QUEEN REARING AND USE OF QUEENS

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Preface to revised edition

The world has moved on since the 'typing pool' version of *Queen Rearing and Use of Queens* was first produced in 1985. As much of the original 'grey literature' referred to is no longer available, the text has been amended to make reference material available on-line and to include more contemporary information on honey bee biology[1]. A reading list has been appended and includes classic texts that reflect the wisdom of generations of beekeepers rearing and using queen bees.

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[1] The NSW Department of Primary Industries web-enabled *Primefacts* are gradually replacing, or have replaced, some earlier series *Agfacts* and *Agnotes* and are an excellent source of information on nearly all aspects of beekeeping (http://www.dpi.nsw.gov.au/aboutus/resources/factsheets).

Introduction

These notes provide a basic introduction to reproductive biology of honey bees, a general review of the methods that have been used to raise queens and a few practical tips on queen raising. An informed and wide-ranging review of the general biology of the honey bee, *Apis mellifera*, is provided by Winston (1987).

Queen raising is an absorbing pastime: it is certainly time absorbing. Its success depends on selection of good disease free stock, simulation of the conditions under which queens are raised naturally, a little background reading and a good deal of enthusiasm. Queen breeding on the other hand is a specialist's job. It requires the resources of artificial insemination, prime stock, large apiaries, considerable expertise and inventive minds.

Reproductive Biology – Basic Genetics

Social insect communities include the termites (order Isoptera) and the ants, bees and wasps (order Hymenoptera). Termites and ants exist only in social communities. Bees (superfamily Apoidea) are essentially pollen collecting sphecoid wasps in which there are special structural or morphological features such as corbiculae (pollen baskets), at least in some species.

Bees and wasps display varying degrees of social behaviour ranging from solitary to communal and fully social. Amongst social bees and wasps, the control of sex ratio, the presence of distinct filial groups of workers (where queens mate more than once) and specialised features of division of labour have, in part, an atypical genetic basis. Honey bee queens and workers have a full chromosomal complement (the jargon term is diploid, that is a set of sixteen paired chromosomes), whereas drones are haploid, having only one set of sixteen unpaired chromosomes [Figure l]. In most living organisms that reproduce sexually, all offspring have both a mother and a father and are both diploid. The parents each contributes half their genetic makeup to a son or daughter and which bits they get varies from individual to individual.

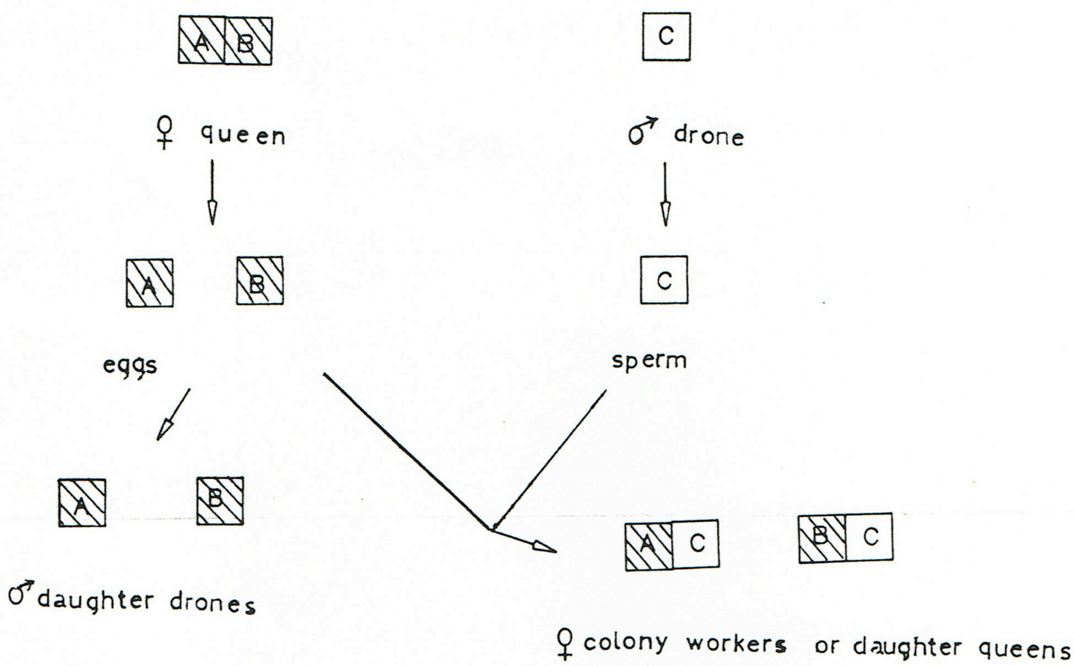

Figure 1 Simplified representation of gene distribution in honey bees

Since drones are raised from unfertilised eggs they only receive their genetic makeup from their mother, usually the queen (workers in queenless colonies can raise drones). Thus the queen's mating affects the genetic makeup of daughter workers or queens, but not the drones. The implications of this genetic anomaly are two-fold:

- the colony can control the sex ratio depending on environmental conditions so as to favour production of workers or drones as they are needed; and
- drones have no father (although they have maternal grandfathers), and since each drone produces identical sperm[2] workers from any single drone father are closely related.

The practical importance of this for queen rearing is that all queens in an apiary (purchased from a reputable queen breeder) are likely to produce good drones even though queens you subsequently produce are open mated. A large apiary of at least 100 colonies with a good queen parentage ensures that an area is flooded with good drones; you may be fortunate enough to live within several kilometers of a well-managed commercial apiary and get some good matings. Secondly it is sometimes possible to pick up a poor queen from her appearance or the appearance and behaviour of her progeny. Queens mate to volume of semen, on average with about ten drones. If there are, for example, small black workers amongst a predominance of even-coloured large workers on a comb, you can reject that colony as a source of stock for raising queens.

If further you are raising a number of queens and can maintain spare nuclei, the daughter queens' progeny and daughter queens' appearance and worker temperament will themselves give some indication of whether the queen mother is worth keeping for breeding purposes.

Since a single drone contributes no genetic variability amongst his offspring, inbreeding amongst selected honey bee strains can be very rapid. Breed from different queens and purchase stock of a different line each season, buying only from breeders with a good reputation. In the extreme situation inbreeding results in as much as half the brood not hatching and developing [Figure 2]. Raising the brood of such artificially inbred queens has been shown to result in the development of small, inbred drones as well as normal workers.

1. Single queen colonies

In most colonies there is only one queen. In response to environmental conditions, mainly incoming nectar and food, the queen may lay worker eggs only or both worker and drone eggs.

There are complex pheremonal (chemical) control processes determining whether drone comb is built, whether eggs are laid in drone comb[3] and when

[2] Drones are commonly referred to as 'flying gametes'.

[3] Queens measure the diameter of cells with their forelegs to determine whether to lay an unfertilised drone egg or a fertilized worker egg, correlating

drones are actually reared or evicted from a colony. Thus, for example, a queen may lay eggs in drone comb at the edge of an expanding brood nest in late winter in some colonies, but drones are not actually raised until needed for normal natural spring queen matings.

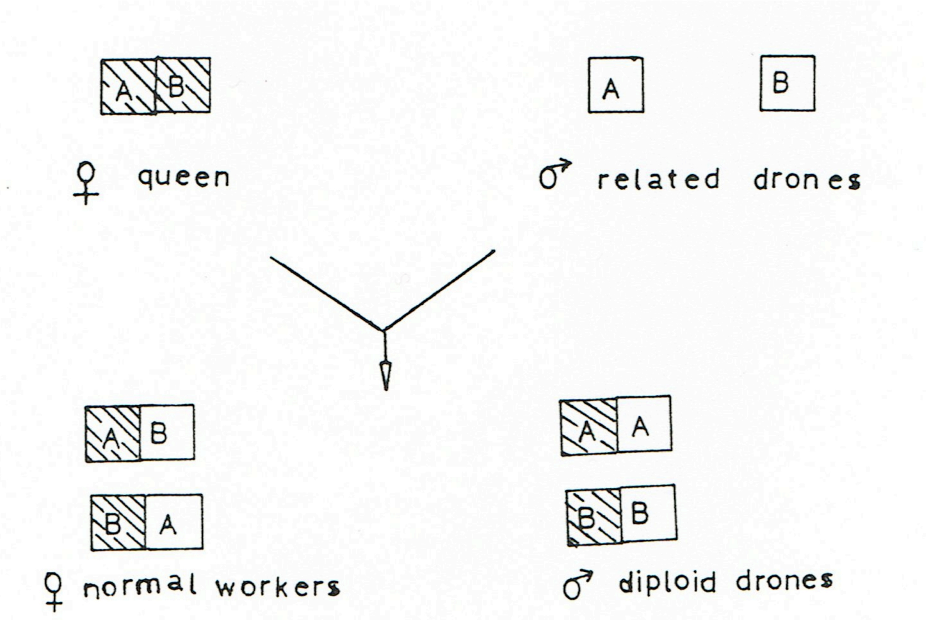

Figure 2 Low hatchaby of inbred queen progeny

Reproductive Processes - Bee Production

The egg laying patterns, and possibly some differences in the ability of workers to raise brood, differ between races. For example, Italian bees maintain large overwintering clusters and will rapidly expand the brood nest under light nectar flow conditions whereas other strains will adopt a more conservative strategy and survive better under adverse conditions. There is so much variability between races, within races and possibly even between colonies of the same origin, that a good case is often made for raising queens from colonies that are loosely described as having done well locally.

Many beekeepers seem to be unaware that colonies often make aborted attempts to raise queens. Some colonies may raise several batches of cells, tearing them down and then finally abandoning all attempts to swarm. Others may swarm at the first opportunity or even as late as early autumn, where in Canberra survival of a swarm in the wild would be thought to be minimal.

Many queenright colonies support varying numbers of laying workers, but their presence normally goes undetected.

2. Queen raising colonies

Queens are raised when colonies become seriously unbalanced, for example when large numbers of workers are raised under crowded conditions. Changes in the adult to brood ratio, changes in honey and pollen flows, changes in reigning queen performance or even reorganisation of the brood

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cell width with a capacity to control release of sperm from the spermatheca. Queens confined to drone brood can nevertheless lay fertilised worker eggs.

nest can induce development of queen cells. In all cases the underlying cause can be traced to poor distribution, or production of insufficient amounts, of queen mandibular pheromones. The three classical conditions for natural queen raising are:

- queen loss;
- supersedure; and
- swarming.

These conditions are often described as distinct processes, but in reality they have many features in common and more than one condition may promote queen raising. Absconding behaviour, where colonies abandon nest sites to seek scarce floral resources, is largely confined to the tropical honey bee, *Apis mellifera scutellata* (Winston 1992). Its evolutionary biology, behaviour and nest structure is radically different to that of the European honey bee.

Within twenty-four hours of loss of a queen from a colony, worker cells containing young larvae are flared and converted to queen cells. Larvae may not be of optimum age, but good queens are often produced. If queens are raised from older larvae (up to four days old) or if they are raised under less than ideal conditions, the new queen may herself be replaced under one of the other conditions under which queens are raised, usually supersedure.

Supersedure, swarming or a combination of these are probably far more common than emergency queen replacement in wild colonies, although starvation and a range of other conditions may result in queen loss and ultimately in the demise of the colony. Both supersedure and swarming differ from emergency queen replacement in that:

- bees build queen cells from scratch and do not modify already started worker cells; and
- queens are raised in response to internal and external colony conditions in the presence of the old queen.

Supersedure often results in queen replacement without colony division [Figure 3]. It appears that physiological aging of the colony queen is inversely correlated with her capacity to produce 'queen substance' or, more correctly, a mixture of queen mandibular pheromones (Winston et al., 1991). Important factors promoting supersedure are disease (notably *Nosema*), intense or prolonged brood rearing bouts, such as occur with long honey flows immediately following spring build up, development of queens under poor conditions and, most simply, old age. The reigning queen is lost often sometime after a new queen is raised (up to 20% of colonies in autumn may have two laying queens present); where the old queen fails almost completely and is then lost. This condition resembles emergency queen replacement.

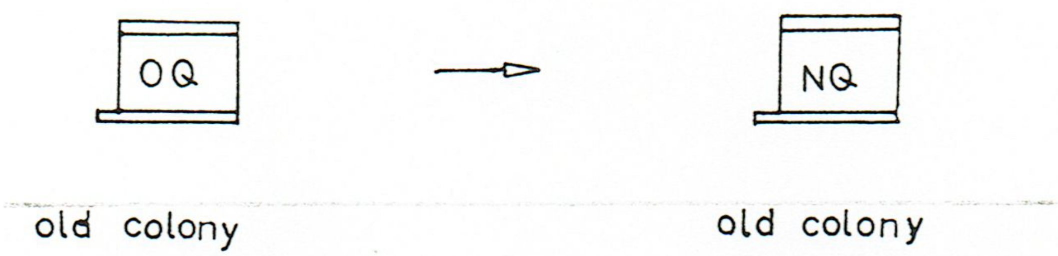

Figure 3 Supersedure with simple queen replacement (OQ = old queen; NQ = new queen)

Where a queen ages but continues to lay well, supersedure induced swarming may ensue. Hence the well known phenomenon of colonies with older queens having a greater propensity to swarm. It appears that supersedure often occurs in this new colony established by the swarm. Technically we could represent the process as double supersedure, replacement of the old queen in the old hive by a queen developed from a cell specifically raised in response to the supersedure impulse followed by, after a short time, replacement of the same old queen in the colony established by the swarm [Figure 4].

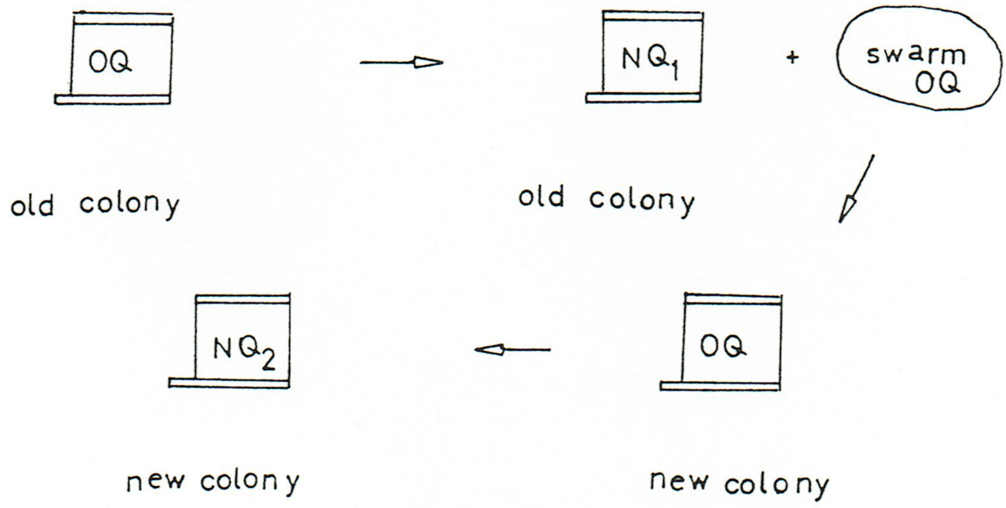

Figure 4 Supersedure accompanied by swarming; the old queen is replaced in the new colony established by the swarm (OQ = old queen; NQ = new queen)

Supersedure in healthy colonies leads to the formation of a few well-developed queen cells on the central comb face[4]. Such cells, from a colony with a good production record and having shown no tendency to swarm, are widely regarded as the best available and will be equal to any that can be raised. If, during a routine inspection, you find ample room in the brood nest and cells are present (i.e. the colony is unlikely to swarm) and you are unable to find the old queen, it is good practice to leave at least one cell to enable supersedure to proceed naturally.

Apart from the potential of using supersedure cells or exploiting the impulse for raising queens, supersedure may, as it often does, go undetected if queens are unmarked. Consequently an inferior daughter queen may head the colony you select to breed from. Then, when you attempt to requeen other colonies, you may not realise that there may be two queens present, the colony mother being superseded and her daughter. Removal of only one queen, particularly the old queen, will usually result in loss of the raised cell or introduced queen. In practice it is a good idea to check all brood frames during requeening to reasonably ensure a second queen is not present.

Swarming is recognised as being caused by many factors, one of the most important of which is crowding. Nuclei are notorious for swarming even with

[4] At most half a dozen cells are produced though they may not all be together; typically there are many more swarm cells, up to as many as several dozen, and these are often on the margin of frames though not always.

young queens of 'non-swarming' strains[5]. The essential feature of swarming is colony division. Note that the old colony obtains a new queen with the issuing of the primary swarm and, to the extent that this increases colony vigour, this partially compensates for the interruption of the brood cycle as well as for the loss of bees and stores that depart with the swarm [Figure 5].

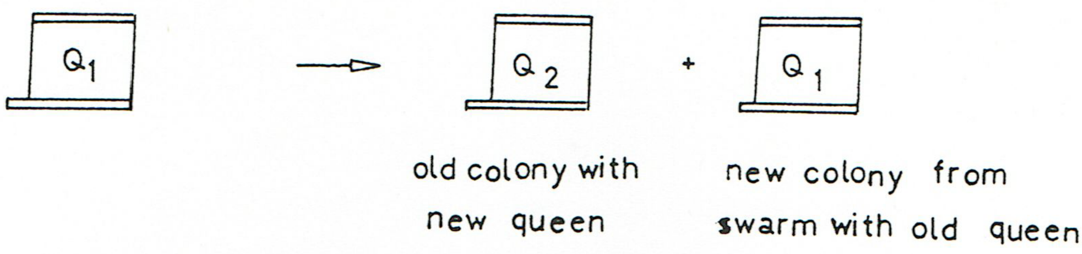

Figure 5 Queen status with issuing of primary swarm (Q_1 = original queen; Q_2 = replacement queen)

Being able to distinguish the supersedure from the swarming condition in the field is of enormous practical importance. Swarm cells need to be removed (or the old queen removed and one good cell left). With supersedure, assuming the colony is not crowded and is therefore not likely to swarm, it is important to leave one or two good cells even if the failing queen cannot be located. With autumn supersedure simply closing the hive up is probably sound practice.

As opposed to emergency and supersedure queen development, where all cells are of roughly the same age, swarm cells are developed progressively at least in some colonies and then predominantly on comb edges[6]. Swarmed colonies may swarm again or even a number of times, occasionally leading to the abandonment of the parent hive and fairly commonly to the old colony then becoming queenless. A number of virgins may emerge with a single after-swarm and sometimes more than one swarm may issue or swarms may unite before establishing a new colony. So check to see if any queen cells have emerged or have been torn down. Searching for virgin queens is not easy but leaving a queen or a cell will prevent the colony becoming queenless. Leaving more than one queen, and not removing some brood, may result in swarming.

After-swarms may establish vigorous colonies with young queens [Figure 6], but are usually of limited value in establishing new colonies because of either small swarm size or a late season start; avoid selecting for swarming propensity by requeening or dequeening and uniting with another colony, that is after a couple of brood cycles when you have checked for disease.

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[5] I once lost several new queens and captured a number of swarms from queens newly introduced into three and four frame nuclei under 'soft' spring conditions. The departing bees completely abandoned brood and some stores.

[6] If a double brood nest is used, it is a good idea to first split the brood boxes and undertake a quick visual check for queen cells on the bottom bars of the upper super. Checking individual frames may not reveal the presence of swarm cells till you have checked most brood nest frames. Also check for the presence of virgin queens if some queens have just emerged.

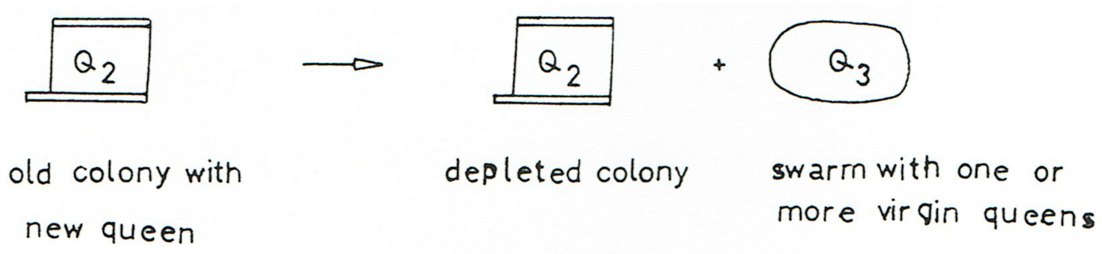

Figure 6 Recently swarmed colony-issuing after-swarm (Q_2 = original colony with a new queen, where an initial swarm – with the old queen Q_1, not shown – has long departed as the prime swarm; Q_3 = after-swarm(s) with one of more virgin queens)

There are a number of cues for queen raising that can be inferred from the known causes of swarming [Table1]. We know, for example, that destroying queen cells in a colony will not remove the swarming impulse, unless coincidentally conditions change or the colony is suitably further manipulated (see **Queen Raising Techniques**, p. 14). Swarming will be delayed if all cells are removed and a new batch will be started (or a batch of introduced cells accepted) under conditions ideal for raising queens. Thus to raise queens, colonies of swarming strength are used, but the queen is either removed (when conditions are ideal for emergency queen replacement) or isolated (when conditions approximate supersedure and only a few cells are started) to ensure survival of cells.

Table 1 Swarming inducing factors

Source of problem	Cause of swarming
Failing queen	Queen unable to produce sufficient mandibular pheromones
Lack of storage space for nectar, lack of brood rearing space and poor ventilation	Decrease in foraging and comb building activity with consequent reduction in distribution of queen pheromones. Storage of nectar in brood nest with consequent reduction of egg-laying and other brood nest activities again reducing efficiency of queen pheromone distribution
Adult- brood imbalance, very large colonies	Large numbers of bees emerging with insufficient tasks to perform, crowding of brood nest that results in reduced efficiency of pheromone distribution. Insufficient queen pheromones for large numbers of bees
Favourable environmental factors	Light honey and pollen flows with limited food distribution and food storage activity that in turn limits queen pheromone distribution. Factors such as external ambient temperature and day length that affect internal colony conditions such as brood rearing
Genetic factors	Variable propensity to swarm probably associated with varying ability of queens to produce pheromones or variable response of workers of different racial groups to such pheromones

Colonies raise queens in mid-to-late spring and start new colonies most successfully in late spring. At this time, the swarming impulse is strong, there is generally a good supply of nectar and pollen to ensure optimal nutrition of queen cells, poor weather is unlikely to prevent successful matings and colonies will have maximum time to recover or be re-established.

Drone-Raising Colonies

There are two conditions under which a colony entirely fails, apart from simple starvation or predation. If a queen fails to mate, for example due to poor weather or lack of drones to mate with, the colony runs down even if the queen survives. In the absence of successful supersedure, an old or poorly mated queen that runs out of sperm, like the unmated queen, will maintain a good brood pattern but only drones will be produced.

If the queen is killed, for example on a mating flight, or there is no replacement queen, as occurs sometimes during winter or after multiple swarming episodes, workers commence to lay. Workers tend to lay more than one egg per cell (as sometimes do newly mated queens), but unlike queens normally lay them on cell walls and, of course being unmated, all are drones. The brood pattern is irregular and brood may be abandoned.

Common features of drone-raising colonies include:

- presence of drone larvae in worker cells and presence of many small drones;
- aged worker population with limited ability to raise brood; and
- progressive colony weakening.

While drone laying queens can be replaced, emerging brood and stores are needed if the colony is to recover and anyway a queen or cell is unlikely to be accepted. A much better practice is to unite drone-raising colonies (after removing any queen) with strong queenright colonies or even better to shake off bees from all frames away from the hive prior to uniting.

Self-Requeening Colonies

Occasionally an unmated queen can raise a few workers asexually (parthenogenically) presumably from tetraploid germ plasm tissue but such offspring has never been recorded as rearing a queen. The South African honey bee, *Apis mellifera capensis*, is well known for its ability to requeen itself from a laying worker colony. The workers produce diploid worker offspring with a full genetic complement and so queens are easily raised.

Life Cycle of Honey Bees

Because of the relatively controlled environment of the honey bees (*Apis* mellifera and *A. cerana*) brood nest, the period of brood cycle [Table 2] is only slightly affected by external conditions.

Table 2 Brood cycle of European honey bee *Apis mellifera*

	Period (days)			
	Egg	**Larva**	**Pupa**	**Metamorphosis**
Queen	3	6	7	16
Worker	3	6	12	21
Drone	3	7	14	24

Doug Somerville's (2001) article on the biology of the Asian honey bee (*Apis cerana*) is instructive; worker brood cycle is also twenty-one days.

Queens have been claimed to emerge a day late in small colonies in cool weather and up to a day early in summer. Similar variations in emergence times may be found with worker and drone brood. There have been claims of synchronous hatching of worker eggs around dawn. Presumably there are some differences between races in brood cycling, but in practice queen rearing follows a well-defined timetable. Queen cells are most safely handled one to two days before they emerge, that is at the pupal imago stage rather than at the easily-damaged early pupal stage.

There are less well defined times for maturation of adult European honey bees. Nevertheless there are some well-known changes in adult behaviour that have been associated with physiological changes. Table 3 provides some guidance of the time required from emergence to reach sexual maturity.

Table 3 Adult development of *Apis mellifera*

	Period of maturation (days)	Lifespan[7]
Queen	approx. 7[1]	years[4]
Worker	approx. 5[2]	weeks[5]
Drone	21-28[3]	months[6]

1. Time from emergence to mating; can be delayed for a maximum of about two weeks in poor weather; time from mating to laying is approximately three days.
2. Minimum period for development of brood food glands. Young bees tend first clean cells and then raise brood, 12-18 day old bees build comb, while bees older bees first orient themselves to the colony and then forage (Eckert and Shaw, 1960). New epigenetic studies indicate that bee size can be adjusted to optimise nectar or pollen collection.
3. Young and very old drones lack vigour for successful mating although sexually mature.
4. Damaged or poorly raised queens tend to be rapidly superseded, as are queens under physiological stresses such as prolonged egg laying or disease. Established colonies that are not manipulated tend to maintain fairly young queens because of swarming.
5. Summer lifespan of commercial bees is, on average, about six weeks; some strains such as *A. mellifera mellifera*[7] are longer lived, but brood

[7] See Wikipedia for descriptions of the morphologically and behaviourally distinct honey bee races, *Apis mellifera mellifera*, *Apis mellifera lehzeni* and *Apis mellifera nigra* originating from different European locations. Of course there is also a wider subspecies classification of the domesticated (non Asian) honeybee including the original German dark bee *A. mellifera mellifera* (as above), the original Italian *A. mellifera ligustica*, the Carniolan *A. mellifera carnica* (also subspecies *remipes*), the Northern African *A. mellifera adansonii,* the Africanised bee *A. mellifera scutella* (Winston 2012) and the Southern African *A. mellifera capensis* but there are a number of other recognised subspecies.

rearing is less intense. Poor protein nutrition roughly halves normal lifespan. Individual bees may live up to three months even in summer, while a high natural mortality of adults about ten days old has been reported.

Workers emerging in autumn may survive to early spring due to cessation of foraging, a wearing and hazardous enterprise, and due to cessation of brood raising. Healthy workers in broodless colonies with some stores survive for long periods.

6. Drones can be evicted at any time of dearth, typically in late autumn in temperate climates, though also in a dry summer. Older drones are evicted first while queenless colonies maintain drones for extended periods.
7. Diseases such as *Nosema* and sacbrood reduce longevity in all castes.

Planning Queen Raising

Anytime, except perhaps winter in temperate Australia, is a good time for introducing new queens, particularly if there are problems of queen failure, disease or persistent efforts of a colony to swarm. My approach is to maintain spare nuclei throughout the year despite the extra work this entails. Always start many more cells than needed to allow for losses and to leave some room for selection of cells and queens.

Colonies with queens introduced in autumn or early spring have the greatest opportunity for building large populations to take full advantage of summer honey flows. Consider how raising queens contributes to the honey gathering process. Queens take approximately three weeks to commence laying from the time of grafting (cells raised from one day old larvae are distributed ten days after grafting and lay approximately ten days later). The first eggs laid emerge[8] as adults after three weeks, and while they immediately contribute to the total work force, they do not themselves become foraging bees (except in colonies depleted of old bees) until a further three weeks have elapsed. While early raising of queens is desirable, a number of environmental constraints must be overcome for queen raising to be successful:

- pollen and nectar must be available in abundance;
- mature drones, at least three weeks old, must be available;
- weather needs to be suitable for manipulation of colonies; and
- weather must be suitable for queen mating.

These conditions are best met naturally in the Southern Tablelands in October and November; spring weather is unpredictable in September and may not be ideal until October. Pollen supplies are often poor from mid-summer onwards (pollen supplements can be used) while bee aggressiveness in late summer and autumn (especially when there is no honey flow) can make queen rearing unpleasant if not impossible.

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[8] It is incorrect is to refer to 'hatching of adult bees'; larvae hatch from eggs, adults emerge from pupae (located inside sealed cells). While cell division commences before eggs hatch, hatching and emergence are much more distinct phases of development. Emergence is the end result of the remarkable process of changing life forms or metamorphosis.

Plan actual raising of queens carefully to ensure that you actually get to the bees on specific days when needed. If you can fit grafting of larvae into Thursday lunchtime, the main work of making up nucs and distributing cells can be left to the following Saturday and Sunday week [Table 4].

Table 4 Queen raising schedule

Activity	Timing
Introduce cell bars one or more days before grafting for polishing	Day -1
Establish starter colony	Early day 0 or previous day
Graft larvae into queen cell cups	Day 0
Transfer started cells to builder (finisher) colonies	Day 1 (or 2)
Establish mating nucs (or early day 10 if weather is poor on day 9)	Day 9
Distribute cells to mating colonies	Day 10

Here is an extract [Table 5] of an apiary record of a late batch of queens raised for autumn and spring use in 1985:

Table 5 Apiary schedule

Beeblebox Queen Raising - February 1985		
Feb	Sun 3/Mon 4	Queen lays eggs
	Wed 6/Thurs 7	Eggs hatch
	Thurs 7	Grafting-cells raised in strong queenless starter/finisher colony
	Tue 12	Larvae pupate
	Sun 17	Cells distributed - nucleus with cells transported to Tharwa and nucs made up and celled
	Tue 19 March	Queens emerge
March	Fri 1	Queens commence laying ± 2-3 days
	Mon 11	First brood sealed
	Sat 23	First workers emerge
	Sat 30	Colonies checked, queens marked, brood checked, stores checked, disease checked.

Queen Marking

Many beekeepers regard queen marking as unnecessary and possibly detrimental to queen performance. However it is widely practiced [Table 6] and can be an excellent aid in apiary management [Table 7]. You can practice on the thorax of drones.

Table 6 International colour coding

Colour code	Year ending	
White	1	6
Yellow	2	7
Red	3	8
Green	4	9
Blue	5	0

Table 7 Summary of marking effects on apiary management

Advantages	Disadvantages
Provides ready reckoner of queen source	Time consuming
Indicates queen problems such as supersedure due to disease	Queens can be damaged if care is not exercised
Helps locate queens	

Marking practice can be simply adapted to needs. With only a few colonies, two colours (such as nail polish red and typing white out) can be used on an alternating year basis. You will know your colonies well enough to know when they were last requeened and the origin of marked queens. You will also recognise natural queen replacement from swarming or supersedure because an unmarked queen will head any such colony.

With a number of colonies, it is useful to operate at an apiary level and there is a place for a slightly more sophisticated marking scheme. These are simple enough to develop, so that if your records are not too good or you locate the queen during a routine inspection an immediate assessment of the queen can be made. A useful practice is to keep a small box with a marking kit[9], spare matches, a few spare mailing cages, tape, spare pencils and adhesive labels. Here is the Beeblebox Apiary marking scheme [Table 8].

[9] Numbered, coloured discs are also available commercially.

Table 8 Beeblebox Apiary record of colour labeling

	Commercial queens	Apiary raised queens	Supersedure and swarm queens
Summer 1984-85	Green	Yellow	Red
Summer l985-86	Blue	Violet	White

Queen Raising Techniques

We have seen how emergency, supersedure and swarming impulses give rise to raising of new colony queens. Manipulation of a colony with swarm cells – removing a nucleus with a selected swarm cell – and replacing frames with empty combs or foundation, will control swarming and establish a new queen[10]. Artificial queen raising can be divided into several distinct phases:

- stock selection;
- starting cells;
- building cells;
- mating queens; and
- evaluating and using queens.

l. Stock selection

At the hobbyist-sideline level of beekeeping, the best that can be done in selecting queen stock is to use one or two colonies with good production records that are also docile and have no record of disease. The chances of a good mating are increased marginally if only good productive colonies are kept, if there are a fair number of colonies (or selected colonies each with the equivalent of one or two frames of drone brood combs) and if an out-apiary is used. Most simply, use of natural swarm cells (Eckert and Shaw, 1960) along with some brood and stores can be used to establish nuclei.

2. Starting cells

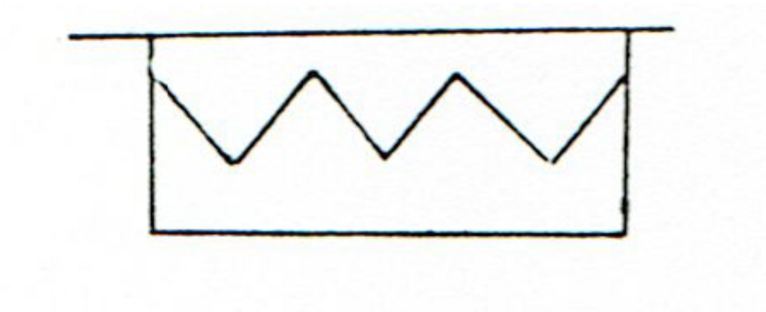
The actual techniques for handling young larvae and their transfer (grafting) to prepared queen cells are widely described (see below). Historically, other distinctive processes for preparing cells have been reported. They are briefly described here:

(a) Exposing cut edge of comb - Cowan and Miller (Snelgrove, 1981b, p. 195; Wedmore, 1945)

Half a sheet of foundation is inserted into a frame that is introduced to the center of the brood nest of the breeder colony. After one week a well-fed colony will have drawn the comb and eggs and young larvae will be present. The lower edge of the comb is cut with a warm knife

[10] If the swarming colony has a good past production record, swarm cells may also be introduced to nucs prepared from other overly strong colonies. However, for obvious reasons avoid weakening colonies too much at the beginning of a honey flow.

and one larva out of every three or four is selected. Using a broad V-shaped pattern can raise more cells:



(b) Using cut strip of comb – Alley (Snelgrove, 1981b; Wedmore, 1945)

Strips of comb with eggs or young larvae raised as above can be attached (with wax and a preheated soldering iron) to cell bars or to the lower edge of comb cut away to leave room for attachment of a strip of comb and room for extension of the cells downwards. With all preparations for handling young larvae, avoid chilling or drying by working under suitable warm but not hot conditions, if necessary covering with a moist cloth and working indoors.

(c) Laying prepared comb flat on blocks in shallow super above brood nest – Pechaczek and Hopkins (Snelgrove, 1981b, p.196; Wedmore, 1945)

This technique, while suitable for raising a large number of queens, has some drawbacks. Presumably the top end-bar lugs must be removed, so the comb can be laid flat. The comb must be new, well and evenly laid up and a lot of preparation is needed to select larvae in both directions on the comb face.

(d) Grafting larvae into prepared queen cell cups – Doolittle (Eckert and Shaw, 1960; Laidlaw, 1978; Snelgrove, 1981a, 1981b)

Plastic cells developed by Ben Olroyd in Australia have made this old technique the most flexible and practical of all queen raising systems. Bill Carlile (1984a, 1984b) provides an excellent description of how to go about transferring very young larvae to queen cells.

Cell bars can be prepared from standard equipment, e.g. by inserting foundation into a shallow frame and attaching cells to the bottom bar. A more conventional set up involves modifying a standard full depth frame (or scrap timber of similar dimensions) attaching blocks or cutting out ledges so that bars can be inserted and easily removed. Use a maximum of three cell bars per frame (a new bar of started cells can be added after the previous batch of cells on a bar are sealed) - if three bars are used leave off the frame bottom bar. Again a soldering iron (Noel Clare's invention[11]) is useful for attaching cells with wax. The Doolittle grafting method is now the most widely employed cell-starting technique.

[11] Noel was a founding member of the Beekeepers Association of the ACT.

(e) Transferring cells with larvae intact (Eckert and Shaw, 1960)

A cell punch is used to remove intact cell and surrounding comb. The comb should be new while honey on the reverse side of the brood should be avoided. The cells are trimmed and attached to blocks or directly to the cell bar. Drone cells and incipient queen cells (those you often find on combs without eggs or larvae) can be used but the larvae must of course be grafted.

So far, we have only reviewed cell preparation. These cells must be introduced to colonies intent on raising queens, starter colonies that can be queenless of queenright:

(a) Queenless colony starters

Simple dequeening of colonies with old queens with a good past production record may work. The colony loses a complete brood cycle (critical in spring) and worse, if unsuccessful, the colony may go down. The technique is not recommended. However if a colony is apparently recently queenless, for example if there is only a small amount of sealed brood (some colonies after swarming become queenless) then introduction of a frame of young brood from good stock can be a valuable emergency field technique if no spare queen is available. If a virgin or recently mated queen is already present, then the extra frame of brood will stabilise the colony and even strengthen it; if no queen is present then one will normally be raised from the introduced young brood.

For serious queen raising, the swarmbox (Swathmore) technique is unsurpassed (Johnstone, 2008). The technique is known to give a strong start to cells and simulates conditions of a swarm settling in a new location under ideal conditions. From experience I can highly recommend this technique.

There are numerous published 'collapsed colony' techniques[12] and two very simple excellent techniques, originally described by Bruce Ward[13], that involve:

- removal of the queen and a super to produce a very strong queenless colony; and
- placing a nucleus with young bees, sealed brood and stores in the original location of the parent colony (the parent colony retains the queen and is moved sideways or backwards and turned around).

[12] Not to be confused with colony collapse disorder, a fairly phenomenon of mass failures of bee colonies in Europe and North America that was first recognised in 1996 [http://en.wikipedia.org/wiki/Colony_collapse_disorder].

[13] The original material produced by Bruce Ward is no longer available, but the same techniques are described by Honey Bees Project Officer, Mark Johnstone (2008).

The colonies need feeding (unless ideal conditions prevail) and the cell bar is introduced to the center of the brood nest.

(b) Queenright colony starters

Dividing the brood nest induces supersedure-like conditions. Colonies must be very strong. By denying the queen access to part of the brood nest (for example by using an excluder) the queen is restricted and her pheromones are less effectively distributed.

Usually a limited number, no more than about twelve cells are automatically raised or up to 10-12 cells can be introduced. Variations on this technique include division of a large single brood box, typically 12-18 frames, using a vertical excluder or screen or use of standard equipment and a conventional queen excluder or a horizontal screen to divide the brood nest. John Hogg (1981, p. 39) provides some fascinating insights into the supersedure process, particularly in combining swarm control with queen replacement. It would seem that the basis of the well-known Demaree swarm control plan [Figure 7] involves diverting the swarm impulse to a supersedure impulse (Snelgrove, 1981a, 1981b; Root, 1980). The best cells are produced by supersedure, so queens once started would not normally be moved to separate builder colonies, although where such colonies start cells daily on a continuous basis the cells must be removed. Under poor conditions cells may be started but not developed.

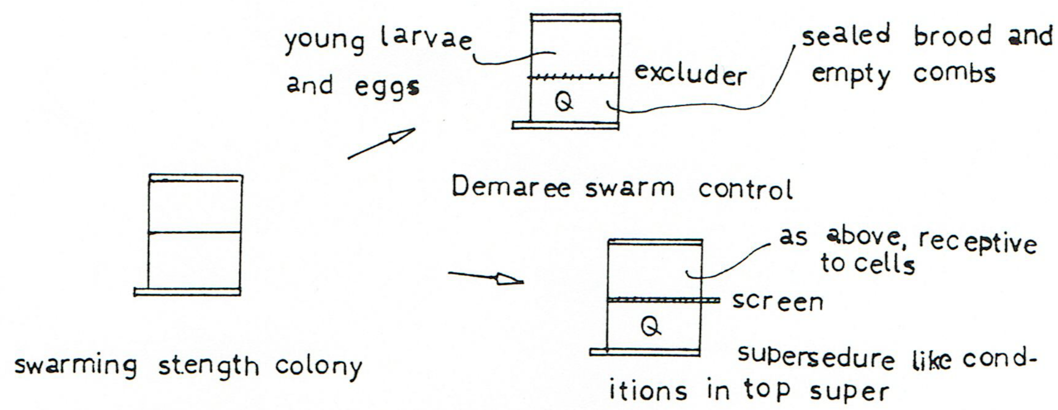


Figure 7 Comparison of Demaree swarm control with induced supersedure queen raising

3. Building cells

Either queenless or queenright colonies can be used to build cells, that is feed, seal and incubate cells, once started. Indeed strong well-fed starter colonies can also be used to build a single batch of cells as occurs naturally. Where continuous production of cells is required, it is more practical to establish separate builder colonies and reuse (with brood or stores added) the starter.

(a) Queenless builders/finishers

The simplest technique employs the strong queenless colony used to start cells. The need for returning to the apiary to move the cells is eliminated, but it is a good idea in any case to check how many cells have taken to plan establishment of mating nuclei.

Cells started in small starter colonies, for example in the Swathmore swarm box or say a four-frame offset nucleus, are unlikely to develop into good cells except under very favourable conditions. The cells should be transferred to a stronger colony that, in a small apiary, would usually be in a normal production colony over an excluder (see Queenright Builders below).

A problem that often arises in queenless builders is the development of emergency cells elsewhere in the brood nest if eggs or young larvae are present at the time of cell introduction. Unchecked, stray queens may emerge early destroying introduced cells. Alternatively if the builder (or starter-builder) is further used to mate a queen emerging from one of the cells raised, and other cells are not detected, an inferior queen may be established without the beekeeper ever being aware that this may have occurred. Either check the brood nest thoroughly after several days to remove any extraneous cells, remove all unsealed brood when making up the builder, or remove the queen from the colony about a week in advance checking for and destroying all cells several days after removing the queen.

However, provided care is taken, provided that the colony is crowded with young bees and provided that stores including pollen are available, excellent cells can be produced from a single colony with an absolute minimum of manipulation. If there is an older queen to dispose of when establishing the builder or starter-builder, keeping her in a spare super or a nucleus colony will provide one extra nucleus (ready but for removal of the old queen) to mate a cell from.

Queenless colonies are sometimes used as drone mother colonies, maintained by regular addition of sealed worker and drone brood from selected colonies. Such colonies have a renowned reputation for maintaining drones under adverse conditions; however, if such colonies become run-down the drones will not have the optimum vigour essential for successful matings.

If neglected, queenless colonies may develop laying workers, colony morale may decline or very occasionally the colony may be requeened with an undesirable stray virgin queen.

(b) Queenright builders

Queens started under the supersedure impulse, that is above a horizontal excluder or beside a vertical excluder in the queenless portion of a queenright colony, may be left to develop until the cells are ready to distribute. However, queens started by any technique can be built in a queenright colony, usually in the center of a super over an excluder and immediately above the brood nest.

Important factors to consider are:

- making the builder strong to overflowing, by, if necessary, removing a super to crowd bees;
- drawing nurse bees to the area where the cells will be built by flanking the cell bar with one or more frames of young brood provisioning cells,

with adjacent frames containing pollen and uncapped honey or feeding sugar water in the absence of a honey flow; and

- ensuring no natural swarm or supersedure cells are present in the colony at the time the cells are introduced. If present the colony may swarm during cell building or, if present above the excluder, emerge and destroy prepared cells.

Finding the queen and placing her below the excluder is an obvious requirement. Hence, it is a good idea to establish a cell builder on the same day as cells are grafted, if an excluder is not already on the colony, ready for use the following day. Look for the queen and queen cells, rearranging the brood nest so that most of the brood including all sealed brood together with the queen is below the excluder. If the queen cannot be located, offset the super shaking bees into the lower brood chamber (queen now below), replace the excluder and allow the bees to move into the super overnight [Figure 8]. A frame of unsealed brood will help draw young bees up.

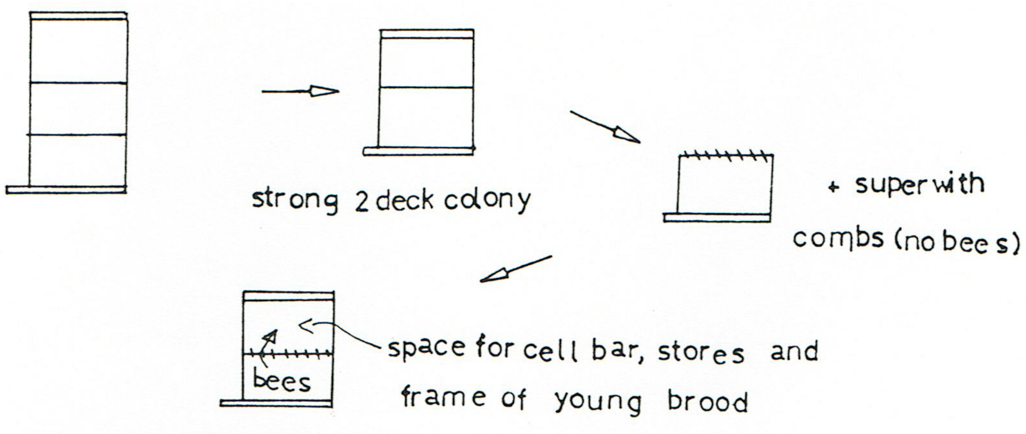


Figure 8 Preparing queenright builder

4. Mating queens

Cells can successfully emerge and mate in colonies of almost any size. Strong, especially savage, colonies have a lower than average acceptance rate for cells or mated queens. If you must use full strength hives, find a reliable alternative ready source of queens, as some requeening will fail.

Queens can be mated from baby nucs containing only a few hundred bees. Special care is needed to operate baby nucs as there is little room for the queen to lay, colonies need constant feeding even under ideal conditions and overheating and chilling can be serious problems. Such colonies also have poor defenses and can be robbed out readily.

An ideal arrangement is the mating and establishment of queens in standard 3 or 4 full depth frame nuclei (these can be made from standard supers by using a solid division board reaching to the floor of a modified bottom board with entrances at diagonally opposite corners; the frame tops are covered with heavy quilting to prevent movement of bees between the divisions and a standard cover is used). A simple alternative is to use a division (or nucleus) board so that while the old queen continues to lay below, the top unit with the cell or new queen establishes itself. If the new queen fails to emerge from her cell, miss-mates or does not return from a mating flight, the old queen carries on and the two colonies can be united. Much the same principle applies to the introduction of a purchased queen. If she is not accepted, the integrity of the whole unit is not jeopardised. If the old queen is failing badly, cells can be introduced above and below the nuc board, greatly increasing the chance of establishing at least one queen. A more subtle advantage of retaining the old queen is that she keeps laying and there is no break in the brood cycle (if the two units - the colony and the nucleus are considered as one unit). The time from cell introduction to new queen laying is approximately ten days or half a worker brood cycle. Both queens can be kept laying (if a small nuc is used, brood can be regularly transferred to the main colony) until say mid November at the beginning of the main normal honey flow and then united. The colony is much stronger, although stores will be more depleted, than if either queen alone had been used [Figure 9].

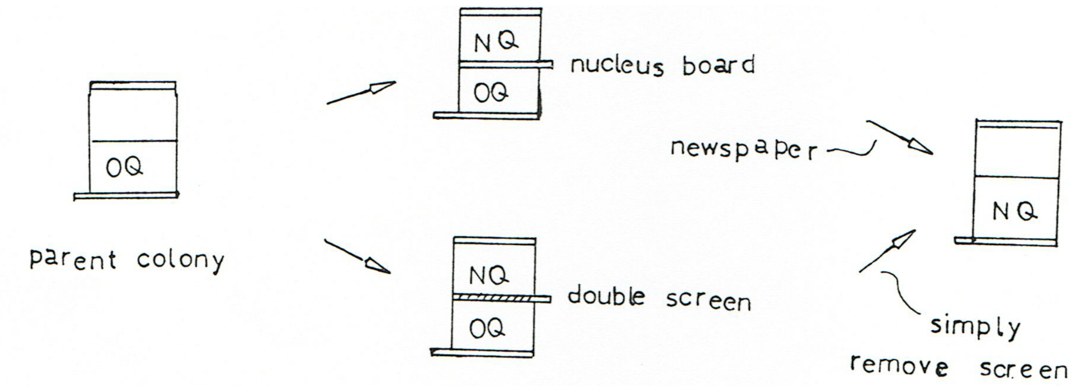


Figure 9 **Establishing a new queen using a nucleus board. If a nucleus box is used, it can be offset to one side of the parent colony and pointed in a new direction: OQ = old queen, NQ = cell or new queen.**

Notes

1. Establish the cell with one or two frames of sealed brood, combs containing pollen and honey and an empty comb. Uncap some honey with a hive tool if the honey is sealed or alternatively feed heavy sugar syrup.
2. Crowd the nucleus with bees if making up in the same apiary to allow for drift back to the parent colony. The emerging brood will strengthen the unit and leave room for the new queen to lay.
3. Use robber screens and ideally locate the nuclei (if nuc boxes are used) half a kilometer or more away from a large apiary if robbing is likely to be bad. Under such conditions, the nuclei will need feeding with sugar water.
4. Establishing a nucleus from the colony to be requeened minimises the chance of disease transmission. If nuclei are used and moved away, mark the parent colony and nucleus with a common letter or symbol so they can be reunited later.

5. If nuclei are used to make increase in the number of colonies in an apiary, a frame or two of sealed brood from disease free colonies every few weeks will build the units rapidly.

6. If a double screen is used in place of a nucleus board, the top nucleus in the super will be strengthened by the rising warmth of the unit below. Since the odours of top and bottom units are intermingled, no newspaper is needed to unite. If the nuc board or double screen is replaced by an excluder, a true two-queen unit is established.

7. Super the top and bottom units if required. When reuniting the two units, keep the brood boxes together, using sheets of newspaper as needed [Figure 10]. Alternatively, simply unite the two units and after a week, reorganise the colony so that all the brood is together, checking for the presence of supersedure cells. It is a good idea to kill the old queen, as she will survive at the expense of the new queen, at least 20% of the time.

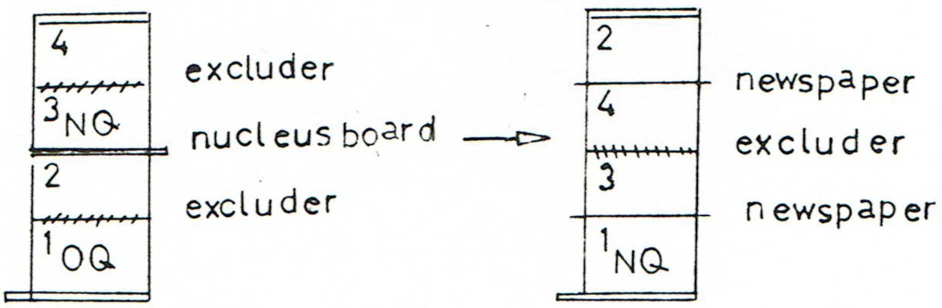


Figure 10 Uniting to requeen.
If a nucleus box is used, shake the bees out of the first super; introduce the nucleus with the new queen and bees and use newspaper to unite as needed.

8. Check the appearance of the new queen and her brood laying pattern before a decision is made to unite the units. Queen acceptance is improved if the new unit is well balanced - i.e. with bees and brood of all ages: the usual rule of thumb is to wait until the new unit has its own sealed brood.

As a parting note, consider the queens you raise as a resource. Raise more queens than you need immediately and maintain sufficient nuclei to replace the odd queen that will fail during or after the honey flow. A few strong nuclei (at least six frames) run as singles over winter are useful for assisting colonies that have queen problems in early spring. Similarly, colonies that fail to build up prior to the main early summer flows typical of the area in and around Canberra can, if disease-free, be strengthened by nucs (or even requeened) so that they become productive units. Good strong healthy colonies headed by young queens are definitely less susceptible to disease, less susceptible to swarming and are less likely to have outbred supersedure or swarm replacement queens with offspring of a savage disposition. They are likely to be good producers. Colonies headed by poor queens are at least as expensive and time consuming to maintain (try finding the small black outbred queen in that unmanaged colony!) as vigorous productive hives. Good queen management is therefore excellent beekeeping practice.

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