy once made a very profound observation, we call it Murphy's law and it simply states that "if anything can go wrong it will". I can see the situation where you work yourselves to the bone getting every hive requeened, well-fed with lots of lovely new combs in the hive and plenty of bees, then along comes Murphy or a bunch of sunspots. What happens? Three-quarters of your hives swarm!

Good luck for the next season.



The value of nucleus hives in commercial apiaries

by D.A. Briscoe, Apiary Instructor, Tauranga

BEEKEEPERS IN many areas of New Zealand find it increasingly difficult to build up standard colonies to full strength in time for the main honey flow of nectar, often because of unfavourable climatic conditions. On the other hand, a few beekeepers in favoured localities are almost embarrassed by early strength in their colonies with the result that a large amount of their time is taken carrying out swarm control measures. Nucleus colonies can also be used to great advantage in requeening programmes and in boosting backward hives.

There should be no "passenger" or non-productive hives in an outfit that employs the judicious use of nucleus colonies.

Apiary locations must be considered when a decision is made about the best time of the year to make up nucleus colonies. As in all phases of beekeeping, planning is essential if good results are to be obtained and the beekeeper must first consider how the bees are to be housed. A division board can be used in the standard super, thus making use of equipment which is readily available. When this type of nucleus hive is being constructed, the entrances to be used by the bees should be at opposite ends of the super.

To do this, a special lightweight bottom board can be made up to suit the division in the super being used. It is also advisable to tack the mat to the top of the partition or dividing board to prevent the bees from passing from one division to the other when the hive is opened. These nuclei can be placed over division boards on top of standard hives, piled one on top of the other or placed in the apiary singly.

However, for ease of manipulation and for better results for mating and with mated queens, I prefer the four frame nucleus. If properly attended to these can be overwintered very satisfactorily. Perhaps in the colder parts of New Zealand, a five frame nuc. could be considered.

Preparation of Nuclei

Before nuclei are made up, it is very important that parent hives are checked out thoroughly for any signs of American Foul Brood (Bacillus larvae). Disease can be spread through an outfit very easily if increase is made up from diseased stock (or equipment).

A few days before making up the nuclei the selected hives should be opened and the required number of capped and emerging brood combs, from which the bees are gently shaken, should be placed above a queen excluder (making sure of course, that the queen remains below the excluder). The nurse bees will very soon be attracted to the brood above the excluder and in this manner, supplies of brood and bees are quickly available when required and no time is lost searching for the queen. A minimum number of field bees are taken with the newly formed nuclei.

After the division has been made a ripe queen cell can be given to each such nuc.

Another method is to slip a queen excluder between the two brood chambers of the hive. After 3 — 4 days an inspection of the colony will show in which super the queen is confined. In areas where there is a quick spring build-up of bees, nucleus hives can be prepared without affecting colony strength substantially. Brood combs from the upper portion of a "Demareed" stock may be used for this purpose.

Thus, the preparation of nuclei and swarm control are carried out in the one operation. However, too much brood and too many bees should not be taken from the one hive, as this may mean sacrificing a portion of the current season's honey crop. Frames of brood may also be taken from weak colonies which would not normally build up sufficiently to catch the main honey flow. (If a programme of operating a percentage of nucleus hives in a commercial holding is carried out, this situation should never arise.

In cooler parts of the country the work of making up nuclei can be carried out in the latter part of summer or early autumn, but in this case the winter stores must be watched and provided for.

In a four frame nucleus, two frames of emerging brood and bees with a frame of pollen and a frame of honey is desirable. When the nucleus has been prepared in this manner, the entrance should be blocked lightly with grass for 24 hours. They can then be transferred to other out yards or left on the original site (a little way apart from the parent colony). Although most field bees will probably return to their own hives if not moved to another out yard, the nucleus will be of good strength if sufficient nurse bees were taken in the first instance.

Requeening

Most commercial beekeepers have their own methods of raising queens. If spring requeening is carried out it is a waste of time and bee force to have virgins mate from honey producing hives. Before a nucleus is given a queen cell, the nuc should be liberally fed with sugar syrup. This will ensure better acceptance of the cell.

After the cell has hatched and the queen mated, she may then be removed and introduced to a colony due for requeening. A second cell may then be given to the nuc immediately.

If a cell is not available, the nuc will rear its own queen, but it must be remembered that a queen reared in this way is usually inferior to one raised from a cell selected stock.

As good queens are essential for successful commercial beekeeping each queen should be examined carefully before she is introduced to a honey producing colony. She should be bred from previously selected stock, be properly mated and laying, good appearance and have a long, moderately tapered abdomen.

The use of nucleus colonies in commercial outfits have many uses and for overall best results the nucs should be distributed throughout all out apiaries in a ratio of about 20 per cent to honey producing colonies. The greatest advantage of nucleus hives is two-fold: 1). The ever-ready supply of young queens and 2) the immediate ability to boost backward hives at any given time, thus eliminating completely non-productive or passenger hives.

A complete nucleus can also be given to any hive that has become queenless for one reason or another.

Nuclei require regular checking. Stores of honey and pollen must be watched carefully and also a very careful check should always be made for B.L. disease. A special examination for this purpose should always be made before any use of a nuc is made for queen replacement or the hive boosting of a honey producing colony.

Q U E E N   C O U R S E

SUBJECT   Spring Vs Autumn Requeening

INTRODUCTION

You - the beekeeper - must first define your own position, e.g.:

A   Climatic conditions - mating.

B   Availability of nectar and pollen - flowering times of worthwhile nectar and pollen bearing species.

C   Labour position - should you feed for maximum populations or do you also have time to requeen and take honey off?

D   Process own crop - capital tied up in equipment, use of skilled labour in unskilled job.

REMEMBER at all times it is the bees that produce honey NOT the extracting plant.

To requeen for maximum production of bees or honey requires: (not considering genetics - success of rearing, mating, etc.)

A   Effective planning and records.

B   High labour input or running less hives per man to achieve greater return per hive - intensive bee farming.

C   Each year a minimum of 60% of all colonies be requeened (10% for patching failures) but preferably 100%.

D   Whole apiaries requeened - better use of labour, more flexible use of labour and time particularly when weather packs up and queens arrive.

E   Colonies must at all times have adequate honey and pollen supplies.

F   Drone stocks must be mature if using cells, e.g. drones should be emerging when first grafts are put down.

SPRING Vs AUTUMN

SPRING	AUTUMN
ADVANTAGES	**ADVANTAGES**
More natural phenomenon. Use of top nucs. Two queen system. Can increase without winter feeding. Young queens in spring build up quicker than over wintered queens. Reduction of swarming.	Failures not so critical at this time of year. Usually settled climatic condition. Hives are populous. Good honey and pollen supplies. Use of cells will remove several cycles of brood which will not need to be wintered. Colonies can be split to winter in single brood nests. Commencement of spring development with no check. Not disturbing the colony except for disease check in spring.
DISADVANTAGES	**DISADVANTAGES**
Inclement weather - leads to poor matings. Labour intensive. ←→ Colonies must be requeened early and extra stimulation required to ensure maximum population. Loss of cycles of brood when using cells.	Honey must be removed. Robbing can be severe. Additional labour required to process crop. Matings with black drones more common. Swarm control more necessary (particularly in second year)

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Ministry of Agriculture & Fisheries

DEVELOPMENTAL STAGES OF THE HONEY BEE

	Worker		Queen		Drone	
Day	Stage	Moult	Stage	Moult	Stage	Moult
1						
2	EGG		EGG		EGG	
3		(hatching)		(hatching)		(hatching)
4	LARVA 1	1^{st} moult	LARVA 1	1^{st} moult	LARVA 1	1^{st} moult
	LARVA 2	2^{nd} moult	LARVA 2	2^{nd} moult	LARVA 2	2^{nd} moult
6	LARVA 3	3^{rd} moult	LARVA 3	3^{rd} moult	LARVA 3	3^{rd} moult
7	LARVA 4	4^{th} moult	LARVA 4	4^{th} moult	LARVA 4	4^{th} moult
8	LARVA 5	(cell sealed)	LARVA 5	(cell sealed)	LARVA 5	
9						
10	(or PREPUPA)		(or PREPUPA)	5^{th} moult		(cell sealed
11		5^{th} moult				
12					(or PREPUPA)	
13			PUPA			
14						5^{th} moult
15				6^{th} moult		
16	PUPA		ADULT	(emerging)		
17						
18						
19						
20		6^{th} moult				
21	ADULT	(emerging)				
22						6^{th} moult
23					ADULT	
24						(emerging)

A.G. Matheson, A.A.O., Nelson
(after Laidlaw, 1979)

ADULT METABOLISM

(Food Requirements of the Adult)

- Proper nutrition is one of the most important factors influencing the longevity of emerged bees.

- The degree of growth and change in body structure of the bee depends on general conditions such as:

  (a) State, requirements, and strength of the hive
  (b) brood rearing
  (c) presence of a queen
  (d) incoming nectar and pollen
  (e) weather

  We are going to follow activities of the hive through the year and try and relate this to:

  (a) food required
  (b) way the body uses the food

1. Let's start with the WORKER BEE

- The first thing she does when she hatches is dry her wings and body, have a feed of honey and of pollen. Twelve hours after emerging 50% or more of the workers have consumed pollen.

- Mass consumption of pollen begins between 42 - 52 hours of age and reaches a maximum at five days of age.

- Tissue growth, organ development, and weight increase accompany this consumption of pollen. For example the:

  (a) hypopharyngeal glands
  (b) fat bodies (glycogen reserves) - similar to the human liver.

- Pollen consumption diminishes at eight - ten days of age.

- A large proportion of the protein and amino acid reserves of the honey bee are stored in the blood. From here they are used to produce royal jelly, repair tissues and produce reserves if there are no brood to feed. The concentrations of protein and amino acids in the blood fluctuate markedly according to the activity of the bee, for example, protein levels are very low just after the bee is born, then they rise as the bee consumes pollen. They reach their lowest point during the time the bee is secreting royal jelly and finally the level rises again somewhat during the foraging phase.

- Older bees only need carbohydrates (or sugars) for energy. All other materials for repair (e.g. vitamins, minerals and lipids) are catabolized from body stores. Vitamins are needed for development of hypopharygneal glands.

- Thus it is important to ensure larvae are well fed as this directly influences the life and feeding performance of the adult.

- Bees can rear one cycle of brood on a carbohydrate diet alone from body reserves.

- Nosema disease:

  (a) Affects the secretary activity of gland cells. Five day old bees nearly ceased secreting.
  (b) Decreases blood protein level dramatically by the 12th day. The amino acid level changed irregularly but generally decreased.
  (c) Directly damages mid-gut, malphighian tubules and indirectly damages the fat body rectal glands, ovaries and hypopharyngeal glands.

- Inverting nectar:

  As the bees get older the hypopharyngeal glands shrink in size and instead of producing Royal jelly they secrete invertase and diastase about day 12 - 20. These enzymes invert the nectar sugars into honey sugars.

- Bees have no storage organs for sugar. Sugars are stored in the blood and are very high compared with man. The level of blood sugar is not constant and is related to the activity of thebee.

Newly emerged	Resting	Foraging
Very low	low	Very high

2. DIET OF THE QUEENS

- Queens when they hatch often have a fill of honey from the comb or are fed by workers.

- Solitary queens can survive for many days on queen candy provided water is freely available.

- But what do queens eat under normal conditions:

  - Foti has demonstrated that queens are fed a protein diet by older worker bees both during the summer and the winter. Protein diet is royal jelly. The queens do not normally eat significant amounts of honey over the winter period as was once thought.

- It is important that queens receive a very cocentrated protein diet because:

  (a) The production of eggs and pheromones is very demanding. In the height of summer the queen can lay more than her weight of eggs per day.

  (b) Queens continue to grow after emergence whereas workers do not.

  (c) Queens live a lot longer than workers.

3. DIET OF THE DRONES

- Very similar to that of the worker bee although adult drones do not forage for food.

- Drones grow quite markedly after emergence, whereas workers do not.

- Young drones (one to eight days) are fed by young workers modified worker jelly (glandular secretions plus pollen and honey).

- Eight to 12 days drones mainly feed themselves.

- 12 to 36 days foraging drones feed themselves from the honey combs.

Young Brood Essential For Good Grafts

A RECENT RESEARCH FINDING REVIEWED BY
G. M. WALTON
Apicultural Advisory Officer
Palmerston North, New Zealand

Research workers often obtain results that, to the layman, appear to be well known and obvious. Some New Zealand beekeepers, for instance, were seeding honey with fine honey crystals 20 years before Dr. Dyce described the creaming process that now bears his name. But experimentation and the publication of results are usually far more meaningful than just statements of the obvious. Research often takes a more than superficial look at a subject. It defines and analyses. It asks why? and under what conditions?

Most beekeepers realize that the best queen-rearing results are obtained when the youngest larvae are selected for grafting. Larvae of 3 or 4 days of age often result in "runty" queens. Although scientific endeavor has examined the diets of the larval honey bee and the time at which worker/ queen determination occurs, little research has been done on the effect of grafting age upon the resultant queens. In a recently published article, Dr. J. Woyke of Poland examined this.

Dr. Woyke, of diploid drone fame, transferred brood of different ages to queen cups which resulted in larvae being fed with royal jelly for differing periods of time. All virgin queens were weighed soon after emergence. Some were allowed to mate naturally whereas others were artificially inseminated with varying quantities of semen. The success of queen rearing and mating was assessed by measuring the number of ovarioles in the ovary, spermatazoa in the spermatheca, and the volume of the spermatheca.

The ovarioles are tubules of the ovary through which pass eggs in different stages of development. The number of ovarioles per queen decreased with increasing age of the grafted brood. Queens grafted from one-day-old larvae contained an average of 308 ovarioles, and two, three and four-day-old larvae resulted in queens with significantly less numbers of ovarioles.

The spermatheca, or sperm-storage organ of the female, decreased in size and volume with each increase of 1 day in the age of the grafted brood. The volume of semen, and the number of sperms in the spermatheca decreased when older larvae were selected as grafting material. Naturally mated queens grafted from eggs contained an average of 6.1 million sperms in the spermatheca. Queens derived from 3-day-old larvae contained only 3.9 million. Spermathecae of different sizes had similar concentrations of sperm.

Woyke's work indicated that the best queens were obtained by grafting eggs. He used the Orosi-Pal method. However, the egg-grafting technique results in a higher degree of grafting failures. For the practical beekeeper, grafting of larvae of the earliest possible age (less than 1 day of age) is recommended.

With each increase of 1 day in the age of the brood used for grafting there was a decrease in body weight in the queens produced. Emerged queens averaging 189 milligrams were obtained from 1-day-old larvae. Two-day, and three-day-old larvae resulted in queens weighing 172 and 147 mg respectively. Woyke recommends that the weight of a virgin queen is an important criterion in selecting for better queens. Heavy queens would not only contain larger spermathecae and more ovarioles but could well be expected to continue in egg laying for longer periods of time.

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Reprinted from March, 1972, American Bee Journal
Vol. 112 (3): 96

Larva surrounded by royal jelly. (Laidlaw and Eckert QUEEN REARING photo)

Later stage of larva in royal jelly. This older larva would be difficult to transfer. (Laidlaw and Eckert QUEEN REARING photo)

Pupal stage of development. (Laidlaw and Eckert QUEEN REARING photo)

from these two queen cells and replace them with very young larva, about the size of an egg or one and one half times that size. These are taken from worker cells.

To remove the tiny larva the beekeeper can fashion a toothpick with the small end shaved to a feather edge and bent upward at an angle of 45°-80°, 1/16" from the end. This makes a good cheap transferring tool for producing a few queens.

Nine or 10 days later the beekeeper should remove the smaller of the two cells, and also any other queen cells that the bees may have produced and may have been over looked. The queen from the remaining cell will emerge on the 11th day from the time the transfer took place and should be laying 14 days later.

A second method that is sometimes practiced is to locate natural queen cell cups on the combs and transfer very small larva into several of these while the queen is still in the hive. Two days later all but the best provisioned cells are destroyed, and the larva in the best cell is removed and replaced by very small larva taken from a worker cell. The new queen that is produced, may supersede the old queen.

THE TWO STORY, QUEEN-RIGHT CELL BUILDING COLONY

These are used extensively as cell finishers by commercial queen breeders and are probably the best means for both starting and finishing cells for the beekeper who rears queens for his own use. The colony chosen must be strong with bees fully covering all the combs in two hives bodies.

EXTENSIVE QUEEN REARING

When queens are needed in greater quantities the methods of cell building used by commercial queen breeders are most suitable. There are many variations which beekeepers practice, nevertheless, all must be based on the proper feeding of the larvae so that they develop completely into queens.

COMB ARRANGEMENT

The comb arrangement is very important. The young unsealed brood is raised into the upper body. The emerging and sealed brood is placed in the lower body, except a comb of sealed brood or honey is placed next to each side wall of the top body. The queen is confined to the lower hive body by means of a queen excluder. Only nine combs are required for the upper hive body since space must be allowed for for the frame containing the queen cells. The arrangement of the combs is important and they should be arranged in the following manner:

```
s                       s
h  s  L  L  l  c  pl  L  h
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h — honey
s — sealed brood
L — older larvae
l — younger larvae
c — cells
pl — pollen

The comb with the pollen is placed on one side of the cell building space, and the young larva on the other side so that the nurse bees which feed the young larva must cross the queen cells to obtain pollen. The entire arrangement must be re-established each week if more than one batch of cells are to be produced.

FEEDING

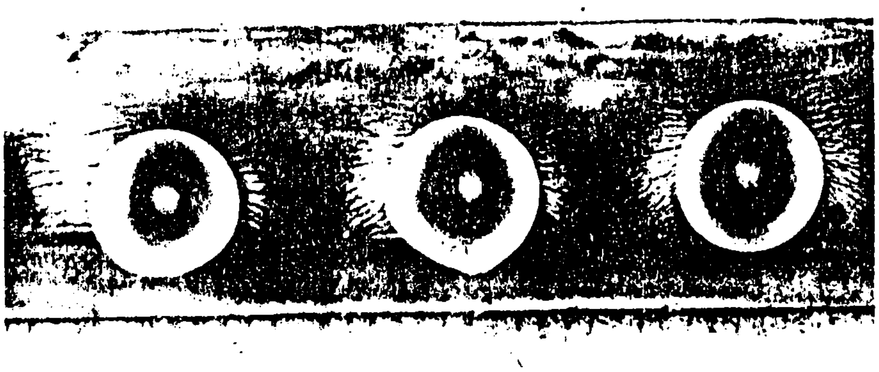
Feeding the colony is very important. We feed the cell builder a 50:50 sugar syrup (by volume) or a honey syrup made of 70 parts of honey diluted with 30 parts of water. We prefer to use the Boardman Entrance Feeder on a friction top pail, with perforations in the lid, in an empty super over the top body; but if we find that comb is being built on the queen cells we change from a liquid food to a candy, and we replace one of the combs in the upper body with a frame of foundation.

QUEEN CELL CUPS

The cell cups can be dipped using the rounded end of a ⅜" (9 mm) round dowel about 8 cm long. Starting 13 mm from one end taper the dowel to 7 mm in diameter at the end. Now round the end to give the bottom of the wax cell a concave form. The dowel has to be first moistened in cold water and the excess water shaken off. It is dipped into, and quickly removed from barely melted beeswax, the tip going about 10 mm into the liquid wax. The dipping is repeated about 3 or 4 times. Between each dipping the wax is allowed to solidify. After the last dip in the wax the new cup is submerged in cold water and is removed from the stick with a gentle twist. It is more convenient however, to purchase the cups from a supplier.

The cells are placed on a bar that can be fitted snugly into a frame between the end bars, the ends of the bar resting on supports on the inner sides of the frame end bars. Fifteen cups can be attached to this bar by means of melted wax, spacing the cells

(Continued on Next Page)



Cell cups "primed" with royal jelly. (Laidlaw and Eckert QUEEN REARING photo)

about 20 mm apart. The cups on the bars in the frame may be placed in the cell builder or in a humidizied incubator over night to warm them before transferring the larvae the following day.

GRAFTING

The transferring of larvae from worker cells to queen cells is called "grafting." There is an automatic needle that can be purchased which is excellent after some skill has been developed. The unskilled beekeeper should prime each of the cell cups before grafting with a drop of royal jelly obtained from natural queen cells. Choose larvae for transferring that lie on abundant royal jelly in the worker cell. The larva should be about 24 hours old. Slip the tip of the grafting tool under the larva, lift it out and deposit it on the drop of jelly in the cell cup. DO NOT LET THE GRAFTED CELLS DRY. It is advisable to put each bar into the cell builder as soon as grafted unless grafting is rapid. Even then the cells must be protected from drying. A damp cloth laid over the bar of grafted cells is helpful. One or two bars of cells may be given the cell builder at one time and succeeding grafts given at four day intervals. Queen cells that develop are removed from the cell builder 10 days after grafting.

MATING THE QUEENS

Adequate Drones — Many beekeepers never think of the drones the virgins mate with. A queen should normally mate with eight to 10 or more drones. Newly emerged drones require eight to 10 days to reach maturity; many require longer or never mature. Colonies with many drones may have only a small portion mature and flying when the queens are out on there mating flight.

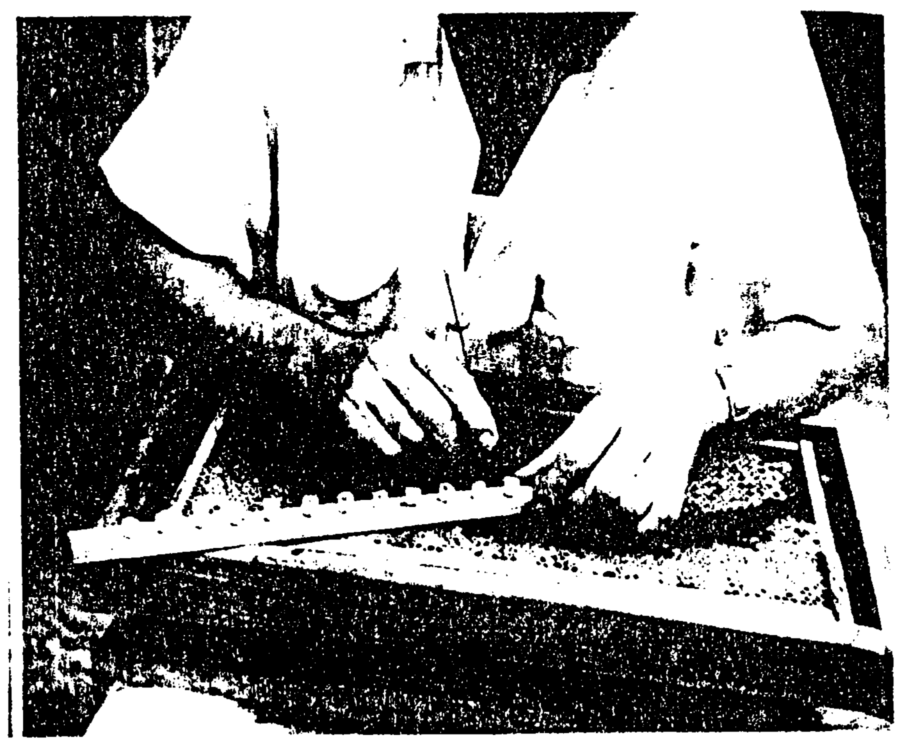
Drone mother colonies should have at least one full frame of drone comb, and drones should emerge not later than the time that the queen cells are sealed. The queens that are producing the drones should be selected with the same care as the queens which are providing the virgin queens.

The first principle in rearing excellent queens was to provide plenty of food and nurse bees. THE SECOND PRINCIPLE IN REARING EXCELLENT QUEENS IS TO PROVIDE AN ABUNDANCE OF MATURE DRONES OF GOOD STOCK WHEN THE QUEENS ARE MATING. Needless to say, the colonies providing the drones should be in or near the queen mating yards.

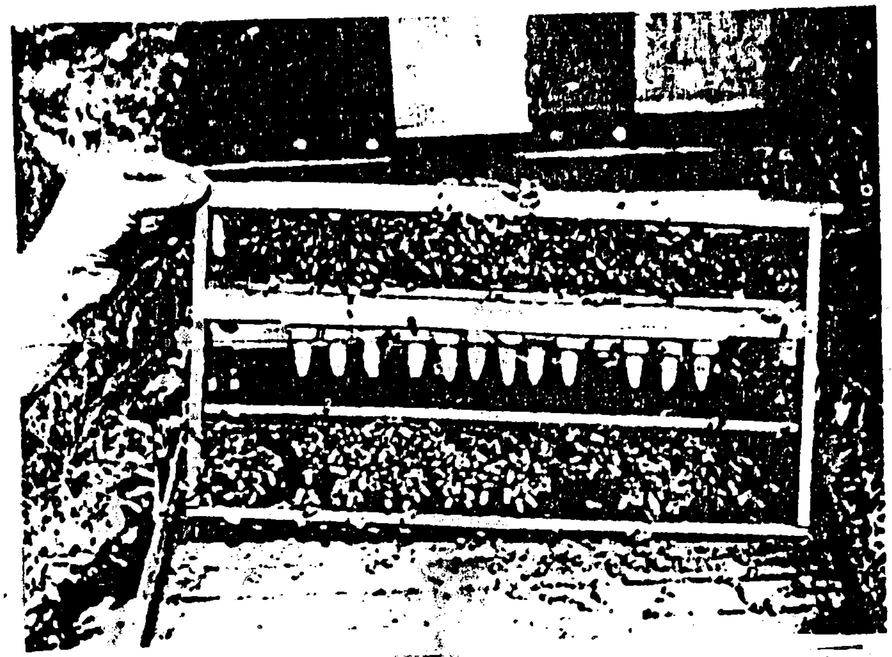
The queen mating yard is stocked with mating colonies since each queen must have her own colony. When more queens are being reared than are needed for immediate requeening new colonies must be provided. If the new colonies are intended for increase they are referred to as dividers and are usually started in the regular size hive bodies. If new colonies are temporary and are established especially for mating queens they are usually housed in small special hives called nuclei or mating colonies. There are two general types of nuclei. One type uses the full size standard frames and these are called standard nucs. The other size uses special small frames and these are called baby nucs. These two kinds of nuclei are established differently but the third important principle in rearing excellent queens must be observed in either case. THE THIRD PRINCIPLE IS THAT THE NEWLY MATED QUEEN MUST BE KEPT WARM SO THAT THE SPERM MOVES FREELY FROM THE OVIDUCT TO THE SPERMATHECA. The nuclei must, therefore, be strong enough to form clusters capable to maintaining the brood rearing temperature of about 34°C.

The standard nucs are established with two to three frames of bees, some brood, honey and pollen. These are set on location immediately and given a "ripe" (10 day old) queen cell. The entrance can be covered with grass to keep the bees from flying.

The baby nucs are established with a cupful of bees, no brood, but are provided with sugar syrup in a feeder. A ripe cell is given and the bees are confined, placing the nuc in a cool dark place, for three days. On the evening of the third day the nucs can be set out on location and the entrances opened.



Transferral of larvae.



Ripe cells ready to put in individual nuclei.

We often use division boards or inner covers for mating queens on regular colonies. In this case it is the emerging and sealed brood, and bees and honey that are raised from the brood nest into a body which is placed on top of an inner cover on top of the hive. The queen and uncapped brood is placed below these inner covers. The unit on top is separated from the old queen by means of the inner cover and is provided with an entrance at the back of the hive by cutting out a small portion of the upper rim of the inner cover. A ripe cell is placed in this unit and the new queen allowed to emerge, mate, and take over the upper unit.

Dr. Laidlaw is co-author with Dr. Eckert of an excellent 165 page book "Queen Rearing;" obtainable from University of California Press, Los Angeles, California or your bee supply company (Library of Congress Catalog Card No. 62-19242).

CHAPTER 5

METHODS FOR REARING QUEENS

"No person is an accomplisht apiarist until he is a thorough master of the queen-rearing part of the business."—*G. M. Doolittle*

Introduction

Although beekeepers do not rear queens without the aid of bees, it is now possible to produce queens in the laboratory without any contact with bees[66]. But it is much easier to let the bees raise queens, and the numerous methods reflect local practices and variations of individual beekeepers. Whatever the method, bees manage the care and feeding of the queen larva until it is "sealed" or "capped" in an elongated peanut-shaped queen cell. It is this cell which the beekeeper harvests—during the interval while the larva metamorphoses into a pupa and before the virgin queen emerges—and the term queen cell refers to the cell with the live immature queen in it.

Beekeepers may be reluctant to undertake the production of queen cells, but there are simple ways to obtain a few cells for replacement of undesirable queens or for increase, and it is a challenge to develop competency with more elaborate methods. Information on queen rearing in general beekeeping manuals is limited, and we hope that this compilation of information from specialized books and articles on queen rearing will stimulate more beekeepers to try this fascinating side-line of their craft.

Natural sources (supersedure and swarming)

It is possible to secure a few cells from a colony which is preparing to replace a failing or aged queen (supersedure). Only when queens are marked, or their wings clipped, are we aware of the frequency with which established colonies quietly supersede their queens without decrease in morale or honey production. If all supersedure cells are removed, the colony will make others, and the old queen does not disturb them. F. J. Wardell[133] was able to secure 263 such cells from one such colony during a season; Grimmond[56] reported 92 present at one time. However, if a new queen is allowed to emerge, she will attack the other cells, kill the young queens, and eventually replace the old queen.

Queen cells with reddish-brown tips, caused by bees removing most of the wax over the membranous cocoon, are "ripe" and the queens due to emerge (11–12 days after cell building began)[109]. The first virgin to emerge inhibits the emergence of the others, but they will start to emerge when the first queen is removed[68]. Queens reared in colonies about to supersede are fed more liberally by nurse bees than those forced to rear cells by the beekeeper[146].

Queen cells from colonies preparing to swarm are also usable, unless it is undesirable to perpetuate the swarming trait. Doolittle recommended manipulating colonies to stimulate the building of cells in preparation for swarming, as he was of the opinion that queens produced under "natural" conditions were superior to those produced by any other method[41]. He is supported by recent findings that queens from swarm cells have on the average more ovarioles than queens from emergency cells or from beekeeper-reared queens[20,152]. The following characteristics distinguish supersedure from swarm cells:

Queen cells	*Supersedure*	*Swarming*
Number	few (1–5)	many (3–30)
Position	tucked away in odd corners	protrude from face of comb
Age	approximately similar	widely variable
Contents of worker cells	eggs present	eggs absent

Woods proposes that his Apidictor can be used to distinguish differences in sounds from a colony 25 days prior to its swarming or supersedure[174].

"Artificial" queen cell production

All methods that stimulate the colony to build queen cells when the beekeeper wants them take advantage of the basic behaviour by which the colony produces emergency cells in the absence of a queen (the Japanese honeybee *Apis cerana japonica* is an exception[62]). The cells are capped 5-5½ days after hatching and can be given one each to queenless colonies or nuclei, where the virgin queens will emerge and fly to mate. Some authors suggest checking the colony for capped cells 3 days after dequeening and destroying any found, as these must have been produced from larvae older than 36 hours. Caste determination occurs shortly after this age, so intermediate forms might develop[4]. From the results of C. C. Miller's experiment it would be a rare occurrence[100].

Irrespective of the method, success depends upon: (1) an abundance of bees (if deficient, add frames of emerging worker brood a few days in advance, or shake bees off frames taken from other colonies); (2) a minimum of 2 full-depth (or 4 shallow) combs of honey; (3) an abundance of pollen; (4) a good nectar flow, or syrup (1 part sugar : 2 parts water) fed 3 days prior to manipulation and continued until the cells are capped. These conditions simulate the conditions in a colony preparing to swarm: an excessive number of bees, brood, nectar, and pollen for the space available[147a].

In queen rearing the time table for procedures must be followed strictly once it is begun, so the colonies used should be gentle as well as populous. The behaviour of large colonies is markedly different from that of small ones, and even in good weather a gentle colony may "boil up" and sting when the brood chamber is exposed. Under adverse conditions, aggressiveness in a colony can make work intolerable, if not impossible, and thus limit the choice of method to one that takes a minimum of manipulation and does not require finding the queen.

Disturbance of the colony resulting from manipulations affects foraging for only 10–60 minutes; the state of queenlessness itself has no effect[92]. Various methods used seem to be equally good, since the weight of virgins produced by them is the same,[137] but the opinion that naturally produced queens are superior to artificially reared ones has been often voiced[85,160]. One investigator contends that the evidence supporting this opinion results from the use of inadequate rearing methods[90]. The hobbyist or sideliner can afford to rear queens under ideal conditions[61]

The seasonal start of queen rearing is determined by the supply of mature drones to fly with the queens about a week after the queens emerge. According to F. W. L. Sladen (1920) drones are not mature enough to mate at 14 days old[46]. Kurennoi found some drones mature when 12 days old, but the greatest number were over 20 days old[80]. In temperate climates operations commencing with the appearance of dandelion or fruit bloom[101] are likely to ensure both drones and suitable weather for mating flights. Rearing should be completed before the hives are crowded with bees and require frequent checking for space and swarming preparations[72]. However, some queen-rearing procedures serve as effective swarm preventives, and the emergence of queens in the colony during the honey flow increases the amount of honey collected[77]. For the hobbyist, it may be more convenient to postpone queen rearing until late summer, as there seems to be no rationale for the traditional rite of early spring requeening[3]. In the north temperate region queens begun in early August are assured of being mated and tested before the earliest possible frosts, although some methods are less successful when used during periods of nectar dearth[1,47]. Since queens 2 or 3 years old perform better than younger ones, it is best to delay a decision to requeen until colonies have an opportunity to show their performance[67,141].

Dequeening

When the ancient Greeks wanted to increase the number of their colonies, they placed in a new hive some combs removed from one of their movable-bar hives[175]. The queenless bees would then produce queen cells from some of the worker larvae. This is the basic technique upon which various modifications of dequeening have been developed. Langstroth moved one queen around between three colonies[84]. Phillips used queen-excluder zinc to make three "divisions" in a hive body, but the disruption of shifting the queen from one side to the other did not always produce good results[122]. A more successful alternative was devised by Beyleveld using a hive mounted on a pipe. A queen-excluder slide was pushed in to make a portion of the colony queenless, and the hive was turned through 180° to get rid of the old, troublesome field bees[18]. The method described below does not require special hives or equipment.

1. Prepare an empty hive (1 brood box) whose entrance has been reduced to $2 \times \frac{3}{8}$ inches (50×10 mm) and closed with grass or window screening to help ensure that sufficient bees will stay with the little colony (nucleus) when the entrance is reopened after 2 days. Keep the hive cool and provide dilute syrup or water.

2. Remove from the parent colony and place in this empty hive:
   (*a*) the queen and the frame of brood on which she is found;
   (*b*) at least one frame of emerging brood, placed next to the frame with the queen;
   (*c*) at least two frames of honey and pollen (one on each side);
   (*d*) additional bees (from at least two other frames) shaken into the nucleus.

3. Complete the hive with drawn comb, or empty frames fitted with foundation, (one frame between 2(*b*) and 2(*c*) above). As more space is required for brood or stores, the frames of honey should be moved out towards the sides.

4. If the queen is to be returned, place the nucleus behind the parent colony with the entrance in the opposite direction.

5. If the nucleus is moved more than say 8 km (2½ miles) away, the entrance can be opened up immediately and all the bees will remain with the new colony. After a week or more, it is closed again (at night), and returned to the home apiary. Very few bees will desert, but if it is not moved from the home apiary initially, field bees will return to the parent colony.

6. Since the nucleus will not have field bees for a few days, it should be fed thin syrup.

7. Queen cells will be built by the bees in the parent colony (from worker larvae 3 days old or younger); these should be removed by the 9th day after dequeening and the old queen returned, or the bees allowed to keep one or more of the cells for requeening. If the old queen is to be killed, she should not be disposed of until a new queen is mated and brood from her eggs is sealed. Alternatively, the old queen can be introduced to a queenless colony or an established nucleus.

8. The bees will seal uncapped brood placed above a queen excluder, and this will be ideal for making into nuclei after 9 days when the queen cells must be removed. The number of cells will vary from a few to 12 or more. If they happen to occur on several frames, each frame with its cell(s) can be used to set up a nucleus.

9. Alternative: Move the colony to one side of its stand, with the entrance at the back. On the parent stand, place an empty hive body containing a comb or two of honey, a frame of pollen, and a frame of eggs from the colony selected (be sure the queen is not on the frames). Fill the hive body with empty comb. The nucleus can be moved or united to the parent colony (provided with a rear entrance) before the major honey flow begins[156].

Induced supersedure

This method does not require elaborate manipulations or special equipment except for a queen excluder or two and a double division screen. The latter can be purchased, constructed[159], or made by stapling fine wire gauze (window screening) on both sides of a queen excluder, to prevent contact by bees. A strong colony is rearranged as indicated below, with a minimum of one deep frame of honey and one of pollen placed at each side of each box of brood:

A. Hive before sorting brood:

1. top cover
2. honey super
3. honey super
4. brood chamber
5. brood chamber
6. floor board (bottom)

B. Hive after sorting brood:

1. top cover
4. box containing combs with eggs and uncapped brood
   queen excluder no. 1
2. honey super
3. honey super
   queen excluder no. 2
5. box containing queen and capped brood
6. floor board (bottom)

Twenty-four hours after the brood has been arranged as in B, queen excluder no. 1 is removed and a double division screen put in its place. If the nurse bees that moved up into the top chamber (4) to care for the young brood then consider themselves queenless, there should be queen cells after another 24 hours, and the screen is again replaced by the queen excluder until the cells are removed within 9 days of starting the manipulation.

An alternative method uses a wooden inner cover with a piece of queen-excluder zinc covering the feed-hole both above and below[36,104,113,153]. This avoids switching screens and excluders (an advantage in regions with capricious weather) but is not always successful. Queen-excluder zinc has also been used to segregate a portion of the combs in the hive[11,122]. A horizontal double-screened board used by Chambers had excluder zinc in slots both above and below. A piece of metal was pushed in to cover the excluder and thus to separate the upper and lower chamber when starting cells in the upper (queenless) portion of the hive[34].

If a flight-hole is provided in the top brood box, a queen can be permitted to emerge, mate, and establish a second colony there, and this can be left in place for the two-queen system of management, or moved to a new site when strong enough to survive, or used for requeening. A virgin queen may be able to squeeze through the excluder, to kill the queen below, so it might be wise to substitute a solid board or double division screen before a queen emerges in the upper chamber, or to use one of these from the outset. The Bee Research Association conducted some research on modifications of the method[163].

Historical note: Separating the queen from the uncapped brood with a queen excluder is similar to Demaree's method of swarm control[40]. C. C. Miller took credit for first reporting that colonies may produce a new queen in a remote box of brood[103]. Doolittle advocated it as the ideal way to raise queens and squabbled with Alley over priority[42]. A letter written by Demaree in 1893 established that he was aware that bees would produce queen cells above an excluder with a queen below[87]. Long before others, A. A. Fradenburg had seen the advantage of using the upper storey of a hive to produce cells and queens, and thus to avoid making the colony queenless[50]. W. T. Cary suggested using two queen excluders[33].

It is curious that, on the page facing Fradenburg's claim to priority over Doolittle in an 1889 issue of *Gleanings in Bee Culture*, another claim appears[48,51]. W. E. Flowers had written to Heddon, Doolittle and Root in 1882, describing his infallible scheme for shaking bees on to frames of foundation and placing the brood in an upper storey with a queen excluder over the lower storey. He complained that his offer to write up the method met no response from Root, in spite of the fact that he could secure affidavits to verify the facts. It seems we should substitute "Flowers" for "Demaree, Doolittle, or Miller". The use of an upper storey for rearing and mating a queen has also been referred to as the Alexander method[6,26,134,157]. Recent work by A. K. Skriptschenko has shown the efficacy of placing the queen and bees on empty combs and foundation, for increased honey production[2].

Cells without locating queens

Directions to "find the queen" can be unacceptable when the hive is as tall as the beekeeper, or when the weather keeps the bees confined and they are quick to boil over and attack at the first exposure. The four methods described below may be useful in such circumstances.

R. Bentley: Place half the brood from a strong colony (at least 6 deep frames of brood) into an empty hive body, along with a minimum of 2 frames containing honey and pollen, and empty frames to fill out the box. Place this box (A2) on the floor board under another strong colony (B), with a solid inner cover separating the two. The upper colony is provided with a new entrance, using wooden wedges (e.g. strips of shingle), auger holes in the boxes, or upper entrances.

If, 5–8 days later, A1 on the original stand has no eggs, but does have queen cells, the queen is in A2 under colony B. If eggs are present, the queen is in A1 on the original stand. Twelve days after the colony was first divided, the queenless box (either A1 or A2) should be placed on a new stand some distance away, and B put in its place. If A2 is queenless, B will remain on its stand, but if A1 is queenless, B will be moved to the A position[16].

F. G. Rauchfuss: A much simpler alternative uses a box of brood above an inner cover with queen-excluder zinc over the feed-hole. After 8 days, the box containing eggs is known to contain the queen and can be set on a new stand. The bees at the old stand will then produce a new queen. If they do not already have queen cells, they will require at least one frame with eggs and newly hatched brood from which to produce them[127].

M. H. Stricker: See No. 9 in section on dequeening above.

Top entrance: This method is applicable to a colony in which an appreciable number of bees are using an entrance in the top hive body, as in spring after wintering with an auger hole as a top entrance. It is undertaken in the middle of a warm day when bees are flying freely. One or two combs of capped brood with small patches of eggs, and two or more frames of honey and pollen with the adhering bees, are placed in an empty hive body. The remainder of the hive body is filled with empty combs or frames to be drawn out (nuclei build worker cells readily). The parent hive is covered with a standard bottom board, and closing the space between it and the lower hive body. An inner cover with screening on each side of the hole (or a double division screen) may be used in place of a standard bottom board. Pieces of shingle or other wedges will elevate the nucleus enough to form an upper entrance. The nucleus is placed on top of this bottom board and covered. The top entrance to the parent hive is closed. Most of the flying bees oriented to this top hole will follow the bottom board into the nucleus, assuring a large enough population to keep the brood warm and to build queen cells.

The nucleus is checked for queen cells 5–7 days after establishment, and for eggs about a month later. At this time, if the nucleus is moved away without disorienting the bees, the procedure can be repeated. The nucleus with a laying queen may be used for a two-queen system, requeening, or increase. If for increase, the parent colony is moved to a new stand, and the nucleus placed on top of additional hive bodies at the original stand[70].

Quantity cell production

Until the 1880s, the only method for procuring queen cells was either to stimulate swarming conditions in the colony or to render it queenless. The cells produced by these methods (3–12 or more) are entirely satisfactory, but they are not always built where it is convenient for the beekeeper to cut them out, and the comb is damaged in the process. If the whole frame is put into a nucleus or colony there is no difficulty, but this limits the number of colonies that can be supplied with queen cells to the number of frames that chance to have cells on them.

To secure more than a few queen cells, it is necessary to use one of the following methods, in which comb containing eggs or young larvae is given to a colony in a way that enables the queen cells to be harvested easily. The additional cost of labour and equipment is compensated by higher yields of queen cells. Techniques for mass queen cell production are usually credited to four Americans (Alley, Doolittle, Pratt, Pridgen), although the basic information was established by European apiculturists. In 1568, 300 years before commercial exploitation, Nicol Jacob in Silesia published the observation that a queenless colony could rear a queen if it had eggs or young larvae in worker cells[162].

The interest in disseminating new races of bees, such as the Italians imported into the United States in 1860, and acceptance of bees by the post office in 1863, provided the stimulus for the American developments. But by 1872 postal authorities ruled to exclude bees from the mails, because of honey leakage and because personnel were stung. In frustration, A. I. Root and others (1873) mailed pieces of comb containing eggs from Italian queens, for introduction into colonies of black bees. Queens were successfully produced by this method, but better methods of propagation were needed. Suggestions began to appear in bee journals, which were developed into methods suitable for large-scale, commercial production of queens. W. J. Nolan summarized the history of this development which rose to a peak in 1881–1890 and again in 1911–1920[63,111].

Strips of brood comb (Alley method)

M. Quinby, in his *Mysteries of bee-keeping explained* (New York, 1853), described requeening queenless colonies by inserting a piece of comb with young larvae between the combs of his box hives, but he did not recommend this technique for producing queens routinely, as he believed the queens were of poorer quality than those produced under the swarming impulse. Support for this view by others has been noted above. Lukoschus suggests that differences in the position of queen cells on the comb (lower edge and/or sides in swarming or supersedure) results in temperature differences that have metabolic effects[93,94].

A. G. Shirach in Germany had advocated this method in 1771[63]. A. J. Cook in his *Manual of the apiary* (Lansing, 1876) recommended that pieces of worker comb be fitted into holes cut in the combs, as J. Dzierzon had done[28]; J. S. Harbison patented this process in 1859 (U.S. Pat. 26,431). D. H. Townsend fastened strips of worker comb underneath the top-bar of a frame, using tacks (drawing pins); J. M. Brooks fastened a strip to the bar with melted wax, after first trimming the cells down to the septum[83]. In 1883, H. Alley published his *bee-keeper's handy book*, pulling together these and other schemes he used in producing queens on a commercial scale, and his method was advocated by Jay Smith in a supplement to his own book[129,150].

Every other row of cells (in dark comb) containing eggs and larvae 1 day old is cut to form a strip, using a thin sharp knife kept warm in hot water and wiped dry before each cut. The cells on one side are trimmed to within 6 mm (¼ inch) of the midrib; a match is twirled in every 2nd and 3rd cell, leaving the 1st cell of three as a potential queen cell. If more space is desired between cells, a greater number of eggs or larvae can be destroyed between those left intact.

The uncut side of the strip is dipped into melted beeswax (Alley used 2 parts rosin), 1 part beeswax [equal parts (1903).] which must not be so hot as to kill eggs and larvae, and attached to a suitable support. This may be: (1) the underside of a comb trimmed back from the bottom-bar about 8 cm (3 inches); (2) the underside of a wooden cross-bar nailed between the end-bars of a frame (a single nail permits tilting); (3) the underside of the bottom-bar of a shallow (or half) brood frame; or (4) the upper side of an opening 8–16 x 4 cm (3–6 x 1½ inches) cut out of a comb of honey (preferably with some open cells). The prepared comb is then placed in a starter cell building colony (see below).

The method has been refined, with holders for individual cells, and punches to cut out individual cells from comb[14,63,73,106,115,155,177]. R. M. Crawford prepared strips by embedding thin wooden slats into a sheet of foundation and then placing two such prepared sheets into a frame with the slats back to back. After the bees built out the cells and the queen laid eggs in them, the sheets of foundation were removed, and a pronged device used to destroy all but every third horizontal row of eggs. Each strip with a slat backing was then cut apart and fastened with thumb tacks (drawing pins) to the bottom-bar of a shallow frame. When the queen cells were completed, the strip was pried loose, and pruning shears used to cut the wooden slat between the cells, to separate them for introduction into a colony[37].

Whole brood comb (Miller method)

This method is likely to succeed at the first attempt, and under optimum conditions will produce sufficient cells for a small operation. The succinct description[112] of the method by "Obed." taken from *Bienenzeitung* about 1860 cannot be improved upon:

"If after depriving a colony of its queen, a horizontal cut be made through a brood-comb containing eggs and young larvae, and the upper section which remains attached to the top slat of the frame be reinserted in the hive, the bees will construct royal cells and raise queens from the larvae on the fresh-cut margin of the comb, even if no royal jelly be used to designate the place where royal cells are desired. This process invariably succeeds if the comb be placed in close proximity to the brood in the hive, and the bees be numerous enough to cover the brood-combs properly. If two or three days after, when royal cells have been partially built, another comb with eggs and young larvae be prepared in like manner and inserted, royal cells will be started on this likewise, and the queens reared therein will mature several days later than those on the former comb. This process may be extended with like success to the insertion of a third or a fourth cut comb, and successive rearings of queens thus secured. The apiarian must, however, be careful to remove and use these royal cells before the inmate of any one of them matures and emerges, or the destruction of the others would certainly follow. By seasonably rearing queens in this manner and placing them, or the royal cells containing them, in small boxes furnished with maturing worker-brood and a few hundred bees, the apiarian may readily multiply queens from a single hive, without interfering with the labours of other stocks; and the population of the hive used for this purpose may easily be kept up, by inserting from time to time, a few combs containing maturing worker-brood taken from other colonies"[112].

Damage to the brood comb can be avoided by trimming back the edge of a newly built comb to just-hatched or "hardly noticeable" larvae (as suggested by Anton Janscha in 1771), so the queen cells built along the edge are easy to remove[7]. This method was also suggested by A. J. Cook and publicized by C. C. Miller with modifications[102].

A half-sheet of wax foundation is fastened in the upper part of a frame with a single embedded top-wire. The frame is placed in the brood chamber of the colony selected for queen rearing, and after a week should have drawn-out cells containing eggs and newly hatched larvae. It is then removed and the bees brushed off, as the comb is too delicate to shake. A series of V-cuts are made along the (lower) edge of the comb with a sharp knife. This should be done in a warm, shady place so that the larvae are not harmed by exposure to the sun. The comb is placed in a queenless cell-building colony (see below); a check is made after 4 days, and cells touching one another are thinned out. In 9 or 10 days the cells can be harvested and distributed.

Narrow V-shaped strips of foundation may also be used, but a colony restricted entirely to worker comb may draw out drone instead of worker cells on worker foundation. To avoid this, remove all but two frames of brood, or provide empty frames in which the colony can produce drone or storage comb at will. If new comb drawn previously is used, newly hatched larvae may be present in 4 days rather than 1 week. M. Prichard placed an empty brood comb in a breeder colony for 6 days and then cut long horizontal strips of comb a few cm (about 1 inch) wide where there were eggs. The comb was then placed in a queenless colony to build queen cells along the upper edge of the openings in the comb[126].

Horizontal comb. I. Hopkins described the method but disclaimed the credit usually given to him (and also to Case) for its invention[60]. A thin knife is run along the sides of every 4th row of cells in a comb of eggs, the intervening 3 rows being removed down to the midrib. In the remaining 4th row every 2nd and 3rd egg is destroyed, leaving the 1st egg as a potential queen cell. The frame is placed face down in an empty hive body over a starter colony; notches need to be cut in the hive body to fit the projecting ends of the top bar. The whole is covered with canvas or cloth. J. Gray provided space for a cluster under the comb; he demonstrated his scheme in England in 1909[55]. Jordan used boxes to hold cut pieces of comb which were then placed in a frame[74a].

L. E. Snelgrove's "B.H.S." method combined the Barbeau punch system with the horizontal brood comb technique by Hiller, as a source of started queen cells; he used one empty frame under and another above such a comb to provide space in which the bees could build queen cells. The frames were covered with a canvas "quilt" and left for two days in an empty hive body above a colony made queenless and broodless[151].

The Stanley system provided cutters and plugs, and a plastic (Perspex) tip for use in a special hive cover much like Swarthmore's[123,155]. Fritz Bauckhage devised a simple pointed metal support on which to fasten a cell containing an egg or newly hatched larvae for attachment to the face of a comb[13a]. A simple triangle of tin can also be used.

Larval transplant (grafting)

In 1876, E. D. L. Larch used the term "grafting" for transferring a worker larva to a queen cell[83]. If strict rules of nomenclature were applied, the earlier "transposition" of J. L. Davis (1874) would have preference[83]. Grafting usually refers to the union of tissues, as in human skin or plant grafts. Since even the exchange of a whole organ is called a transplant, the removal of an entire organism should imply more than a "graft". However, the term transposition often implies a rearrangement of parts, as in grammar, music, mathematics, etc. The substitution of the term "transplant" for either transposition or graft would give a description closer to the actual process, and perhaps be more meaningful to the uninitiated.

In grafting (described in detail by Wm McKinley[96]), a worker larva 12–36 hours old is lifted out of its cell with a "grafting needle" and placed into a wax cell cup. Woyke supports the preference of commercial queen rearers for larvae less than 1 day old[176], but bees are less demanding[24]. Oettel observed that a colony chooses larvae that form a circle at the bottom of the cell[161]. Weiss found that queens reared from older larvae weighed less (those from eggs weighed least), but there was no significant difference between the numbers of their ovarioles[172].

On a small scale, queen cells harvested from old combs are highly acceptable to the bees; they were used by F. Huber in 1791 for repeating Schirach's investigations on producing queen cells from worker brood[83]. When offered a choice of natural or artificial queen cups, bees tear down the artificial ones[31]. Anticipating queen rearing, bees include queen cups when they draw out natural comb[8].

J. L. Davis transferred eggs, mailed to him by A. I. Root, into drone cells in queenless nuclei[83]. Wardell at Root's also used drone comb; he transplanted eggs into every 4th cell, first enlarging the opening slightly with a blunt stick[133]. J. D. Foosche reported using drone comb and exchanging larvae in queen cells[49]. Bees prefer larvae grafted into drone cells which have been used for brood rearing a few times—or not at all—to larvae grafted into comparable worker cells.

Queen cell cups

For large-scale production, machine-made wax cells and wooden cell receptacles can be purchased from supply houses or hand-dipped. There is no significant difference in acceptance[114]. Artificially made cell cups (8·9 mm) were preferred by bees to punched worker cells, but not if they were 7·8 mm in diameter[169]; experimental work in which larger cells were provided for rearing queens resulted in larger, heavier queens that laid eggs both earlier and later in the season[79]. When plastic cells are used, they should be sterilized before reuse to prevent disease transmission[76,95].

Hand-dipping of cell cups requires wooden dipping sticks, which can be bought from European supply houses or made from teeth of a wooden rake or pieces of dowelling 8–9 mm ($\frac{5}{16}$–$\frac{3}{8}$ inch), rounded and smoothed at one end. Wax is melted in a double boiler or can be placed in a pan of hot water. Bees will not accept cells made from scorched wax, and the wax should be refined with distilled or rain water. The stick is soaked in water and drained well before it is dipped about 12 mm ($\frac{1}{2}$ inch) into the just molten wax. It is lifted out quickly and redipped when the wax has set, although not as far as the first time. This is repeated 3–5 times, dipping a shorter distance each time. Cooling in water may speed the process, or a series of dipping sticks can be mounted in a holder so that several can be dipped together. The cell is carefully twisted off and mounted on a small block of wood with wax or softened propolis.

W. H. Pridgen mounted dipping sticks on a wheel and produced wax cell cups at the rate of 2000 an hour[125], and Rauchfuss used a similar machine[83]. Pratt's "Grace cell-compressor" pressed cups from solid plugs of cool wax *quickly* and the cups were less easily damaged. The melted wax was poured into wooden cups (length 12 mm, $\frac{1}{2}$ inch; diameter 9 mm, $\frac{3}{8}$ inch) with holes 8 mm ($\frac{5}{16}$ inch) in diameter and 9 mm ($\frac{3}{8}$ inch) deep[123].

Commercial queen rearing

On a horizontal stick or bar 12–20 cells are mounted at intervals, leaving a space 2 inches at each end. Staggering the cells rather than placing them in a straight line may reduce building of burr comb between cells, as does placing a piece of foundation at each end[86]. To save space, grooves or slots may be cut in the side pieces of a frame so that 3 sticks, 5 cm (2 inches) apart, can slide in and out easily. Alternatively, a nail through the frame into the bar will provide for tilting the bar and the frame can thus be laid flat[57], or a wedge-shaped centre portion can be made removable[61].

The wooden cell receptacles, each fitted with a wax cup, are pressed into a streak of wax placed along the bar. Adequate illumination is needed in front of the operator, who uses a transfer tool; this may be purchased, or fashioned from a matchstick, quill, toothpick, bent darning needle, copper wire, twisted horse-hair, a suitable hardwood twig or grass stem, short piece of watch main-spring attached to a wooden handle, etc. The chosen tool is inserted underneath a larva to lift it from the worker cell with as much brood food (royal jelly) as possible; the larva is placed in one of the cell cups on the frame bars. With experience and optimum conditions, up to 85% of the transplanted larvae will be accepted and reared by the bees as queens.

Various precautions are believed to influence acceptance by the bees, though some may not be critical[167,170]:

1. Giving the wax cups on a frame to a colony a few hours before using ("acclimatizing") has been shown to be unnecessary[24,171].

2. Priming cells with royal jelly before placing larvae in them results in stunted larvae. The jelly is quickly removed by the bees[49,74,118], and if it gets on both sides of a larva, it will block the spiracles[136]. Small colonies prefer "wet" grafts (larvae on a drop of brood food)[24].

3. A damp cloth or paper towelling kept over the frames from which the larvae are being taken, as well as the cell cups that will receive them, minimizes drying of the larvae. Bees will have been brushed off the comb before use.

4. A shed or room that can be kept at 25–30°C (80-93°F) and relative humidity of about 50%, or a portable shed or tent in out-apiaries, can prevent overheating or chilling larvae. When manipulations must follow a schedule in spite of poor weather, the value of a beehouse for queen rearing is indisputable[142].

5. The cells into which larvae have been transferred should be placed as quickly as possible into the hive prepared for them; (1) swarm-box; (2) starter colony; (3) combination starter-finishing colony; or (4) strong nucleus (if only a few cells are introduced). However, larvae can survive outside the colony from 3 to 24 hours depending on their condition and age[167].

6. A bar of 12–20 cups is usually given on three successive days, or all three bars might be given together to a very strong colony. When a deep super is used for queen rearing, the cells can be mounted on the bottom-bar of a shallow or half frame with open honey and pollen in the comb. Phillips recommended a frame without a bottom piece, so that the cells could be lowered into the mass of bees occupying the space, and the bees would then cluster on the cells immediately. Rosser and Arthur pushed cells into each side of a brood comb between the brood and pollen areas, where bees usually build queen cells for swarming[135]. C. A. Greig fastened the cell cups at intervals over the surface of a comb containing fresh pollen and honey, dipping the base of the cells into hot wax before pressing them firmly into position[172a].

7. Without a honey flow, sugar syrup must be fed at least 3 days prior to transplanting, and throughout the cell building period. Phillips[122] preferred to rear queens during a light flow, or none at all, to avoid the mess of burr comb and honey around the cells, and this point is underscored by Roberts[130]. More royal jelly is produced during a poor nectar flow than during a good flow[30].

8. Little or no smoke should be used during manipulations.

Zhdanova found optimal conditions for queen rearing during the main flow and recommends that young nurse bees be provided 25 days before transplanted larvae are offered. She removed brood and other queens 10 days beforehand, and fed syrup until the cells were sealed[178]. The classical Zander method in Bavaria used a colony queenless for 9 days[136].

Double grafting

In "double grafting" a worker larva is transplanted into a queen cell, and 1–2 days later it is replaced with a new young larva. The queens produced by this technique are slightly heavier than those from single transplanting[20,98,107]. Volosevich considered double-grafted queens almost as good as queens from swarm cells, but single transplants poorer than queens from other methods[160]. Weiss found no significant correlation between queen weight and number of ovarioles[172], although Hoopingarner and Farrar did[59a].

Cocoon transplants

Pridgen transferred the cocoon containing a larva to a cell cup, to avoid disturbing the young larva as in Atchley's method of fastening the cocoon on to a pointed stick[125]. Perret-Maisonneuve designed special equipment for this procedure and sharply rebutted criticisms that the method was difficult[120].

Egg transplants

The transfer of eggs into cell cups was practised by Gusev before 1860, and advocated by Reidenback in 1893. In 1952, Örösi-Pál developed a technique of punching out a cell base containing an egg for use instead of a grafted larva; his method required about as much time as double grafting with larvae. He found eggs just over 2 days old more satisfactory than those less than 1 day old or nearly hatching[5,117].

Jordon tried Örösi-Pál's method and obtained superior queens, but 50% of the transplants failed[75]. The various ways that Weiss tried for transplanting eggs resulted in poorer acceptance than the use of larvae, and he did not find the age of the egg critical (except that the colony would not accept eggs older than 3 days)[164,165]. He recommends attaching pieces of comb to cell cups[168]. Pieces of comb with eggs (*Eistück*) can be sent by post, and withstand a temperature as low as about 18°C for not more than 2 days, but must be introduced into a colony when or before they are 2½ days old[166]. Such conditions might require personal transport on a plane. Taber devised forceps with which the eggs can be removed from comb and transferred to a container, and 75% hatched whether in a colony or an incubator[158].

Historical note

G. M. Doolittle is generally credited with the transplant or grafting method as used today. In a letter to C. C. Miller, now in the University of California Library, Davis, Doolittle indicated that he used cell cups in 1875–76 and dipped cells in 1880 or 1881, but not later than 1882. He remembers that in the bee papers "someone" had proposed making queen cells to order on a stick. A. I. Root also mentions that "somebody" spoke to him of making artificial queen cells by dipping a wet stick into melted wax[83].

In 1883, Doolittle met D. A. Jones of Canada, who since 1879 had been in partnership with F. Benton of the U.S.A. in a bee-breeding venture in Europe. It is not unlikely that they heard of the transfer of larvae by Weygandt in 1880, and the ingenious implements and methods for raising queens by transplant which W. Wankler devised and exhibited between 1881 and 1883. Benton purchased a set of Wankler's equipment at an exhibition in 1883[17]. German texts can fairly discuss queen rearing methods without reference to American work.

In 1878, W. L. Boyd suggested fastening just-started queen cells on a stick for transfer of worker larvae, and L. Heine reported some success with "artificial queen-cells" but was sceptical of their practical value.[63]. A. G. Beljavsky upset all claims for priority by revealing that in Russia E. Goosev [Gusev[5]] had received a prize for the transfer of eggs in 1860[15]. F. Mehring, the inventor of comb foundation, is said to have transferred larvae in 1866[99].

Pratt "locked" pressed cells into a frame like that printers use for type, and placed it in a queenless, broodless nucleus[124]. A laying queen introduced 6 hours later was expected to lay eggs in the cups, and thus eliminate the "troublesome task of transplanting larvae by hand". Örösi-Pál succeeded in getting queens to lay eggs in as many as 65 of 70 cups, but the larvae did not develop, and the bees eventually discarded almost all the eggs[116]. Queens whose front legs had been amputated have been observed to place eggs in artificial queen cells[147]. Bognoczky was successful in getting queens to lay in hexagonal plastic tubing 6 mm in diameter and 7 mm deep, coated with wax[23].

Swarm-box for starting queen cells

A colony preparing to swarm, or which has just swarmed, is excellent for rearing not more than ten maximum-weight queens[59]. For routine queen cell production on a large scale this arrangement is impractical, and a closed, screened box is commonly used, for instance by about 60% of the southern U.S.A. queen rearers[131].

Nolan's description of the Alley and Pratt swarm-box methods summarizes the procedures and theory:

"Alley advised smoking and drumming a sufficient quantity of young bees into an empty hive-body and keeping them there long enough to realize their queenless condition. It was his idea that they would then have a large amount of larval food on hand, since they had been deprived so suddenly of brood, and had filled up with honey on being smoked and drummed. The prepared cell-cups were next inserted between frames of honey and pollen in another hive-body, which was then set over the hive-body containing the queenless bees. At the end of 24 hours the cells were transferred to another colony, queenless but with brood, and were left there until sealed. Then they were given to a third queenless colony, each queen cell protected in a nursery cage. Doolittle, on the other hand, advocated the rearing of queens over an excluder in a queen-right colony. His success in this manipulation is attested by the fact that in a single season he reared 600 queens in the same colony over an excluder. [Of southern producers, 15% use queenless colonies, and 85% use a queenright cell finisher[131].]

"Pratt combined to some extent the two methods. In devising the Swarthmore swarm-box he followed Alley but instead of first confining queenless bees, shaken or drummed into an empty hive-box, he confined them in a specially constructed five-frame swarm-box containing only three frames of honey and pollen, with an empty frame-space on each side of the center comb. In slits in the cover over these vacant spaces were fitted slats for containing the cell-cups. The swarm-box, as soon as filled with bees, was given empty cell-cups. It was then well covered on top, and set in a cool place. When the empty cell-cups had remained in the swarm-box for about six hours, larvae were transferred to them and were left in the swarm-box about eighteen hours for acceptance. Pratt in this way could give his swarm-box a new lot of cell-cups every twenty-four hours, thus using the same bees for about three or four successive lots. Pratt considered the combination of a cool place and a warm covering for the top a most essential factor in the manipulation of swarm-boxes. It was his idea of this operation that the cool air outside would cause the bees to tend to cluster tightly, while the warm covering at the top of the swarm-box would cause the upper part to be so warm as to induce the bees to form and keep their cluster there. Thus the bees would remain clustered tightly around the cell-cups and the young larvae would at all times have sufficient heat and other conditions conducive to their proper acceptance. The cell-cups, after being started, were transferred to a cell-finishing colony either over an excluder or even in the lower story, provided an excluder nursery cage as devised by him was fitted over the bar of cells."[63]* The superiority of broodless, queenless colonies for acceptance of newly grafted larvae is borne out by analysis of beekeeper practices in England.[52].

Various modifications have brought us present practices; some are set out below.

(1) Jay Smith noted the new swarm-box Swarthmore recommended in the "Government bulletin on queen-rearing"[65] and gave it prominence in his later writings. He advised that its depth should be twice the depth of the standard frame to ensure that the bees would not suffocate. The wooden bottom had a 5-cm (2-inch) rim above it, making a container for food or water as needed. The sides below the frame space were screened for ventilation. Jay Smith used 6–8 lb (3–4 kg) of bees (spare bees from three or four colonies) for 50 cells, and 10 pounds for 100 cells[150].

(2) W. B. Bray published a "Modified Pratt [Swarthmore] system"[25] and noted the importance of light intensity in causing the cluster to break. R. A. Morse has since shown that bright light inhibits the onset of comb building by clustered bees[108].

(3) Instructions for making ventilated boxes with covered slots for introducing frames of cell cups can be found in books by Smith[149] and Sladen[148].

(4) Use of a funnel for filling boxes with bees during active flight will ensure that most are young nurse bees[148].

(5) If the bees are knocked to the bottom by jarring the box, relatively few escape when frames are removed or put into the box.

(6) Bees no longer needed are shaken out in front of the colony from which they were taken.

(7) Water must be available, and can be given in a comb or in feeders. Substitution of thin sugar syrup for honey prevents spread of disease organisms in honey.

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* The practice by F. J. Wardell in 1899 of raising queens "*a la* Doolittle" in the brood nest, with the queen present and carrying out her normal activities[132], was also reported by Lensky and Darchen in 1962[89]. Nearly 100% acceptance of cells was obtained if the colonies were large (20–30 frames of bees), with a substantial proportion of nurse bees and a limited number of worker larvae[88].

After a misunderstanding of verbal directions, one of the authors (TSKJ, 1961) placed a frame of queen cell cups into the middle of a 10-frame brood nest of a queen-right colony. There had been no prior preparation, but the bees built queen cells in spite of the presence of the queen. Such observations undermine the rationale of methods which require the removal or isolation of the queen from the cell building portion of the hive in order that cell building may occur.

Cell-starter colony

Since bees in a swarm-box are confined and must be renewed frequently, commercial rearers in California commonly use a two-storey queenless colony to start queen cells; two-thirds of them use the same colony to finish the cells[131]. J. Smith used 15 lb (7 kg) of bees in a hive box to start 50 cells and added a further 6 lb and 50 more cells every third day throughout the season, removing completed cells on the next day. Three such colonies furnished 1000 mating hives with cells[149].

In the cell-starter colony, the queen and brood are moved away, whereas in the swarm-box it is the bees that are moved. One strong starter colony which can provide 45–90 cells daily requires 3–6 finishing colonies, into which bars of 15 cells each are placed. Queenless bees have the impetus to start more queen cells than they can properly feed[130].

Method A. The queen, and 2 or 3 combs of sealed brood and honey with the adhering bees, are placed in an empty hive body (nucleus) behind the parent colony with its entrance facing in the opposite direction. The remainder of the combs of unsealed brood and eggs are brushed free of bees and given to some other colony to care for, but the combs of honey, pollen and sealed brood remain with the parent colony. If the starter colony does not cover most of the combs, additional bees should be provided from other colonies.

Larvae in cell cups (or larvae from some other method) should be given to the starter colony 2–4 hours after the colony has been set up. Bees desert a queenless hive, and if queen cells are not given for 24 hours, the colony will be considerably weakened[145]. Accepted cells are removed 24 hours later and given to a finishing colony, and a new set of grafted cells given to the starter colony. After starting a few sets of cells, the starter colony and brood are reunited with the parent colony. If the starter colony is to be maintained on a continuing basis, combs of emerging brood must be added every 7 days or as required, since the number of cells started decreases with advancing age of nurse bees[126]. If stores of pollen are not also replaced, the number (and quality?) of queens produced will be affected[131].

Laidlaw and Eckert suggested leaving two combs of young larvae with a comb of pollen between them[83]. These combs of larvae are removed 1 hour prior to the time of grafting, and the frame of grafted cells put in their place to ensure a cluster of nurse bees on hand to accept the cells immediately. G. W. Phillips advised removal of the bottom bar of the grafting frame, to avoid breaking up the cluster as the frame is lowered into the hive[122].

Method B. L. Stachelhausen used a queenless colony established above a queen excluder on a strong colony, 8–9 days prior to grafting. The hive body was prepared with 4 or 5 combs of open brood from other colonies, and the rest of the box filled with empty combs. In 8–9 days this brood was capped. A frame was removed to provide a vacant space for a frame of grafted cells, and this upper storey moved to a new stand. A few hours later, cells were given to this colony to start, and the next morning it was returned to its original position over the parent colony[154].

Method C. The queen and capped brood are confined in the bottom brood chamber with a queen excluder. When the young brood in the upper box is capped, 8–9 days later, the lower box with the queen is placed on a new stand. The top box is placed in position on the bottom board and the grafted cells

inserted. The excluder is left under this top box to prevent any virgin queens entering and destroying the cells[105]. Gontarski recommended this as the best method to meet the requirements for queen rearing. The queen is confined on a comb in a cage made of queen-excluder zinc for 9 days, and then removed for 1 day, when a comb of eggs is placed in the colony. Larvae are punched out of the comb, and attached to bars from which the workers rear queen cells to be removed on the 14th day[53].

Method D. "Go to a very good colony, take away the queen and use her as you like. Leave the colony queenless six days, when queen-cells will have been started. At the end of the six days take all the brood, queen-cells and all, away from the colony. They will then want a queen so badly that they will be willing to give cells the best attention. Then give back grafted cells to this colony containing larvae from the queen you wish to use as a breeder. This colony will rear a nice lot of cells. Try this if you do not believe me"[9].

Method E. Any strong one-storey colony can serve as a starter colony if it is made temporarily queenless. The queen and the frame she is on can be placed in a hive body above a queen excluder on another colony, or in a nucleus. G. W. Phillips caged the queen amongst her own bees and released her when he removed the accepted queen cells the next day. It would be best if the cage used were one which will contain a whole frame, so that the queen is not subjected to the stress of sudden cessation of egg laying. She could also be put in a side compartment made of queen-excluder zinc, large enough to hold 2 or 3 frames, including emerging bees.

Doolittle recommended an upper storey over a queen excluder as the most desirable, since it created artificial "supersedure" conditions. He placed a frame of unsealed brood on either side of the grafted frame, and 24 hours later the accepted cells were removed and placed in a finishing colony. Nolan credits Fooshe with originating this method[63]. Queens reared with combs of open brood receive more royal jelly[19], as do queens reared in colonies about to supersede[146], resulting in heavier queens with more ovarioles[21]. Weiss found no significant correlation between weight and number of ovarioles[172].

Finishing colony

A queenless, broodless starter colony will accept a high percentage of cells. These may be left to be "finished" in the colony if this is moved outside its original flight range, so that the field bees remain to bring in pollen and nectar; cells may, however, not get the best care in such a "stage of emergency". The started cells are therefore commonly transferred to finishing colonies in which a supersedure impulse is created by confining the queen to a lower brood chamber. However, recent evidence indicates that queens reared in queenless colonies are slightly heavier than those from queenright colonies[98]. Queenless colonies were found to feed all larvae three times as frequently as queenright colonies, to cap worker cells sooner, and to produce worker pupae with three times as many ovarioles and larger pharyngeal glands[81]. Of queens sold in the Southern United States, 85% are from queenright cell-finishing colonies[131].

In the Stachelhausen technique (B above) the starter colony is housed on the finishing colony (as it can also be in C), and moved to a separate stand when cells are to be started.

1. The queen on the frame where she is found, and empty combs in which she can lay eggs, are confined to the lower brood chamber by a queen excluder.

A check for space should be made in one week.

2. Emerging and sealed brood is placed in an upper chamber.

3. Unsealed brood is removed and placed in other hives but can be returned after the queen cells are finished.

4. The colony has all stages of brood, except those requiring feeding, and will give full attention to the 15 queen cell cups introduced the next day, and every second day thereafter up to a total of 45 cells.

5. If the nectar flow is light, colonies are fed several days before they are given cells, and throughout the period when they contain cells.

Combination starting-finishing colony

A. A strong colony with brood in most parts of two brood chambers can be used for both starting and finishing queen cells, and will be most likely to appeal to beginners because it does not require excessive manipulation, disruption of colonies in preparing starter colonies, precision of timing, nor additional equipment. The hive is prepared essentially as in the "induced supersedure" method described above, except that it is used for a single frame of queen cell cups (or prepared comb) and can be kept in use continuously. It was Doolittle's method of choice[43] and warmly seconded by E. Penna[119]. A. S. Ivanova recommended it after extensive trials[64], as have W. C. Roberts[130] and Z. M. Marshenkulov[97].

1. The colony should have brood in 2 lower hive bodies and honey in at least 1 super on top.

2. One queen excluder is placed between the honey and the brood, and a second excluder is placed above the box of honey on which another hive body is placed (cell building chamber).

3. The arrangement of combs in the upper cell-building chamber (starting at one side) is: honey, pollen, open brood, open brood (youngest larvae), space for cell cups, open brood (youngest larvae), open brood, pollen, honey.

4. Empty combs are used to replace the combs of open brood taken from the brood chamber.

5. When the open brood in the cell-building chamber is capped, the combs should be exchanged with uncapped combs from the brood chambers below that in which the queen is laying. This will ensure the continuous presence of nurse bees in the upper cell-building chamber.

The colony can be used over a period of time, and requires only that unsealed brood be lifted up from the lower brood chamber when new cells are introduced.

B. A two-storey colony with at least 6 combs of brood is used. The comb with the queen and adhering bees is placed into an empty hive body along with at least one comb each of honey and pollen. After the box has been filled with empty combs and emerging brood, it is placed on the bottom board and covered with a queen excluder. The remaining box of brood and stores is placed above the excluder, with a crown board (inner cover) and a feeder in an empty box above it.

After at least 3 days of feeding (unless there is a good nectar flow), rearrange the boxes, placing the bottom one with the queen on top, and a bottom board or other solid board under it. A small entrance is provided towards the rear. The foragers will join the queenless bees below, and in a few hours be in ideal condition for starting queen cells. The feeder should be replenished if necessary.

Once started, the colony is rearranged again, the box with the queen being put back on the bottom board, and the queen excluder over it. The box with started queen cells is placed above the queen excluder, and the box with the feeder is again uppermost[34a].

Disposition of queen cells

If more cells are produced by starter and finishing colonies than can be handled, it is best to discard the smaller ones, since these are correlated with queens that weigh less and have fewer ovarioles[91]. But queens from small emergency cells may have as many ovarioles as the larger beekeeper-reared queens[152] (see Weiss[172]). Mitchell suggested "candling" queen cells by holding them up to a strong light (as done with eggs), to detect those with dead queens and avoid the loss of time and bees in providing them with a mating nucleus[105a].

The average number of cells produced by a finishing colony per day (6–10) requires some 100 mating colonies (50–200 per starting colony). Here the queen will emerge, take mating flights, and begin to lay eggs. If the cell is mounted on a wooden block or cup, it can be pressed into the face of a comb and held in place by pushing the neighbouring comb against it. C. C. Miller used a hive staple to hold the cell in place, but Wankler's wire holder bent over the top bar is less likely to slip, as are some of the alternatives devised by Perret-Maisonneuve[121].

The spiral coiled queen-cell protector devised by West can also serve as an introducing cage, but J. B. Free and Y. Spencer-Booth[52] found that the use of cell protectors did not increase the percentage of mated, laying queens produced. They also found that queen cells given to colonies dequeened for 3 hours or less were the least successful, those in colonies dequeened 3 days or more being the most successful.

Commercial queen rearers use "baby nuclei" to reduce costs, but a standard shallow or deep hive box can be divided into three compartments each holding three frames. Tiny colonies are more economical of bees when rearing 30 000 to 50 000 queens in a season, but they require close attention and experience for success[69]. Queens in the smallest nuclei were found to take longer to mate, and only 70% (60% in USA[131]) were successful. With three times as much comb area, the rate of success increased to 92%[45]. On the other hand, the stress of sudden interruption of a queen's egg laying may be less when she is taken for shipment from a small nucleus than when she is removed from a larger colony.

Increasingly, commercial beekeepers in the northern United States move a portion of their bees south by truck in the fall, and return the next spring bringing 4–6 nuclei produced from each colony. Such nuclei build up better than packages, and fewer queens are lost from nosema disease and other causes[32].

Cells can also be placed in "nursery" cages for the queens to emerge, before they are introduced as virgins to mating nuclei. This was once done on a commercial scale, and one Canadian and most European supply houses still sell such equipment. Introducing virgins is hazardous, but for research purposes it might be desirable to have queens available in an incubator for selection of particular characteristics[71]. Settman suggested a "queen-tube" for incubation in the colony (where conditions are optimal) as part of an elegantly simple system of queen rearing[144].

A. W. Woodrow found that water was the critical factor in survival of queens in cages outside the colony, whether attendant bees were present or not. Survival is best at 25–30°C and 45–70% humidity[173,114]. The method of storing queens each under a plastic cup on the outside of a screen cage, with bees inside, has the attributes of simplicity, easy management, and demonstrated success[44]. M. Reid investigated the role of diet in determining length of life[128].

Hives for queen rearing

Special hives for queen rearing are not common. The most elaborate may be Beyleveld's double-compartment revolving hive[18]. J. F. Diemer used a double hive with three compartments, as did J. W. Bain[39,12]. Bain's hive also contained small frames for mating nuclei; it was described in bee journals between 1934 and 1949, but was never produced commercially[13]. Schmitz designed a hive with a compartment for rearing queens or housing a nucleus[140]. The long hive body of Goodacre extended behind the hive to provide a separate section for queen rearing[54]. E. R. Harp[58a] has reported the techniques developed by C. L. Farrar, using normal strong colonies in which the queen was confined in a two-frame compartment of queen-excluder zinc. Twice a week the two combs are removed to a brood-rearing colony (and left there until they are capped), and replaced in the compartment by empty combs.

A special bottom board with space for two hives can be used to switch flying bees from one hive to another; such a device was used by J. E. Hand and modified by L. H. Johnson[58,73]. Alternatively, shifting of bees can be done vertically by the use of a modified bee escape board (inner cover, crown board), for instance that designed by Snelgrove or Morris[151,27]. A combination hive-cover and nucleus-box can be used for feeding and queen rearing[38].

Swarthmore's box for holding shell cups for queen cells above the brood frames was the forerunner of Perret-Maisonneuve's *hausette d'élevage* and Stanley's Perspex cover for queen rearing[123,121,155]. The Eriksson model (*drottningodlingslåda*) is available in Sweden[22].

Swarthmore and Keyes attached small boxes (or larger ones to hold a frame) to the sides of the hive for producing queen cells[123,78]. Settman used a tinplate box in which to confine the old queen until the new queen was mated and laying[143]; a queen excluder covered a hole in the side, and one or two frames of emerging bees were placed with the queen. M. Ambrožič used a large cupboard with 60 compartments, each holding a six-frame nucleus and with passageways for uniting when laying queens were removed[29].

Most of the hives designed especially for queen rearing are concerned with providing small colonies (nuclei) in which the queen cells are placed to emerge and mate[35,71,82,110]. Partitions placed in hive bodies divide them into compartments of various sizes for regular or small frames[10]. If shallow hive boxes are used, there are more frames of brood (although not more brood) with which to make nuclei.

Critical factors in successful queen rearing

1. Schedules for queen rearing must arrange for the mating of queens to coincide with the availability of mature drones.
2. Optimal conditions prevail during the swarming season, or in the early part of a honey flow.

3. Bees must be fed if there is no nectar flow.
4. Colonies must have ample stores of honey and pollen.
5. Colonies should have an abundance of young bees.
6. Simple methods should be used while the operator learns more demanding techniques such as transplantation.
7. Methods which do not require the beekeeper to find the queen or eggs may be as successful as those which do.

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QUEEN-CELL RAISING - MY WAY

H Cloake
New Zealand

Quite early in my beekeeping experience I learned that the queenless colony started a larger number of queen cells than any other colony and that the best cells were raised by a queenright colony.

Many times during my past long association with beekeeping my mind has sought a better method of using the impulses under which bees raise queen cells.

I have proved -

FIRST - that most successful colony for STARTING queen cells is queenless.

SECOND - that the best QUALITY queen cells are built in a queenright colony under the supersedure impulse.

THIRD - that the best results in queen cell raising are obtained from the colony that has had a minimum of disturbance.

I decided that if I could incorporate these three conditions into one system, I could secure excellent results.

I have experimented with most of the accepted methods of cell raising.

Some of these I could manage quite well but others were failures. The success or failure of a particular method often depends partly on local weather conditions and partly on the skill of the person involved. The systems that were a success in California or Queensland just would not work for me in the deep south of New Zealand.

Up until two years ago I successfully used the "swarm box" method of starting cells which were then finished over a queenright colony. I had good success with this method but it entailed a lot of work and used a lot of time. It is necessary to have a constant supply of bees to fill the "swarm box". This entails going to out apiaries, shaking bees from the hives, storing them in some manner, such as adding to hives in the cell raising apiary, then shaking them as required into the "swarm box", and no matter what the weather this had to be done.

After filling the "swarm box" the bees must be allowed to settle for a period of time before the cells are introduced for starting. Next day the started cells must be removed and placed in the cell-finishing colonies. These cell-finishing colonies also require attention from time to time. This uses a lot of time and energy.

...2

This is the most commonly used method of raising queen cells in our area. The hives from which bees had been taken for queen rearing did not build up sufficiently well to return a crop of honey similar to those from which no bees had been taken. With the need to raise 4000 queen cells in six weeks of early spring, for our own requirements foremost in my mind, I gave the whole question of cell raising a great amount of thought. Bearing in mind the basic principles required to raise cells, it appeared to me it should be possible to create a queenless condition in the top super of a hive, start the cells in that super, and by some means return the bees in that super to their queenright conditions to finish building the cells.

An attempt was made to do this by placing a plywood division board between the two supers after the queen was confined to the bottom super. The division board allowed an entrance to the top super but the bees promptly left this top super by way of the division board entrance and returned to the hive by the normal hive entrance. Insufficient bees were left in the top super to start the cells. To overcome this, the top entrance was closed, but the bees became agitated and were reluctant cell starters.

The problem was to control the bees in this top super so as to give a queenless condition to start the cells and then change to a queenright condition to finish the cells with as little disturbance as possible. To do this, a special division board was built. It consisted of a wooden outer frame, size 30 mm x 20 mm grooved on the inner edges to allow a metal slide to be slid into position to form a complete separation. This gave a front entrance to the top super only when placed on the hive, and when the slide is removed, allowed freedom of movement by the bees between the two supers with an entrance in both supers.

With this special division board it was possible, by inserting the metal slide, to divide the hive into two parts. A queenright colony in the bottom super and a queenless colony in the top super. The whole hive is returned to a queenright state by removing the metal slide. Really very simple and effective.

After experimenting for some time, our system of starting and finishing cells in the one hive was successfully developed. I shall now outline the methods we use to raise 4000 cells in about six weeks.

Even strong hives of bees, all headed by young queens, are brought to the cell raising apiary about four weeks before cell raising is due to start. The hives are set down with the entrances facing the sun and fed sugar syrup to which Fumidil B in the recommended dosage has been added. The hives are then fed continuously until cell raising is completed or a natural honey flow is experienced. Fumidil B is added to the syrup from time to time as necessary to combat any possible outbreak of nosema. Ample pollen must be available. If it is not, natural pollen must be fed as a supplement and must be fed right through until cell raising is finished. This is most important.

A week before cell raising is due to start, the hives are turned around so that the entrance is at the rear of the hive. The queen is then confined to the bottom super with three or four frames of brood. Frames of pollen, stores and bare comb fill the super and the queen excluder is placed over this super. The special division board with the metal slide removed is then placed over the excluder in a position between the two supers that gives an entrance to the front towards the sun.

The top super is then placed on the division board and filled with three or four frames with brood and sufficient other frames of pollen and stores to make up to seven frames in all. This will allow space for two frames of cells. A feeder is placed over this top super and finally the lid. All must be bee tight. It is important to feed from the top of the hive to induce the bees to use the top super. After assembling the hive in this manner the original entrance at the rear is closed. The bees will adjust to using the entrance provided by the division board and this will then become the main entrance to the hive. After building, the colony should be left undisturbed for one to two days.

CELL RAISING

On Day 1, the day before cell raising is to commence, the metal slide is placed in position in the division board to isolate the bees in the top super to a queenless condition and the rear or original entrance opened. Bees flying from the rear entrance will return to the hive by the front division board entrance and so add to the number of bees in the top super.

On Day 2, the cells to be started are introduced into the top super between the frames of brood. I usually graft forty cells into each hive.

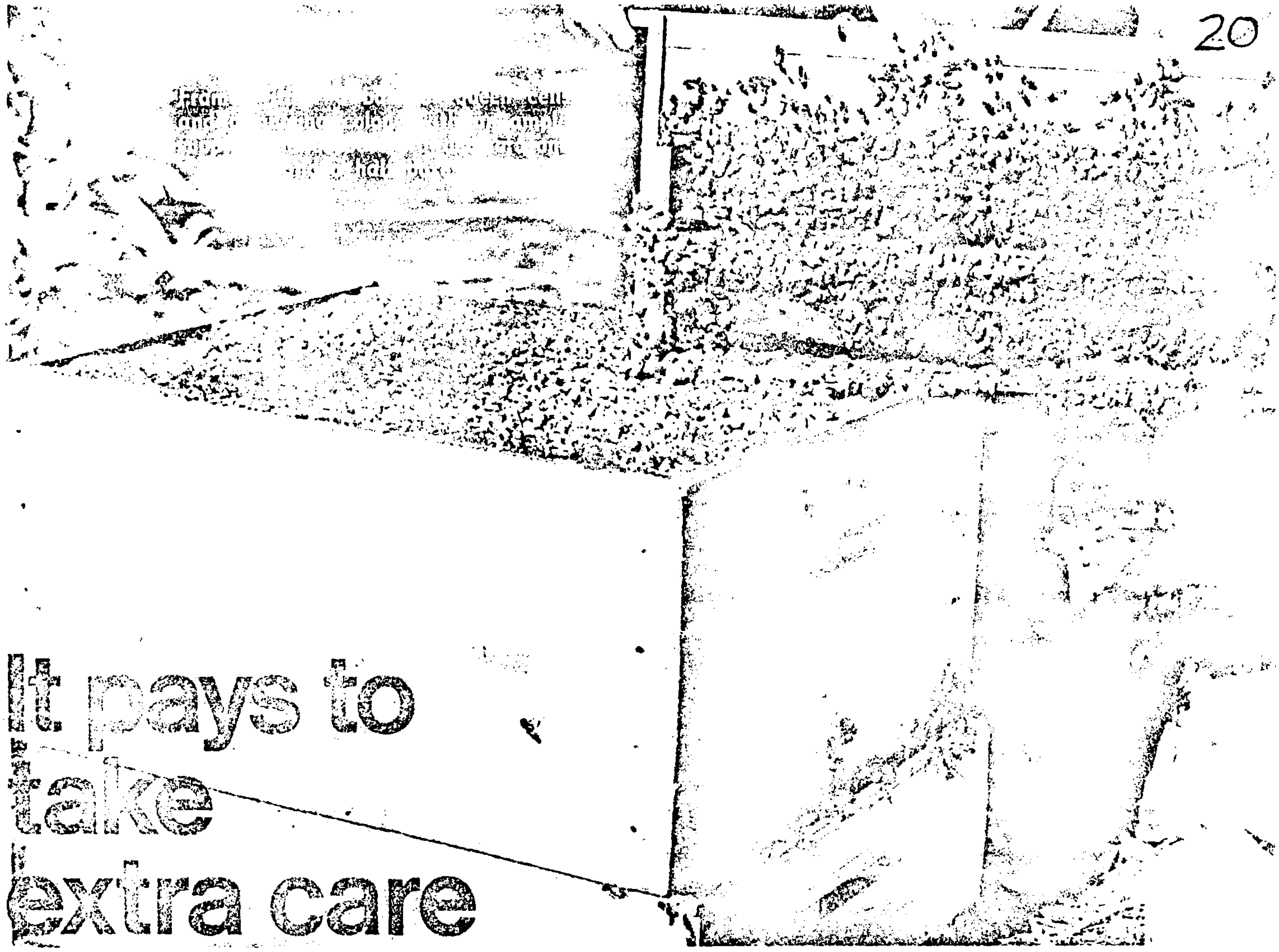
On Day 3, the metal slide is taken out and the rear entrance is closed. The hive is now queenright and the cells are left in the hive until ready to be introduced to the queen mating nuclei.

From day 3 when the slide is removed it is not necessary to disturb the colony until the cells are ready to be removed. But if it is necessary to use the hive to raise more cells before the removal of the ripe cells then further cells can be grafted and introduced to the top super to be started when the first cells are sealed. The procedure to be followed is as previously described, that is, place the metal slide in position the day before the cells are introduced and removed the third day.

It is essential to check the brood in the top super at appropriate intervals for rogue queen cells which must be destroyed. Also, when the brood in the top super hatches add frames of brood from the bottom super. It is important to have at least three or four frames of brood in the top super during the period of starting and finishing queen cells.

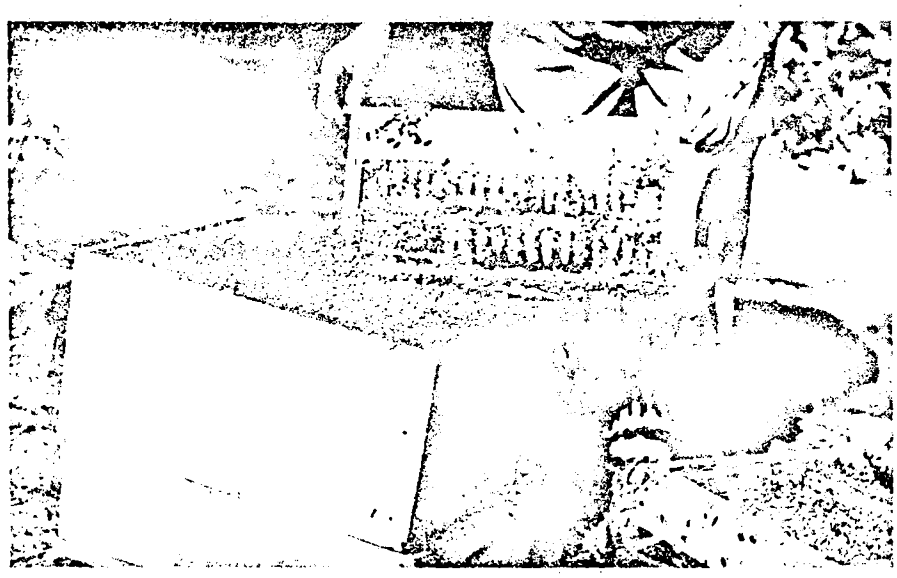
Should the bee strength dwindle for any reason, introduce brood and bees from other colonies, but this is rarely necessary. It is absolutely imperative that the cell raising colonies are strong in bees.

When the cell raising is completed, the division boards are removed and the colonies with undiminished strength returned to their original sites to become honey harvesting colonies.



It pays to take extra care when raising queen bees

By L. A. M. GRIFFIN, Apiary Instructor, Dept. of Agriculture, Christchurch.



The same frame as above with some bees removed to expose the queen cells.

Modern beekeeping demands the best queen bees that can be produced. Those prepared to give extra care to raising their queens will not only produce better crops but will find the colonies building up more evenly in strength and with much less work on the part of the apiarist.

TO RAISE the best queen bees demands more attention to detail than many beekeepers think necessary. Not only should larvae be well fed before being transferred to the queen cups; they must have food and attention immediately after the transfer is completed. They must also have ample food during the rest of the feeding period, to ensure that all queens are fully developed and not affected by malnutrition.

The first thing is to prepare a satisfactory starting colony. This colony—or the bees—must be in a condition to care for the grafted queen cups immediately, and to be producing sufficient chyle food to feed the grubs right away. Any cell-starting colony not in a condition

RAISING QUEEN BEES

(continued)

to do this within a few minutes is unsatisfactory.

Select a very strong colony with, preferably, a two-year-old queen. Take three to four combs of the youngest unsealed brood, with bees, and place these in an empty box on a floorboard. Shake the bees from two more combs of brood into this box and place a heavy comb of honey and pollen on each side of the brood. Fill out with empty combs at each side.

Rearrange the combs in the colony from which the brood was taken, placing all brood with the queen in the bottom box below the excluder, with a comb of honey and pollen at each side against the wall of the hive. Also see that the queen has laying room below. Give an empty comb or two if necessary. The honey super, with any spare brood, is placed on top of the excluder.

Now move this colony about six feet to the rear of its original stand and put the prepared hive in its place. If this is carried out before midday, when the bees are flying strongly, it will collect all the flying bees from the parent colony.

The young nurse bees in the new colony are already producing chyle food for feeding the brood. In a very short time they will begin to produce larger amounts, with the idea of raising queen cells from the larvae in the combs. To assist the bees in producing this food, place a tray-type feeder on the hive and give the bees a mixture of honey and pollen. This is important.

Scrape a heavy pollen comb down to the midrib, mix the pollen wax, etc., with a little honey and feed them three to four tablespoonfuls of this mixture. It cannot be stored as honey, or pollen, so is consumed and turned into brood food. A divided feeder is the best, as diluted honey can be placed in one side and the pollen mixture in the other.

In the afternoon graft the queen cups from your breeding stock, using only the food the young larvae are floating on. This food is of the right age and freshness for 24-hour-old larvae. If an artist's sable-hair brush, size O, is used for this transferring, it is possible to remove all the food with the young larva and roll it off the brush in the centre of the queen cup still on its bed of food. Take care not to roll the grub over in the food, or it may suffocate.

The grafted cell cups are placed in the starter colony after removing all the brood and shaking the bees from the combs back into the hive. These cells are accepted right away and the larvae fed within a few minutes. The cells will also be well supplied with food before being removed to the finishing colonies the following day.

Queen cells should not be left in the starting colony for the bees to complete. Queenless bees are in such a hurry to raise a queen that, when many cells are in the hive, a large percentage of the larvae are not fed sufficient food for full development of the queens before the cells are sealed over, so not all will be first-class queens.

The brood removed from the starting colony is returned to its original hive and placed in the centre of the second box above the excluder. This colony later will be used as a nursing colony.

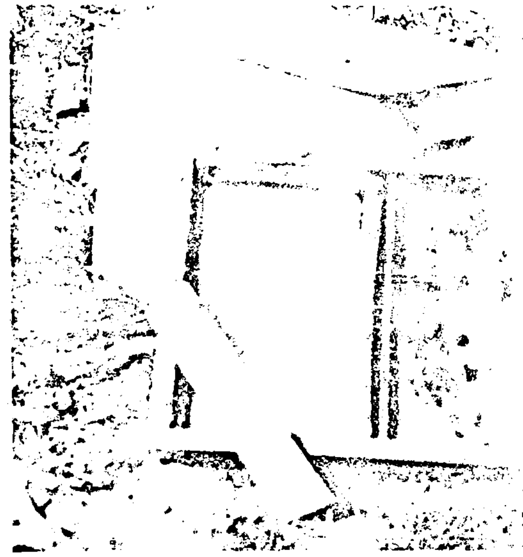
Other strong colonies—as many as are required for nursing the cells—are fixed up in the same way. That is, two combs of very young feeding larvae are placed in the centre of the second box above the excluder, with the queen below, in the bottom box, and room given for her to lay. In these hives crowd the bees down to two boxes where possible.

If 60 to 70 grafted cell cups were given to the starting colony, then five strong colonies are needed for nursing colonies.

The colony from which the starter was made up can be one of these nursing colonies unless the starter is needed for beginning more cells. This is moved back to its original stand and the bees in the starter placed back on the hive as a super after giving it its complement of cells to nurse. The started cells are now placed between the combs of feeding larvae in the second box above the excluder to finish off under a supersedure impulse.

The colonies should be slow-fed with diluted honey while feeding the cells. This allows for each colony to feed 12 to 14 cells, which is probably the greatest number of cells a normal strong colony can feed to produce first-class queens.

The best queens are normally rasied from swarm cells, at a time when the colony is at peak strength with more young nurse bees than the colony requires. Even then, only six to eight cells or so are raised. These are perfect cells and perfect queens. Under a supersedure impulse,



A divided feeder with the centre cover removed showing the metal container for feeding diluted honey on one side and pollen mixture on the other.

a colony raises only from two to four cells—also perfect cells and queens.

Under emergency conditions, when a colony has suddenly lost its queen, 12 to 20 or more cells may be raised. Most of these cells, however, are poor. The larvae are underfed, the cells sealed too soon, and many are nothing much more than bumps on the comb face. Open up these small queen cells and it will be seen that the larvae have consumed all the food that was placed in the cell by the nurse bees. In most cases the pupae are small and under-developed.

Where only a limited number of nursing colonies are used, and 30 or more queen cells are given to each colony to nurse, different management is required to ensure that the cells are well supplied with food and that the resulting queens are fully developed.

Feeding a large number of cells in conjunction with the normal area of feeding brood is a great drain on a colony; and, although the bees will do it, many cells are not given sufficient food to produce first-class queens, especially those cells at the ends of the cell bars.

Not only must these colonies be fed with diluted honey and two tablespoonfuls of the pollen mixture daily, but an extra box of young nurse bees should be united with each colony before any cells are given for nursing.

There must be a large surplus of young nurse bees beyond all normal colony needs. There must also be ample protein food in a form that must be used and not stored. The pollen mixture, plus diluted honey and surplus nurse bees, ensures that the cells will be as well supplied with food as swarm cells. ■

Bee Behavior

by STEVE TABER
of Taber Apiaries
7052 Pleasants Valley Road
Vacaville, Calif. 95688

MORE ON QUEEN REARING

I HAVE been raising queens almost every year since 1946 and it is one of my favorite subjects, so I hope I don't bore you with too many columns on queen rearing. At the present time queen rearing is an art, not a science. I say this because if the people in science could figure out exactly how to raise queens in the laboratory, then we would know the requirements for good queens and excellent queens as well as mediocre and poor queens. Queens can be raised in the lab, but the same food and the same batch of larvae will produce intermediates (queen-workers) and even workers. So what have the scientists found out about queen rearing that we do know?

1. **The necessity of moisture around the queen larvae.** Smith (1959) was not the first to raise queens from larvae in the lab, but he found how important moisture was — 95 per cent humidity around the growing larvae. Taber (1978) found that eggs would not hatch unless the humidity was 90 per cent or higher. In Smith's article he fed the larvae once every 24 hours. What that tells us about queen rearing is that frames of larvae to be grafted and the grafting area should be kept as moist as possible. Here we routinely wrap grafting combs in wet toweling and after each bar is grafted, it is placed with the cells in a small container lined with wet toweling. Be sure to keep the amount of air in the space with the cells small and the towels wet.

2. **The number of bees needed to raise a good queen.** Liu (1975) was able to raise a queen on an adequate diet by using 400 mixed-age worker bees. Most normal colonies with just average queens laying 1,200 to 1,500 eggs per day would have several thousand bees of the proper age (i.e., 4 to 10 days of age) which means that great populations of bees in the queen rearing colony are not necessary. Keep the population manageable, so that you can handle the colony with the least effort.

3. **The necessity of pollen proximate to the queen larvae.** Taber (1973) showed the importance of the proximity of pollen to where it is used. Bees don't move pollen and the older the larvae get (worker, drone or queen) the more brood food made from pollen they demand. The bees need to have an adequate diet of quality pollen and honey next to the queen cells. If you don't have pollen combs to place next to the queen cells, make up a pollen-sugar-water dough mixture. Do not use a pollen substitute.

How do you tell if the pollen is of good quality? Look at the drone brood. If you see any patches of drone comb in the brood nest area that are empty or full of honey, the pollen quality is poor. Pay no attention to the pollen entering the hive or to stored pollen for a pollen quality examination.

There are lots of things that queen breeders do that we know don't make any difference in quality queens. I know this will start an argument, but here goes: The grafting tool to transfer larvae that you use makes no difference. I use a piece of baling wire that is shaped and filed. In talking to other queen breeders I have found

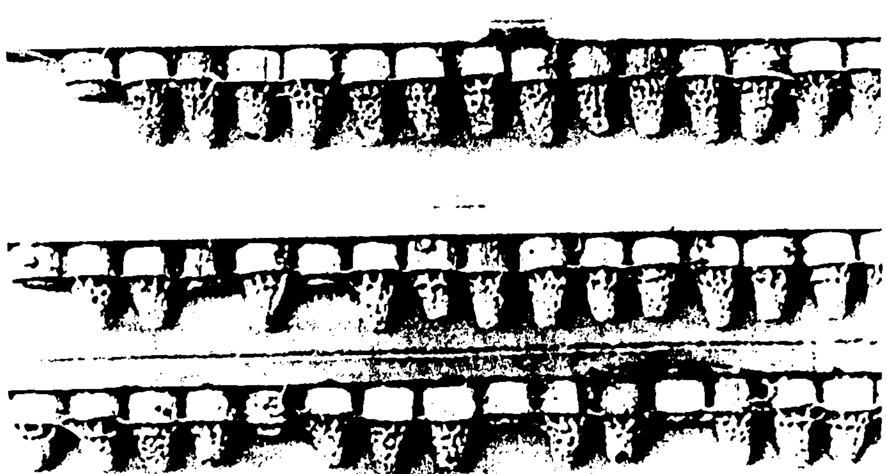


Photo 1. Bottom two bars of 10-day-old queen cells are poor and most were discarded. Top row of cells were much larger and most were used.

that they use very small hair brushes, toothpicks, a carved piece of hardwood, and the little curved spring mechanism that is sold as the Pierce grafting needle. I don't think there is a whit of difference, what tool is used as to speed or quality of the ensuing queen that is reared.

The method of building cells in the cell-building colonies doesn't matter. I get reports from people getting good queens from breeders using diametrically opposed systems. So, set up what is easy and convenient to you as a cell builder. I happen to prefer using a cell starter of queenless enclosed bees, giving them 4 bars of 18 cells each for the first 24 hours. This unit is made up of about 3 pounds of bees stocked with honey and pollen and sponges containing water. Then the bars are transferred to queen-right cell builders above a queen excluder for the next 9 days when they are removed to the incubator.

Queenless bees will do an excellent job of cell building, too, but every 5 days about 2 pounds of bees 4 to 10 days old should be added to the unit in order to have the number of proper age bees for queen larvae feeding as determined by Liu.

4. Quality control. The last point has no scientific references, but is the most obvious — quality control. All queen rearing steps have to have quality control. This means you have to look at what you are doing all the time and remove any cells or queens that don't come up to expectations. I think that the first 24 hours are critical. If the amount of royal jelly around the new larvae is not huge, discard the cell. If the 10-day-old cells are not large, discard. If the emerging virgins are small, discard them, too. The last place for quality control before the queens are shipped out is when they are caught and placed in the shipping cage. Look at the queens, look at the eggs, look at the just-hatched eggs. What do you look for? Well, it takes a lot of practice and it is not something that can be adequately described. Does the queen have all her parts? Legs? Is she big? Don't assume that small queens are just as good. Are the eggs all together and laid neatly as if the queen knew what she was doing? Now take a look at the just-hatched eggs. Are they grouped evenly in any small section (postage stamp size) of the comb? You should be able to find one section that has all the larvae exactly the same size.

Don't hesitate to kill queens that don't come up to your expectations. This spring I had a number of nice people working here and before I knew what was happening I found out that one of the people could not kill a queen. That person was picking up and sending out every queen straight down the nuc yard row. Needless to say, I received some complaints but the point here is that when you catch your queens or if you are asking (paying) someone to catch your queens, emphasize that this is the last chance for quality control. Have them also keep track of the number of queens they discard.

Nothing here has been said about a lot of subjects pertaining to queen rearing, particularly the kind of stock to use. Don't hesitate to use as a breeder queen the best queen you have available (please test her for disease resistance first). One of the first rules of genetics in the improvement of stock (any kind) is to first take advantage of all the good genetics you already have by improving the environment. There is no genetic difference between the worker and the queen only environment. Be sure your queen rearing environment is the best that we know how to provide. For a full description of queen rearing methods, see the book, *Contemporary Queen Rearing* by H. H. Laidlaw.

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Photo 2. Our new style queen cell bar that is a bit wider and permits 18 to 20 cells to be more nearly in the center of the brood nest area. In cold weather the outer cells are frequently less well developed.

81(51)

QUEEN AND CELL INTRODUCTION WITH THE USE OF A SPLIT BOARD

By M. Charlton, E. Podmore and W. Winner

Many of the techniques utilised by commercial beekeepers can be of great assistance to smaller beekeepers.

We get many inquiries from beginners wishing to expand their hive numbers or just to requeen their present hives.

In most cases they are not sure of a technique that will allow them to do so. The majority ask for advice on how to make up a nucleus hive.

The following method is very simple and successful, if the instructions are followed carefully then good results can be achieved.

MAKING UP A NUCLEUS

For this example we will prepare to requeen a two deck 10 frame full depth hive. The bottom box or brood nest is separated from the top box or super by a queen bee excluder.

Remove three combs from the top box, lift the top box off and remove the excluder, bumping the bees on the excluder in front of the hive. Remove three combs of **sealed and unsealed brood** from the brood nest carefully shaking all three combs in front of the hive entrance to ensure that all bees are off the combs. this ensures that the queen will be in the bottom box. Push the remaining brood combs in the bottom box together and then place the three combs removed from the top box in the bottom box. Replace the queen excluder and lift the top box back onto the hive. The three brood combs are then placed in the centre of the top box.

Overnight or **by later in the day** nurse bees will move up and cover the brood combs that have been lifted up. The queen will not be able to get into the top box because of the queen excluder. Sufficient bees will be present to form a nucleus which will benefit from the warmth of the hive underneath.

Hives can be split in this way days before cells or queens are ready. The split board is only inserted when the cells or queens arrive. If making up **early** use more unsealed than sealed brood. If making up **late** use more sealed brood. Tend to make the top half stronger to allow for drift of bees to the lower half, and if there is a honey flow watch the lower half for crowding.

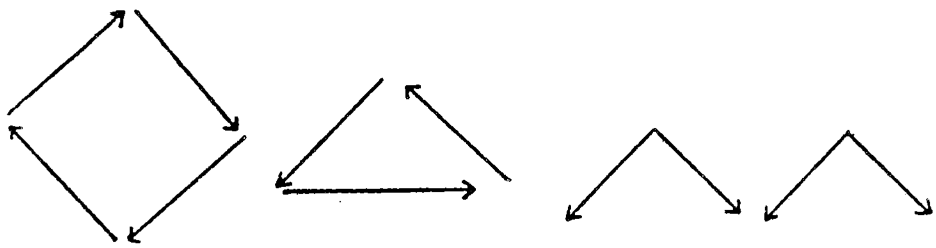
In autumn failing hives can be split and a cell given top and bottom but the best principle is NEVER KILL A QUEEN UNTIL YOU HAVE SOMETHING BETTER TO PUT IN ITS PLACE.

In the morning lift the top box off. Place into position a "SPLIT" BOARD or nuc board. The entrance of the split board is toward the rear of the original hive. Replace the top box and leave overnight.

The nucleus will now be ready to accept a queen cell or caged queen.

It helps the success rate of queen acceptance if the hives are moved just prior to the above process being carried out.

Loss of queens can be minimised by locating hives in and around trees, avoiding open sloping ground and windy areas and setting hives in staggered groups perhaps in a large "W" pattern or in diamond shaped or triangular shaped arrangements as illustrated. The locating of hives in such formations will greatly assist the queen to orientate the position of her nucleus in the apiary for the time that she returns from her mating flight.



The above diagrams indicate some basic patterns that a beekeeper can position his hives in. The arrows indicate the direction that the entrances should face. Locating hives in this manner assists the newly mated queen to return to her own hive. It is wise to arrange the hives in single rows.

Another helpful suggestion is to place a **small branch or tuft of grass in one side of the entrance,** this provides a landing area for the newly mated queen to land on as well as providing a marker for field bees from the nuc **to orientate** to.

No attempt should be made to unite the two colonies until at least sealed brood is present.

The beekeeper wanting to make two hives out of one, can now move his hives back to the original location, but only after placing a new lid or cover on the original hive and a new bottom board under the nucleus. The original hive is ready for an excluder and super to be added the nucleus already has the original excluder on top of it and only needs the honey super. (The branch or tuft of grass has also been removed at this point).

If you are only requeening the old hive then you can search for the queen in the original hive and kill her, then remove the top box, take the split board **right off** place **two large sheets of newspaper over the bottom box, perforate** the paper in a few places with the hive tool (Not big enough to let bees get through). It may pay to **leave a twig** about the thickness of a pencil at the rear to allow the bees a rear entrance into the hive, plus added ventilation. it will then take a day or two for the bees to chew through the paper and unite.

Why the paper? You are trying to unite two individual hives both have their own distinct scent. To put the two hives together without giving them time to adjust to each others scent would result in fighting. The time it takes the bees to chew through the paper allows the bees to gradually get used to the new scents.

Commercial beekeepers rarely kill the old queen beneath the split board they simply paper the top hive on and theoretically the young queen will kill the old queen below.

To allow the beekeeper to replace the excluder he can then shake all the bees in the top box in front of the entrance or over the bottom box thus ensuring that the queen is in the bottom box. He then puts the excluder in place and replaces the top box. (The excluder having been left on the hive all along but under the cover or lid.).

How successful is the above method. We have been told by commercial beekeepers that they are able to make up between 250 and 300 nucs a day. A 95% successful queen introduction rate is common.

The split technique practiced in a honey producing yard gives a ready supply of young queens on site. It leads to development of various two queen systems which produce the real honey gathering hives.

Simple and effective is the best way to describe the above procedure.

SPLIT BOARD DESIGN — M. CHARLTON

For many beekeepers the problem of keeping hives strong as well as making up seasonal losses is really one of not having the equipment to start the numbers of nucleus hives they need to handle all their queen cells or mated queens.

An easy way is to use the extra supers which are often not in use with the addition of a split or demaree board. The board is a sheet of galvanised flat iron with a 9.5mm (⅜") timber strip nailed around the rim on either side and with an entrance provided in one end or side.

Making "Split" Boards — 10 frame size.

Galvanised iron 406mm (16") x 508mm (20") — with 6mm (¼") cut off each corner. Tempered masonite will do but not preferred.

Rims of 19mm (¾") x 9.5mm (⅜") timber.
4 pieces each 489mm (19¼")
4 pieces each 387mm (15¼")

Assemble so that ,on each corner the 489mm (19¼") piece overlaps the 387 (15¼") piece on the opposite face of the iron. (See diagram).

Nail the rim strips from one side through iron and lower timber using 25mm (1") or 31mm (1¼") nails. If driven firmly, the nails will go through the iron without bending. Clinch other side.

Mark two diagonal lines 102mm (4") apart on one end (or side) and drive a larger nail through the centre to act as a hinge. Cut off excess nail length and clinch.

With saw cut both marks through timber to iron so that the diagonal piece swivels and becomes an entrance.

Paint timber as usual. Entrances can be coloured yellow, blue, or green to help bees orientate — a burst of pressure pack spray is quick and easy.

"Splits" are used to split weak doubles for requeening or to start nucs on top of established hives.

Splits make maximum use of material you already have and avoid the bother of storage and keeping wax moth out of special nuc boxes. They often double as emergency bottoms and lids or as stack covers on supers. **The more you use them the more uses you find for them.**

(**Acknowledgements :** My special thanks go to Murray Charlton (Terranora N.S.W.) and Eddie Podmore (Orange, N.S.W.) for their assistance in the preparation of this article. We regularly purchase queen bee cells from them and it was through this contact that we adopted the use of split boards in our apiary. Readers interested in contacting either of the above refer to their half page advertisement in the rear advertising pages of October issue. — Editor.)

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Finding Queen Bees

By V. A. COOK, Apiary Instructor, Dept of Agriculture, Oamaru.

FINDING queen bees is an integral part of commercial beekeeping management. Queens have to be found for a variety of reasons and at various times of the year.

Fig. I. The queen surrounded by her court.

Fig. II. Place the upper box on an inverted hive lid or similar stand.

For a beekeeper who runs his hives under a single-queen system of management, the busiest time for queen finding is in the spring or autumn, when two-year-old queens must be found and removed so that young queens can safely be introduced. Much time can be wasted in queen finding through inefficient methods and the wrong mental approach to the job.

The one queen in a hive is different in appearance from her thousands of workers; she is larger, but not enormous by comparison; she is longer and proportionately more slender, and usually more graceful in her movements about the combs. She is, however, not so strikingly different that she can easily be spotted in a strong hive by a beginner.

Fig. I shows a queen characteristically surrounded by her "court" of worker bees. Unfortunately, queens are not always found in such a situation; when a hive is opened the bees may become excited and disorganised, with the result that the queen becomes hard to find.

Finding queen bees is a skill which is acquired with experience; the main requirements for success are the right mental approach and the use of a systematic searching technique. The mental approach to the job is particularly important. Faced with a strong hive it is easy to imagine that finding the queen is just about a hopeless task.

This state of mind produces a negative attitude toward the job. The right approach is to be confident a queen is in the hive, and that a systematic search of the combs will reveal her pretty quickly.

Adequate protective clothing should be worn during queen-finding operations to reduce stinging, which interferes with concentration and causes wasted time. I find that a sound veil which gives clear vision is essential, and well fitting leather bee gloves with long gauntlets are also very useful. Overalls tied in at the ankles are then required to ensure complete protection. A hive tool is necessary, and also a smoker filled with clean sacking, well lit.

The brood nest of a hive usually comprises the two bottom boxes and is separated from the honey supers by a queen excluder. When a queen has the run of two boxes they must be separated and the upper box placed on an inverted hive lid or similar stand, as shown in **Fig. II**. The boxes should then be covered (**Fig. III**) to keep the bees calm and to minimise the risk of robbing.

Never start searching in the top box and work gradually down, because unless the queen is found quickly in the top box, she will run down the combs, away from the light and the smoke, into the bottom box to join the masses of excited young bees gathered there. All manipulations must be carried out quickly but quietly. Noise or vibration will excite the bees and finding the queen will become more difficult.

When brood nests comprise two boxes I have, over the years, found many more queens in the upper box than in the lower one, particularly in springtime, and so, after separating the boxes, I always search the upper box first.

The queen is normally found on combs containing eggs or young brood, but she may be anywhere, so the search must start when the hive is being dismantled. Look carefully at queen excluders and on the undersides of hive mats. It is rather disconcerting to find a queen on a hive mat or queen excluder after all the combs in the hive have been searched two or three times. A quick eye will sometimes see a queen disappearing down between the combs when a hive mat is removed, or when two boxes are separated.

It is sometimes claimed that a relaxed position, such as kneeling or sitting on a box, is important for finding queens. I have found that by adopting such positions, time is wasted in getting up and kneeling, or sitting down, finding boxes to sit on, and so on. Also, it is easy to become too relaxed when sitting or kneeling; an urgent job becomes a pleasant pastime, concentration is lost, and the queen remains free.

I can find queens more quickly by standing and bending down to carry out the necessary manipulations of boxes and combs. Continual bending of this sort can, however, cause an aching back, but the discomfort is reduced if the separated boxes are placed on portable stands to bring them up to a convenient working height.

My own technique for searching a box of brood combs for the queen is as follows:

Remove the cover and smoke the bees very gently, just enough to subdue them; not enough to excite them. Quickly search the underside of the cover before placing it to one side. Remove two outside combs from one side of the box and, after searching them quickly, lean them against the front of the hive, as shown in **Fig. IV**. The queen is not likely to be on these outside combs and their removal facilitates the removal of further combs. The remaining combs can now be examined one by one and then returned to the box.

Gently, but quickly, ease the next comb free with the hive tool **(Fig. V)** and lift it out of the box. When it is being lifted glance briefly over the comb surfaces. A queen stands higher than the workers and may be seen because of this.

Before searching the comb in hand, look first at the exposed face of the next comb, a typical view of which is shown in **Fig. VI**. This is where many queens are found, but you have to be quick, because queens try to keep away from the light, and will often run round to the back of the comb.

The comb being held is now searched. **Fig. VII** shows a beekeeper's view of a comb of brood and bees; it must be searched quickly and in a set pattern. If a queen is making for the edge of a comb she is most likely to be found near the bottom. For this reason, look across the bottom first, then up one side, across the top, down the other side and across to the middle. By this method the whole surface of comb is thoroughly searched very quickly.

When the comb has been searched on both sides it is returned to the box and placed against the side. When further combs are examined and returned to the box they must be placed close together, as shown in **Fig. VIII**. This is very important, because if large spaces are left between the combs the bees will "bunch" and so make queen finding very difficult if the box has to be searched again.

Each brood box should be searched in this way, and when some experience has been gained, queens will generally be found during the first examination.

If a queen cannot be found by comb examination, the bees can be shaken from the combs into an empty box, and driven by smoke through a queen excluder into a box of combs below. The queen will be found on top of the queen excluder. ■

Fig. III. The boxes should then be covered.

Fig. IV. Lean the outside combs against the front of the hive.

Fig. V. Ease the next comb free with the hive tool.

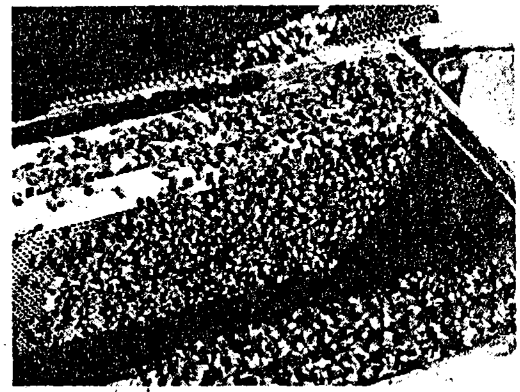


Fig. VI. Before searching the comb in hand, look first at the exposed face of the next comb.

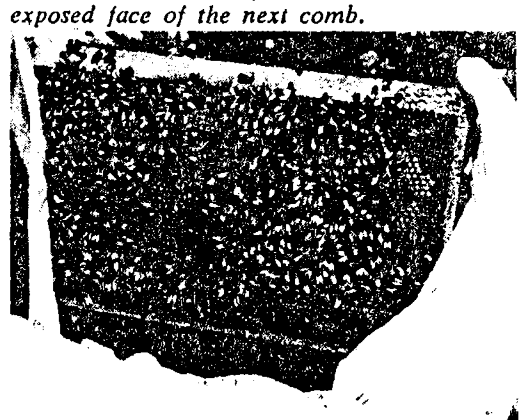


Fig. VII. The comb must be searched quickly and in a set pattern.

Fig. VIII. When returned to the box, the combs must be placed close together.

SELECTING HONEY BEES FOR INCREASED PRODUCTION

Murray Reid
Apicultural Advisory Officer
CHRISTCHURCH

Almost everything that we eat or wear is the product of our domesticated plants and animals. Most of these living forms have been cared for and propagated by man since long before the beginning of written history.

Now, while no one can ever lay claim to having domesticated the honey bee, beekeepers have certainly learned to manage colonies of bees for the benefit of all agricultural producers. And, what a vital role the honey bee plays. The gross value of honey and wax pales besides that of the meat, cereal or horticultural industries, and yet as much as one third of our total diet is derived directly or indirectly from bee-pollinated plants.

Bee Breeding and Animal Breeding

Like all populations of plants or animals, bees show great variation in colour, temperament, disease resistance, productivity and so on; in short, there are bees AND bees. The successful beekeeper is continually keeping an eye out for those super colonies that out-produce all the others and yet don't chase him out of the apiary. He records their progress over one or two seasons and evaluates them as potential breeders. The beekeeper certainly has a tremendous gene pool to work from even though importations of queens from other countries have been prohibited for over 20 years. // But, even with all this great variety of stock, little real progress has been made in breeding. This is unfortunate as much of a beekeeper's basic operating expenses are the same regardless of the quality of bees used. Thus, a more productive bee can increase profits rapidly. Greater uniformity of an improved stock would help to reduce operating costs.

Problems in Bee Breeding

Honey bees were used for some of the earliest studies of genetics. Then, for nearly three quarters of a century no further work was done with bees. We may well wonder why. The main reason appears to be the promiscuous mating habits of the bee which have tended to create what can only be described as genetical confusion. Queens will mate only on the wing and with an average of 6-7 drones from hives as far afield as 16 km. Professor Rothenbuhler, an American Geneticist, has outlined many of the problems met with and explains how"the geneticist cannot take an individual bee for his studies as he can take an individual cow, a sheep, or a fowl. He cannot even take a natural colony of bees as an individual or as a family. A colony of bees is a sort of family but it is composed of a mother, several fathers of unknown origin, now deceased, and daughters and her sons. Several fathers are involved because the queen mates naturally with many different drones. Most of the workers in the hive are half sisters. In other words, the bee colony is a super family in which a whole lot of sub families are mixed together. The queen is the mother of the super family but each drone with which she mates is the father of only one sub family. The geneticist is unable to devise a technique by which he can analyse such an unspecified assemblage of half sisters."

Fortunately, mating can be controlled using artificial insemination. Scientists have attempted to inseminate queen honey bees since 1791 but only in the past 50 years has the technique been perfected and used successfully. So now colonies of bees can be produced in which the workers are full sisters and therefore genetically alike. Using artificial insemination, scientists have been selecting for such things as resistance to some of the major brood diseases, the ability to pollinate certain types of crops, especially lucerne and cotton, gentle behaviour and so on.

On the debit side the technique of A.I. is a rather delicate one and the success rate for an experienced operator may average less than 70-80%. Also, the process is very labour intensive and time-consuming so the only places using the technique on a large scale are universities, bee research institutes and some bee manufacturing supply firms.

Testing for Selection

Without recourse to artificial insemination how can the average beekeeper improve his stock by selection? The principles involved are the same as in any other flock or herd although as we have seen, for most characters of economic importance the colony as a whole is a unit of performance on which selection of breeding individuals is based. A superior colony is chosen on the basis of brood rearing qualities expressed through the queen and the behaviour of the workers.

Ideally, all colonies selected to provide breeder queens should be evaluated over two seasons. They should also be brought together in one location for the second season so they all have equal opportunity to develop and produce. If single colonies are selected at different locations, they should be evaluated and chosen on the basis of the average performance of the yard they are in. A colony bringing in medium honey crops in a low producing area may be as good a selection as a much higher producing colony in a high producing area. When groups of colonies are to be compared and they cannot all be placed at a single location, equal numbers should be placed at each of several locations. Hives should be arranged in irregular patterns so that there is little drifting of field bees between the hives.

What to select for

Important qualities to look for in the queen are - long life and superior egg-laying capabilities. Workers should be observed for such characteristics as fast buildup in the spring, wintering ability, willingness to enter supers and draw comb, a lack of swarming tendency, good handling qualities such as quietness on the combs and temper, resistance to disease and honey and pollen production. Such characteristics as length of tongue, size of honey stomach, wing area and other physical characteristics, are secondary. If they are advantageous they will automatically be selected along with honey production.

How many Breeder Queens?

In short, the more the better. If a beekeeper uses any one breeder for two years in succession, some virgin queens will mate with some drones of their sisters reared the previous year'. If only one breeder was used the previous year, then all virgins will mate with sons of their sisters. Such close inbreeding brings together similar sex alleles and reduces the effectiveness of selection by increasing homozygosity. Such effects show up in a patchy brood pattern laid by the queen. Many eggs fail to hatch or are destroyed by the workers. Using a single but different breeder each year will also be too much inbreeding. The beekeeper should use as many breeders as is practicable and re-queen all his production colonies each year to prevent back crossing to the same source of drones.

What about Drone Stock:

Few beekeepers actively select for drones and this is understandable when the difficulties of evaluation are appreciated. The drone develops from an unfertilised egg so this means he doesn't have a father but he does have a grandfather, thus whatever characteristics the drone transmits are derived from his mother alone. These can be ascertained from the performance and general qualities of her sisters, i.e., the worker bees of the colonies from which the queen is descended. The performance of the workers in the drone colony (the half sisters of the drones) cannot be used as direct evidence in judging the breeding value of the drones although they should be taken into consideration in finally selecting the colonies which supply the drones.

Since it is impossible to know in advance which colony will provide drones giving the desired characteristics, the use of only one drone colony in a mating station involves too great a risk quite apart from the other disadvantages of such a restriction. For this reason, numerous selected drone colonies should be stationed in the mating yards. At least 50 sexually mature drones should be provided for each queen to ensure an adequate mating. In mating stations which are not completely isolated, the number of drones per queen should be much higher. By "saturating" the mating area with drones from a chosen stock, the chances of queens mating with undesirable drones are greatly reduced. The requirements are, therefore, as follows :

For a completely isolated mating station

* 1 drone colony per 50 queens at one time

For a mating station that is not so isolated

* 4 drone colonies per 50 queens at one time
* 6 drone colonies per 100-150 queens at one time
* 10 drone colonies per 400 queens at one time
* 20 drone colonies per 800 queens at one time.

Ministry of Agriculture & Fisheries

HOW TO REDUCE DRIFTING IN APIARIES

Many beekeepers have seen the effects of drifting within their apiaries, but few realise what it is costing them, and even fewer do anything about it. Drifting occurs when flying bees become dis-orientated and return to the wrong hive.

It is made worse by the fact that drifting occurs in certain patterns - where hives are placed in straight rows bees drift to the ends of the rows, and where two or more rows are used, the front row collects bees at the expense of hives in the rear.

Effects of drifting

It is important that the number of drifting bees in any apiary is reduced to a minimum because:

1 When excessive drifting occurs in an apiary, some hives become over-crowded and swarming conditions result.

2 Other hives become so depleted in forager force that they are made useless as economic honey gathering units.

3 The beekeeper must spend time trying to overcome these inbalances by swapping brood and stores, especially in spring.

4 If bees drift from a diseased hive, they may spread disease to other hives in the apiary.

5 If a queen returning from her mating flight is confused and enters the wrong hive she may be killed.

6 Honey production records of hives in apiaries where excessive drifting has occurred are of little value for the selection of future breeding stock.

7 It is impossible to manage a commercial apiary as one unit if a lot of drifting is going on. Each hive must be treated individually (e.g. for feeding, requeening, supering, swarm control, etc).

8 Canadian studies show that overall honey production can be reduced by up to 11 kg per hive in apiaries where excessive drift occurs.

How to prevent drifting

Three simple methods which can be integrated into any apiary management programme are effective in reducing drifting between hives:

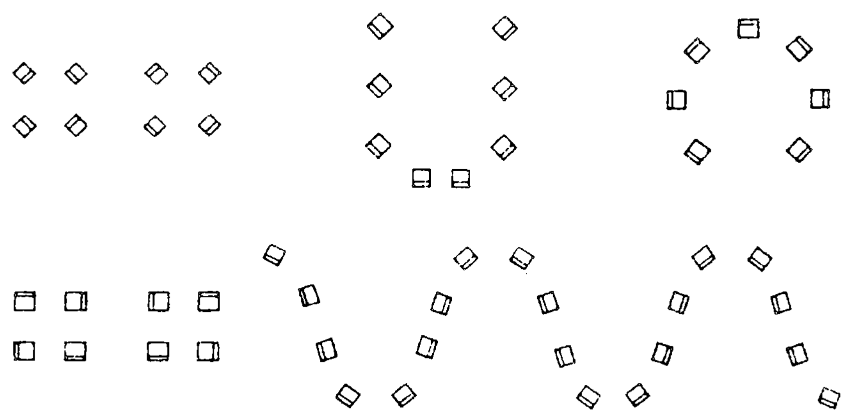
1 the use of irregular or non-repetitive layouts (patterns) of hives, and placing the hives within each layout to face different directions;

2 the use of coloured hives, or coloured strips above or below the hive entrances (black, white, yellow, blue);

3 the use of landmarks near hives (trees, bushes, fences, etc).

1. Hive placement

This is perhaps the easiest and most effective technique for beekeepers to use. Almost any placement is satisfactory if the entrances of neighbouring hives face different directions. Hives should be 1 - 1.5 metres apart so that the beekeeper can move easily between them. Most of the layouts work well in unprotected field sites, but drifting is reduced even further if shelter is provided.



Five useful hive layouts to prevent drifting. The double line indicates the hive entrance.
(*above*): diamond, U-shape, circle; (*below*): square, "snake"

When choosing a particular layout, or series of layouts, a beekeeper must consider the following: the area of a particular apiary site; the presence or absence of wind-breaks; the ease of colony management; lines of bee flight within the layout; access for any heavy equipment likely to be used (trucks, loaders, etc); finally, and most important, the personal preferences of the beekeeper himself.

2 Hive colour

Painting boxes different colours is also effective in reducing drifting. A common trend in New Zealand beekeeping is for a beekeeper to paint all his hives the same colour for the sake of "neatness". While this may be aesthetically pleasing for the beekeeper, it must be remembered that the hives are there for the bees' benefit. The beekeeper should be prepared to think as a bee does, rather than expecting bees to develop a human's taste for colours.

When painting boxes, it is a simple matter to use different batches of paint. Then by sheer chance any hive is going to have a different combination of colours from its neighbour. Using a different colour each year may also be useful in providing information about the age of boxes and effectiveness of timber preservation methods.

Colours which are distinctive for bees will be most useful in reducing drifting, e.g. white, blue, blue/green, yellow, black.

3 Landmarks

Queen breeders often ensure that landmarks are left in mating yards, where drifting is extremely costly. Rather than being "cleaned up", the apiary site should be left with a reasonable number of shrubs, rocks, and other features to assist with the bees' orientation.

Although this is not entirely practical in a honey yard, it should be borne in mind when preparing apiary sites.

A.G. Matheson
Apicultural Advisory Officer
Ministry of Agriculture & Fisheries
Nelson

February 1982

The prospects for boosting queen bee production

by Grahame Walton, chief advisory officer (apiculture), presented at the Tauranga Beekeeping Seminar.

I PROPOSE to examine some of the opportunities which I believe exist for the production of queen bees, and why New Zealand has the potential to establish itself as a major supplier of bees to the world market.

During the past decade New Zealand has been an exporter of queen bees to most corners of the world; to Canada, Thailand, Britain, Iran, and countries of the Pacific Basin. However, our volume of exports has been relatively small.

Even during the heyday of our exports to Canada during the early 1970s, when over 8 000 queen bees per annum were exported, we were still operating in a relatively small way. The exporters were mostly commercial honey producers who, for a few months of the year in autumn, switched to queen bee production.

I believe that potential is there for New Zealand to develop its production of queen bees. However, to be successful it will require proper marketing.

Let us take a look at some international prospects:

Canada

Canada depends upon an annual supply of bees from outside its borders. It has also been a country that has been very particular about the quality and health of its bee stocks.

The United States has been Canada's traditional source of supply for bees. It has been a standard practice of Prairie Province beekeepers of Canada to kill off their colonies in the autumn and to start afresh in the spring with package bees obtained from the southern states of the USA – mainly California. Over 200 000 package bees are imported annually.

The Canadians have supplemented their supplies of bees from the USA with occasional shipments from other countries including New Zealand. However, in the past year Canada has tightened its importation policy and will now only import bees from just the United States and New Zealand.

The reason for this is the concern in Canada about the introduction of harmful bee diseases, and undesirable genetic characteristics. It also indicates a Canadian confidence in the health of New Zealand bees and our disease control and export certification measures.

Although package bees remain the major import requirement for Canadian beekeepers there has been a rapidly increasing demand for queen bees. Many commercial beekeepers in Western Canada are switching to the overwintering of hives. This has led, in the spring months, to a need for queen bees to make up winter losses, for requeening purposes, colony increases and for the establishment of two-queen units.

New Zealand has an opportunity to tap this market for queen bees, but to do so, New Zealand's efforts must be properly organised.

In 1968, I saw some of the New Zealand stock under test at the Beverlodge Research Station in northern Alberta. At that stage it was very early in the testing programme but by then the researchers had established that the New Zealand bees could compete at least on a par with the traditional Californian stock, in terms of honey production; and were somewhat quieter to handle.

Subsequent tests have confirmed the quality of New Zealand bees under Canadian conditions.

In developing the export trade to Canada, I acknowledge the efforts of Mr Jasper Bray and his ad hoc group of beekeepers, who helped supply a seasonal quota of queen bees. This group of beekeepers were faced with and overcame, most of the technical difficulties associated with transporting queens over such long distances. There were problems; and these mainly related to co-ordinating the shipments, storing queen bees, and in market promotion and distribution.

The export of queen bees to Canada peaked in the 1973-74 period with over 8 000 queen bees exported per annum. It has since dropped to a trickle.

The Canadian market is one [illegible] could be re-established. It has a potential of tens of thousands of queen bees per annum. To develop this market, it will be essential to appoint an agent at the Canadian end to co-ordinate and to promote the marketing of New Zealand bees, and to arrange the import permits necessary for New Zealand bees.

United Kingdom

Like Canada, the United Kingdom has shown great concern at the prospects of introducing undesirable bee diseases – in particular, varroa disease. So much so, that in the past two years the United Kingdom has amended its bee importation requirements four times. The lastest change took place earlier this month.

Britain has prohibited the importation of queen bees from all countries without prior permit approval. In general this will only be issued for the purchase of queen bees from countries which have a so-called "high bee health status". New Zealand is recognised in this category.

Britain imports 12 000 to 15 000 queen bees annually. New Zealand exporters could perhaps have a slice of that market. To do so the New Zealand Ministry of Agriculture would need to examine and certify bees for acarine, nosema, amoeba, apimyasis, and varroasis.

Other prospects

With proper market research and development New Zealand could export bees to a number of countries in Europe, the Middle East and possibly central America.

Australia is gradually tightening its door. In 1981 it is proposed that a honeybee quarantine facility will be in operation on the outskirts of Sydney. Imported queen bees will be bred from, the progeny released, and the imported queen and escorts destroyed.

New Zealand bee health

Why does New Zealand hold a "high bee health" status in the eyes of some importing countries?

The reasons are that New Zealand:

- is free from a number of serious diseases and pests of honeybees that currently affect beekeeping in other countries;
- has effective legislation and procedures for controlling the importation of bees and bee products likely to transmit bee diseases;
- requires beekeepers to at least annually inspect all hives, report serious bee diseases immediately and to take appropriate control measures.

Control on the introduction of honeybees, honey and other bee products

The [illegible] appliances is strictly controlled by the Apiaries Act 1969, and its amendments.

In administering this law MAF has prohibited the entry of all honeybees since 1956. This prohibition has been maintained because the bee itself is the major means of spreading diseases and pests. In my view New Zealand's relative disease-free state can be attributed to this policy.

In 1978 an amendment to the Apiaries Act 1969 extended this control on introductions to include honey and other bee products. European brood disease, and other bacterial diseases, can be transmitted through honey.

Foraging bees can be attracted to exposed honey, even in so called empty honey containers dumped with household rubbish. Because of those dangers the entry of honey into New Zealand is prohibited from all countries or states where European brood disease has been detected.

The entry of all bee products requires a prior permit issued by the director, Advisory Services Division, MAF.

The New Zealand market

I am not advocating the export of queen bees at the expense of the supply to the New Zealand market. I believe both can go hand in hand.

In 1974, with the assistance of apiary instructors, I carried out a survey which examined the queen introduction, rearing and breeding procedures adopted by commercial beekeepers in the North Island.

Altogether 60 out of the 80 beekeepers in the North Island operating more than 250 hives responded to this survey – a tremendous response for a five page questionnaire.

This survey showed that although virtually all beekeepers would have liked to have re-queened each colony at least once every two years, in practice the re-queening rate averaged at between three to four years per colony – probably no better than natural supercedure rates.

On a New Zealand-wide basis using this year's hive numbers we would need to produce over 130 000 queen bees per annum to satisfy the assumed commercial demand. We are nowhere near this figure.

Another aspect of the 1974 North Island survey showed a clear commercial beekeeper preference for springtime re-queening. Queen bee producers interested in export could make use of this by raising bees for the New Zealand market in the spring and developing the export market in the autumn, to meet northern hemisphere requirements.

The survey also showed that over half [illegible]commercial beekeepers who responded to the questionnaire raised their own queen bees and preferred to do so.

In my view the production of good quality queen bees in large numbers is a specialist beekeeping operation. There is a difference between raising bees and breeding bees; and breeding bees is a very skilled art.

The 1974 survey concluded that opportunities existed for the establishment of further queen breeding enterprises in New Zealand. Since 1974 apiary section staff have presented some considerable time in promoting queen bee production and breeding. I believe that as a result of these efforts of individual advisers, as well as the training courses which have been held at Flock House we are now starting to see the results. The number of queen bee breeders now advertising in "The New Zealand Beekeeper" is perhaps testimony of this.

Financial assistance is available for the development of beekeeping enterprises, including queen bee enterprises.

I believe that the prospects for queen bee production are excellent; but our success in the international arena will be dependent upon a co-ordinated marketing effort and a willingness to "think big" – not just a few hundred queen bees, but several thousands.