

Australian Beekeeping Guide



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Australian Beekeeping Guide

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Foreword

Australia's honey bee and pollination industries make a fundamental contribution to the Australian economy and way of life. Healthy honey bee colonies are necessary for the pollination and economic viability of honey bee dependant horticultural and seed crops. In addition to commercial and sideline beekeeping enterprises, thousands of hobby beekeepers throughout Australia gain considerable recreational pleasure by keeping honey bee colonies.

The Rural Industries Research and Development Corporation invests in research and development that is adopted and assists rural industries to be productive, profitable and sustainable. The Corporation seeks to increase knowledge that fosters sustainable, productive new and established rural industries and furthers understanding of national rural issues through research and development in government-industry partnership.

The Rural Industries Research and Development Corporation's Honey Bee and Pollination R&D Program aims to support research, development and extension that will secure a productive, sustainable and more profitable Australian beekeeping industry and secure the pollination of Australian horticultural and agricultural crops.

The Australian honey bee and pollination industries face a number of significant and economic challenges, including several biosecurity threats. These include exotic honey bee parasitic mites that occur in neighbouring countries. Their establishment in Australia could put at risk the supply of bee colonies for pollination of crops.

This book brings together available basic information about the craft of keeping bees and honey bee biosecurity. It will provide a strong platform for beginner beekeepers to grow their hobby and provide a useful foundation for beekeepers contemplating beekeeping as a sideline or full-time commercial enterprise.

RIRDC funding for the production of this book was provided from industry revenue which is matched by funds provided by the Australian Government. Funds were also provided by the Victorian Department of Economic Development, Jobs, Transport and Resources.

This book is an addition to RIRDC's diverse range of over 2000 research publications and forms part of our Honeybee R&D program, which aims to improve the productivity and profitability of the Australian beekeeping industry.

Most of RIRDC's publications are available for viewing, free downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

Craig Burns

Managing Director

Rural Industries Research and Development Corporation

Preface

The first successful introduction of European honey bees (*Apis mellifera*) into Australia occurred in Sydney in 1822. From that small beginning, there are now over 10,790 registered beekeepers and approximately 563,700 hives kept throughout Australia.

Honey bees are kept for the production of honey and beeswax, but most importantly for pollination of honey bee dependant horticultural and seed crops. The importance of honey bees for pollination, and this unique and specialised honey bee industry, is well recognised by the general public, the Australian Government, and all state and territory governments.

Keeping honey bees can be a very fascinating and rewarding hobby, as well as a profitable sideline or full time occupation.

Beekeeping is essentially a craft that is learned over a number of years. Challenges will occur and mistakes will be made, but accompanying these will be a growing success and reward. It is really a matter of practice, and building experience and confidence.

If you have decided to become a beekeeper, you can easily build your knowledge of bees and beekeeping. You can join a beekeepers' club, attend beekeeping field days and short courses, and get guidance from books written for Australian conditions. Fact sheets and information may be downloaded from web sites of your state department of primary industries, Rural Industries Research and Development Corporation and Plant Health Australia BeeAware site.

This book provides basic information to assist beginner and sideline beekeepers. It draws on the knowledge and experience of apiculture scientists, various state and territory apiary inspectors and apiary officers, and most importantly, the many beekeepers who enjoy keeping bees.

The book follows in the tradition of its predecessors. *Beekeeping in Victoria* was first published in circa 1925 and was followed by five revised editions. In 1991, an extensive revision was published under the title *Beekeeping*.

The *Australian Beekeeping Guide* is an extensive revision of *Beekeeping* (1991). It builds on the work of our fellow authors of that time, Laurie Braybrook, Peter Hunt and John McMonigle. It provides additional information, particularly in the field of bee diseases and pests. It contains information about beekeeping in temperate Australia.

We wish you every success in beekeeping.

Russell Goodman and **Peter Kaczynski**

Russell Goodman is a senior officer – apiculture with the Victorian Department of Economic Development, Jobs, Transport and Resources (DEDJTR)

Peter Kaczynski is a former senior apiary inspector with the former Victorian Department of Primary Industries. He is now retired.

1. Introduction to the honey bee

The European or Western honey bee (*Apis mellifera*) is a social insect that lives in colonies of up to 60,000 adult bees. With many generations of bees being raised, honey bee colonies can live for many years.

Honey bee colonies nest in cavities, such as tree hollows, that provide protection from the weather. In today's world, they also nest in man-made structures such as walls of houses, chimneys and compost bins. On rare occasions they build their combs in the open, fully exposed to the weather and predators.

The honey bee nest has vertical wax combs that consist of hexagonal cells built on both sides of a midrib. The cells are an engineering masterpiece. Each cell wall forms the wall of an adjacent cell and so there is no wasted space anywhere in the comb. The cells are just the right shape and size to accommodate the roundish larvae and the pupae that are reared in them.

Adult worker bees construct comb using beeswax secreted from eight wax glands on the underside of their abdomens. The wax initially secreted as a liquid, forms small, irregularly-shaped, wax flakes when in contact with the air. The bees remove these tiny flakes with their feet and knead them into small pieces of wax of the desired shape with the help of their strong jaws. Little by little, wax is added by the bees to build the cells and entire combs. Although not being done continuously, comb construction can be done at great speed, if necessary, during times of good nectar flows and expansion of the brood nest.

Bees build worker comb and drone comb. Worker cells are a little smaller than drone cells. The comparative sizes are best presented as: five worker cells per linear 25.4 millimetres of comb and four drone cells per linear 25.4 millimetres of comb. The cells have a slight incline with the opening a little higher than the rear of the cell which is sufficient to prevent the partly processed nectar or honey trickling out.

Worker cells are used primarily to raise worker bees and to store honey and pollen. The cells of drone comb are used for raising drone bees, and also for storage of honey and pollen. In nature, bees prefer to store honey in drone comb, but in modern day beekeeping because of the foundation wax sheet used by beekeepers, bees are compelled to construct mostly worker comb. This is because high numbers of drones are considered unnecessary by beekeepers as they don't forage for nectar or pollen. They are almost a liability in the hive as they always need to be fed. Only a few get to mate with a young queen. However, most healthy colonies have a number of drones and perhaps these are good for the 'morale' of the colony.



Combs built in the space of a machine.

Daniel Martin, DEDJTR



Capped brood cells: bullet-shaped drone cells upper half; smaller convex worker cells lower half.



Capped drone cells near wooden top bar of frame; capped and open worker cells remainder of comb. Some open worker cells contain white worker larvae.

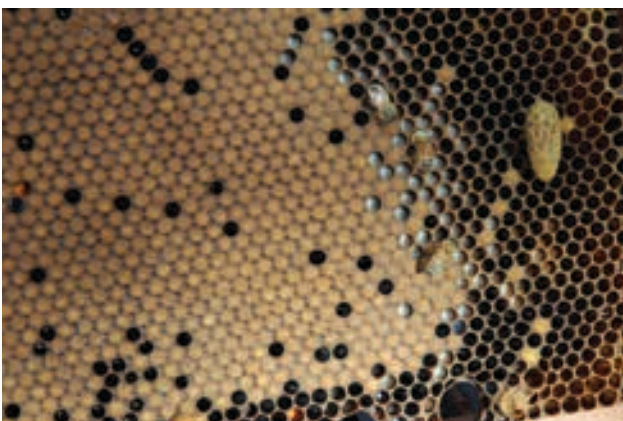
With its own distinctive shape, the queen cell is only constructed when it is necessary for the colony to raise queen bees. This peanut shaped cell is built on the surface or edge of the comb. It is generally gnawed and removed by the bees soon after the new queen has emerged from the cell.

The question is often asked by those unfamiliar with bees, “why do bees gather nectar and pollen?” The answer is simple. Pollen is the bees’ protein food, providing them with vitamins, minerals and lipids (fats and their derivatives). Nectar, and honey which is processed from nectar by the bees, provide is their carbohydrate food.

A beekeeper should aim to provide bees with the best opportunities to prosper and store honey. Honey that is surplus to the bees’ requirements can be then harvested by the beekeeper. However, the greatest benefit of honey bees to humans is the pollination of horticultural and seed crops.



Comb: yellow-grey capped cells contain honey; brown capped cells contain worker pupae; open cells with yellow deposits contain pollen.



A capped (sealed) queen cell; worker larvae in open cells.

Members of the honey bee colony

The queen and workers are females and the drones are males. New beekeepers must make it a priority to quickly learn and identify the differences of the castes. It is important to acknowledge that all members of a bee colony rely on each other and cannot survive individually.

The Queen

There is normally only one queen in a colony. She is basically an egg laying machine and can lay more than 1,500 eggs per day during the peak brood rearing season of spring and summer. She is also the largest member of the colony having a long body and tapered abdomen well designed for backing in to the hexagonal brood cells to lay her eggs. Her abdomen will decrease in size, a little, when the flush of egg-laying is over for the season, and when she ceases to lay over winter. Her tongue is shorter than that of the worker bee and her sting is not barbed.



Queen bee.

Asls Sha'Non

Since the queen mates outside the hive during flight with a number of drones, her female progeny will consist of several sub-families who have different father drones but the same mother queen.

In nature, queens may live up to five or more years. However, at any time, the colony may rear a new queen to replace one that is declining in egg-laying capability. This declining queen will lay in usually four to six queen cells constructed by the worker bees. Approximately 16 days later, the first fully developed queen that emerges from her cell will immediately attack all the other queen cells by opening the side walls of cells and stinging the occupants. Nature determines that if another virgin queen has already emerged, then they will fight until one is killed.

Several days after emergence, the queen will take orientation flights to familiarise herself with local landmarks. She will then mate with 14 to 24 drones during mating flights taken over the next few days. Semen is stored in the queen’s spermatheca where it remains viable. When mating occurs in poor weather, or very early or late in the season when the drone population is low, the queen may not have an adequate store of semen and she will be superseded in a very short time.



Queen bee on brood comb with attendant worker bees.

Most queens in managed hives are generally replaced after two years by the beekeeper because peak egg-laying diminishes after that age. Some beekeepers requeen their colonies annually.

Workers

The worker bee is the most familiar caste to us as she is the bee we see foraging on flowers in our gardens. She has a tapered abdomen and is approximately half the weight of the queen or drone, but she is specifically adapted to her tasks in life. The number of workers in a feral honey bee colony may be around 10,000 individuals, but as high as 60,000, or more, in a productive colony managed by a beekeeper. Workers have a number of roles such as feeding honey bee larvae, building comb, processing nectar, storing pollen, cleaning cells and the hive, removing dead bees, collecting water, foraging for nectar and pollen, and defending the colony. The worker's flight is fast, and usually direct to and from the hive. She is capable of carrying heavy loads of pollen or nectar. The tongue of the worker is long to enable deep penetration of flowers to reach nectar. Her sting is barbed which she uses exceptionally well in defence of the colony.



On this foraging trip, this bee is a nectar gatherer (tongue extended to access the flower nectaries) and a pollen gatherer (dark cream pollen pellet forming on hind leg).

Maree Belcher

Drones

Drones are rectangular in shape, broader and larger than workers and not as long as the queen. The wings are large and almost cover the stumpy abdomen.

There are about 400 drones, and often more, in a colony during the main brood rearing season. They are generally reared from spring to mid-autumn. Although drones don't forage, their presence in the hive is considered to be good for the well-being of the colony. They are not designed by nature to forage and they make no contribution to the colony's food supply. Newly emerged drones are fed by workers for the first few days of their life and older drones feed themselves directly from honey stored in the combs.

The role of the drone is to mate with a virgin queen, but he shows no interest in her inside the hive. Instead, mating occurs outside the hive and on the wing. Drones are powerful fliers and have large eyes with approximately 8,000 lenses that helps them to detect queens taking mating flights. The compound eyes almost meet on the top of the head reducing the size of his face. Very few drones mate with a queen and those that do mate, die immediately after mating. Drones are sexually mature approximately 16 days after emergence and live up to ninety days.

At times of severe food shortage and during late autumn, drone brood and adult drones are ejected from the hive. Drones are not normally seen during winter although sometimes the colony will tolerate some if the colony has become queenless prior to the onset of winter.



Drones are larger than workers bees.

Caste differentiation

The three castes, queen, worker and drone, develop through each of the life-cycle stages of egg, larvae, pupae and adult.

Female honey bee workers and queens develop from fertilized eggs that result from the fusion of a sperm cell with an egg cell. There is no genetic difference between the egg that produces a queen and the egg that produces a worker.

Larvae destined to become queens are fed royal jelly in abundant quantities by nurse bees. The jelly is a mixture of products of the hypopharyngeal and mandibular glands of worker bees. Larvae that are to become workers are fed royal jelly but on day three onwards they are fed only the secretion from the hypopharyngeal glands and then later, more pollen and honey. The food given to worker larvae has less protein, sugars, and vitamins than royal jelly. The amount of food given to workers is less than the quantity fed to queen larvae.

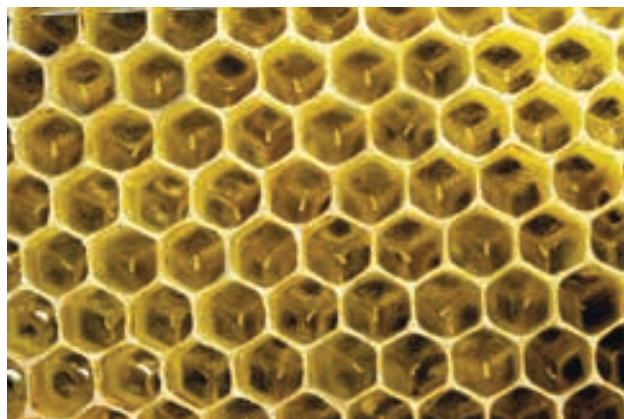
Drones develop from unfertilized eggs and so do not have a father. The queen can control the release of sperm from her spermatheca into the vagina as the egg passes, and this enables her to lay both fertilized and unfertilized eggs. The queen is able to measure the size of the brood cell using her front legs as callipers and determine which cell will receive a fertilised egg. Drone cells receive unfertilized eggs and smaller worker cells receive fertilized eggs. Drones only have 16 chromosomes and are haploid organisms. Female bees have 32 chromosomes, 16 from each parent and are referred to as diploid organisms.

Life-cycle of bee

Development begins with the egg, laid by the queen. The egg hatches into a small larva, which curls into a small 'c' shape at the base of the cell. The coiled larva grows quickly and almost fills the cell.



A recently laid egg in a worker cell.



Eggs in a worker cells.

The cell is then sealed (capped) with a wax cap by workers. The larva then spins a cocoon on the cell walls. After spinning its cocoon, the larva lies longitudinally on its back in the cell with its head near the cell opening. This stage is known as the pre-pupal stage. The pupal stage follows in which the larva develops into the fully formed adult. The ready to emerge bee chews the cap around the perimeter of the cell and pushes the cap outwards to open the cell and climbs out. The cap placed on brood cells is porous to allow movement of air into the cell. The caps on healthy worker cells are slightly convex and those on drone cells are domed or bullet-shaped.

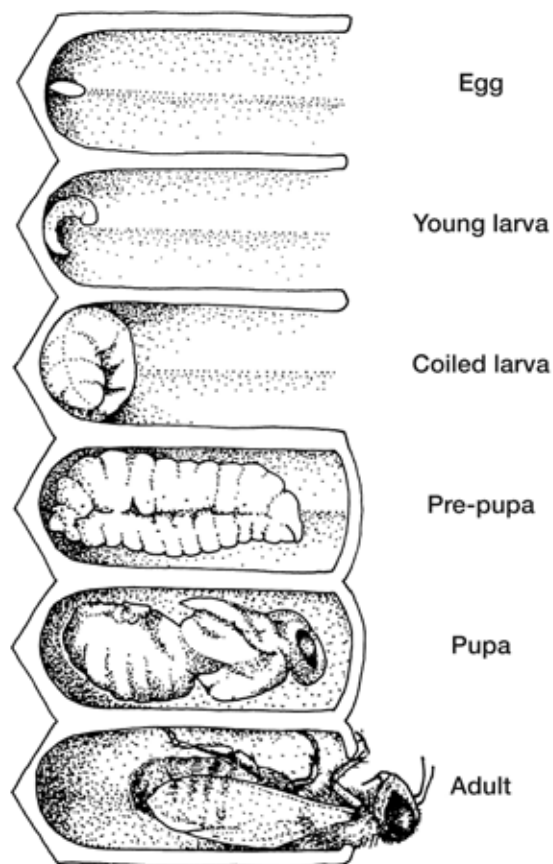


Figure 1. The major stages in honey bee development. Adapted from *The Hive and the Honey Bee*, Dadant and Sons, Inc. Used with permission.



Worker larvae in open cells, pupae in capped cells and honey in open cells (right).



Drones emerging from their cells.

The average period for the stages of development of the honeybee, from egg to adult, is dependent on environmental and genetic factors as well as the caste of the larvae (Table 1).

Workers

Adult workers may live from 15 to 42 days during the busy foraging period of spring, summer and autumn, but can live right through winter. The variation in lifespan is related to pollen consumption and the intensity of brood rearing by workers. During spring and summer, workers are involved in intensive brood rearing and this may cause workers to have low body protein levels and reduced longevity. Brood rearing usually declines and may cease altogether during mid to late autumn and winter. As a result, overwintering workers can have higher levels of body protein and increased longevity. In general, workers are worn out by ceaseless activity, including foraging.

Workers cannot mate, but in queenless colonies, one or more workers may lay unfertilised eggs in worker cells. These eggs only develop into drones and because workers are not being reared the colony will ultimately die. The workers that lay eggs are known as laying workers.



Guard bees at hive entrance.

There is a general order of tasks for workers to do, but this may be altered according to the needs of the colony, and to some degree, the age of the individual. During the first three weeks of its life, an adult worker may clean cells, feed larvae, fan air for hive ventilation and cooling, attend to and feed the queen, cap cells, build comb, pack pollen into cells, receive and process nectar, and carry out guard duties. In the latter two to three weeks of their life, during the food gathering season, workers collect nectar, pollen, water and propolis. Workers are the only caste that forage.

Table 1. Average developmental period of the honey bee worker, queen and drone.

	Average number of days			Total number of days and emergence of adult from cell
	Egg hatch	Larva in uncapped cell	Pupa in capped cell	
Worker	3	5.5	12	21
Queen	3	4.5	7.5	16
Drone	3	6.3	14.5	24

Foragers generally only fly as far as they need to collect nectar, pollen and water. A distance of two to three kilometres is common, but they can comfortably fly five to six kilometres. Sometimes greater distances may be flown, but such long flights require more fuel than the shorter trips and so there comes a point when a long flight is not economical.



Forager resting on almond flower.

Bees use water to cool the hive, maintain humidity, and to dilute honey when brood food is being produced. A strong colony may use over a litre of water to cool the hive on a hot day. Water is carried to the hive in the bee's honey crop, in the same way that nectar is carried. However, water and nectar are never collected together by a bee on the same foraging trip.

Propolis, a gum or resin, collected by worker bees from plants, is primarily used to seal cracks in the hive. It is collected on relatively warm days when it is pliable. It is carried to the hive in the worker's pollen baskets (See *Honey bee anatomy* below).

Worker bee anatomy

The head carries the main sensory and feeding organs, including:

- a pair of antennae used for touch, taste and smell
- three conspicuous simple eyes and two compound eyes
- mandibles (mouthparts) that are used for chewing, as a weapon when fighting, and manipulating wax when building comb
- proboscis for sucking liquids, honey, nectar and water.

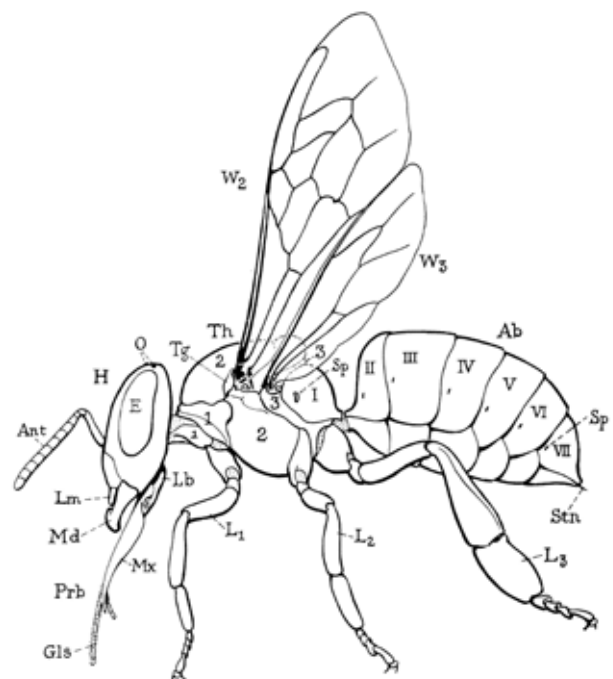


Figure 2. External structure of a worker bee. Courtesy *The Hive and the Honey Bee*, Dadant and Sons, Inc.

Key: AB, abdomen; Ant, antenna; E, Compound eye; H, head; I, propodeum; II–VII, abdominal segments; L₁, L₂, L₃, legs; Md, mandible; Prb, proboscis; Sp, spiracle; Th, thorax; W₂, W₃, wings; 1, prothorax; 2, mesothorax; 3, metathorax.

The head also contains the brood-food glands called hypopharyngeal glands. These secrete royal jelly that is fed to bee larvae and also to the queen. A pair of salivary glands is located in the head and a second pair in the thorax.



Worker bees with proboscis (tongue) fully extended collecting sugar syrup from a household sponge.

The thorax contains the flight muscles and carries the two pairs of wings and three pairs of legs. During flight, the forewings are hooked onto the hind wing by a row of small hooks located on the leading edge of the hind wings. The pollen baskets are situated on the hind pair of legs. The baskets are slightly concave areas on the outside of the legs and are specialised to carry pollen that is combed from body hairs during foraging.



Foragers with pollen baskets full.

The abdomen comprises a number of overlapping external plates that contain much of the alimentary canal and other organs including the sting, wax glands and heart. The plates allow for the expansion and contraction of the abdomen which changes in size according to the volume of material carried in the honey crop and rectum.

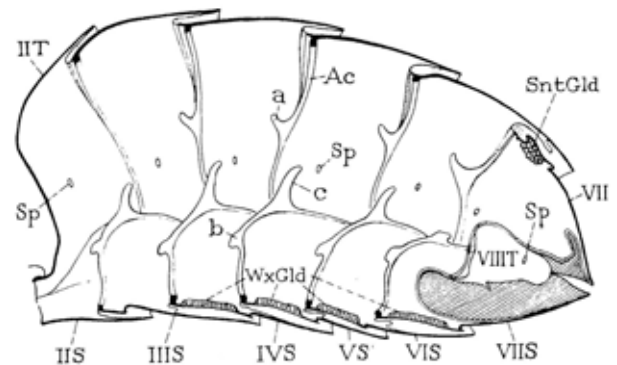


Figure 3. Internal view of right half of abdomen of a worker bee. Courtesy *The Hive and the Honey Bee*, Dadant and Sons, Inc.

Key: *SntGld*, sent gland; *Sp*, spiracle; *WxGld*, wax gland

The alimentary canal starts at the mouth and includes the sucking pump that enables bees to suck up fluids (nectar and water). The oesophagus is a tube that runs through the head and thorax to the honey crop or sac in the abdomen. The crop (also known as honey stomach or false stomach) is used by the bee to temporarily store and carry nectar, water or food during foraging. The true stomach or ventriculus is for digestion and absorption of food. It is lined with finger-like projections termed 'villi' which release cells into the stomach where they breakdown to liberate digestive enzymes. Water is absorbed in the intestine. Food waste is accumulated in the rectum, which can expand to hold a large quantity of faeces that accumulate over period of time when bees are unable to fly and defecate outside the hive.

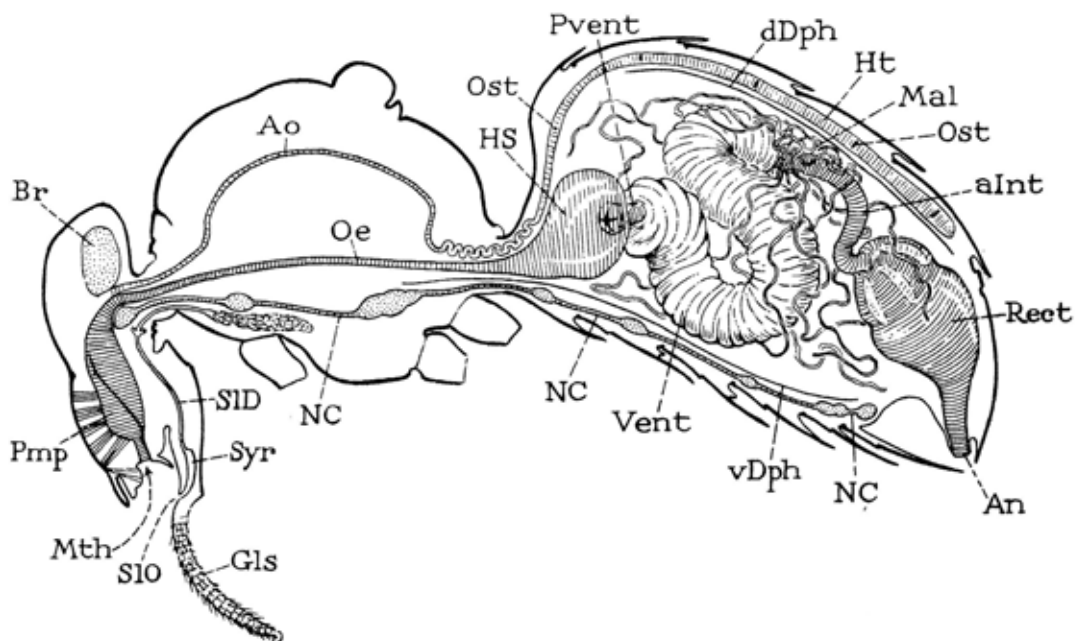


Figure 4. The alimentary canal and other internal organs of a worker bee. Courtesy *The Hive and the Honey Bee*, Dadant and Sons, Inc.

Key: *alnt*, anterior intestine; *an*, anus; *Ao* aorta; *Br* brain; *dDph*, dorsal diaphragm; *Gls*, tongue; *HS*, honey stomach; *Ht*, heart; *Mth*, mouth; *NC*, nerve cord; *Oe*, oesophagus; *Ost*, ostium; *Pmp*, sucking pump; *Pvent*, proventriculus; *Rect*, rectum; *SID*, salivary duct; *SIO*, salivary orifice; *Syr*, salivary syringe; *vDph*, ventral diaphragm; *Vent*, ventriculus.

On their return to the hive, nectar gatherers pass their load of nectar to hive bees for processing into honey. The nectar passes from the honey crop, through the oesophagus and the mouth to the tongue and then to a hive bee.

The process is similar for water gatherers, except that the water may not be required for some time. On very hot days, water may be collected early in the morning and retained by bees in the crop until it is required later in the day. In preparation for extreme temperatures, many foragers may be recruited to become water gatherers.

The respiratory system draws air into the body through small openings known as 'spiracles' in the thorax and abdomen, to air sacs and then to small tubes 'tracheae' that distribute air to all parts of the body. Air is drawn in and forced out of the respiratory system by expansion and contraction of the abdomen.

The blood, or haemolymph, fills empty cavities throughout the bee's body. Its main purpose is to distribute digested food that has passed through the wall of the alimentary tract and to transport waste products to the excretory organs. The heart is a slender tube that forces blood from the abdomen through the aorta and finally to the head. The blood bathes various organs as it flows back to the abdomen. There are no other blood vessels.

The sting is contained within the sting chamber located at the end of the abdomen (See chapter 3. *Handling bees and safety* for more information on stings).

Pheromones

Chemical messages, or pheromones, play a key role in honey bee communication. Pheromones in minute amounts are secreted by bees through a number of glands. They are spread throughout the colony by air or as a liquid transferred from one bee to another via food, grooming, contact of the antennae and on hive surfaces.

The queen produces pheromones from the tarsal, tergite and mandibular glands, which are transferred to the workers during the grooming and feeding of the queen. The queen's tarsal or footprint pheromone is deposited on comb surfaces on which she walks. Queen pheromones inhibit worker ovary development and queen rearing.



Bees at hive entrance showing Nasonov gland.

The worker Nasonov gland secretes a pheromone which attracts other colony members. This can be seen by beekeepers when the worker exposes the gland as it raises its abdomen and fans its wings. The pheromone guides other bees of the colony towards them, for example, at the hive entrance or when swarming.

Workers also use alarm pheromones to recruit other workers to the defence of the colony. One of these pheromones is produced by the worker mandibular gland, and the second is released when a worker exposes its sting and releases a small amount of venom. This latter instance can be a warning sign that the bees are not happy.

Seasonal size of colonies

There is a normal cycle of variation in the population of adult bees and brood rearing according to the change in seasons. In general, the onset of late autumn and winter brings cold weather and in many districts few if any sources of nectar and pollen are available and there is little opportunity for foraging. At this time of the year, brood production in hives is low, or it may have ceased. The healthy, adult bee population remains stable or declines slightly.

When warmer weather arrives in late winter and early spring, workers who have lived through the winter begin to die. When brood production at this time doesn't make up for this loss of overwintering adults, the size of the colony declines. This natural phenomenon is known as 'spring dwindle'. The number of workers in a well-managed colony then increases to reach a peak. Given favourable foraging conditions such as the availability of pollen and nectar and good weather, this peak number of bees will be maintained through the remainder of spring, summer and much of autumn. When these conditions are present, the beekeeper can look forward to a crop of honey.



A comb of honey showing cells full of honey capped with new white wax. The open cells will be capped by the bees when they are filled with honey. A few open cells, near the bottom bar of the frame contain orange pollen.

2. The hive and its components

Careful assembly and regular maintenance of hive components will ensure that hives give good service over a long period. Failure to do this will mean that the considerable financial investment made by a beekeeper could be wasted.

The hive

In nature, bee colonies occupy and build their combs in tree hollows and similar cavities. The beeswax combs are usually attached to the upper surface and sides of the cavity. Similarly, when a colony occupies an empty bee hive that doesn't have frames, the combs are attached to the upper surface, walls and sometimes adjacent combs. The combs cannot be removed without first cutting them free. These hives are known as 'box hives'.

Box hives, whether they are boxes, drums, hollow logs or similar cavities, are illegal under various state and territory legislation. This is because the combs cannot be removed for inspection for brood disease. The combs break or are squashed as the beekeeper attempts to lift them.

In movable frame hives, combs fit snugly in frames that hang side by side. The frames are made so that when the end bars of adjacent frames touch each other a 'bee space' of 8–10 mm is formed. Bees do not normally build comb, including brace comb, in the bee space. As a result, frames can be handled and lifted out of the hive without damaging the comb surface and injuring bees. Hive boxes are manufactured to a size that forms a bee space between the top of the frames in a box and the bottom of frames in a box immediately above.



A plastic frame with comb.

Boxes

The hive box, or body, rests on a floor known as the bottom board. Depending on the beekeeper's method of management, the bottom board may or may not be fixed to the hive body. A lid, also called a cover, sits on top of the hive. These components together make up a 'single' hive.

In a favourable season, with nectar coming in, or with large scale brood rearing taking place, space in the hive may become limited. To give more space, another hive box containing frames with beeswax foundation or drawn comb is added to make the hive a 'double' or a 'double decker'. At this point, the box on the bottom board is called the 'bottom box' and other boxes above it are known as

'supers'. The bottom box may also be known as a brood box, but brood in some hives may not always be confined to this box.

Hives may be built up to any manageable height whenever the bees require more room. Most beekeepers have no more than three boxes for each hive. Above that height, management and manipulation of the combs becomes difficult. Extracting surplus honey and returning empty combs to the hive, will give honey storage capacity without the need for extra supers and combs (See chapter 8. *Extracting honey*).

The hive box commonly used in Australia is the full-depth 'Langstroth' box. Shallower boxes such as 'WSP', 'Ideal', 'Half Depth' and 'Manley' are less common, but are used by beekeepers when lifting excessive weight is a consideration. Some beekeepers use a full depth bottom box for brood and shallower boxes for storage of the honey crop. However, this means that the frames and combs are not inter-changeable. Half depth and ideals are suitable holders for honey comb sections.



Left: Nucleus hive with spring clip fastener. Right: 8-frame 'single' hive showing Emlock fastener and strap, entrance closure (note arrow) and migratory cover with ventilation grids.

Langstroth boxes are available in two sizes, eight or ten frame. Ten frame supers full of honey are heavier than eight frame supers, but they can hold more combs of honey for overwintering colonies. Eight frame hives are common in Victoria, but are less common in New South Wales and Queensland.

All hives in the apiary should be of standard size whichever type is adopted. Think carefully before buying different sized hives. Maintaining one size, either eight or ten frame will make packing, loading, comb manipulation and other routine apiary operations much easier.

Sometimes a shallow super will do where a hive may be too congested but does not need the addition of a full depth super. Against this, nearly twice the number of frames will need to be handled during honey extracting, hive inspection and other operations, as compared with full depth combs.

Supers, either rebated or 'lock corner' (sometimes referred to as dove-tailed) type, may be purchased from beekeeping equipment suppliers in ready to be assembled form, or already assembled. Supers should be glued using water-proof/weatherproof glue and nailed together using eleven 65 mm x 2.8 mm nails at the corners of the box. Alternatively, use Tek screws. Ensure that all hand holds are on the external sides and ends of the box before nailing the box. When nailing, check from time to time that the box is square. Holes may be pre-drilled to prevent splitting of the timber, especially the outside lugs of lock-corner boxes. Punch all nail heads below the surface of the timber. Round the corners of the box, using an emery disc or rasp, to enable paint to better adhere to the corners.

When assembled, boxes may need to be planed flat to prevent wobbling when placed on another box, and to ensure there is no space between the boxes for bees to escape.

Plastic boxes made with long lasting plastic are available in ready to use assembled form, or, in the flat requiring assembly using screws.



A modern plastic hive box with bottom board and cover. The cover has been moved to one side to show frames.

Bottom boards

The floor of the hive, or bottom board, is raised off the ground by two hardwood or treated pine cleats, about 50 mm x 50 mm, which are fixed on the underside at each end of the bottom board. The cleats are important, as they keep the floor of the hive clear of the ground, and also assist with ventilation under the hive. As the cleats are in contact with the ground, it is important that they are well painted before being securely attached to the bottom board.

Bottom boards are made from tempered hardboard, solid pine timber or metal. Three strips of timber, known as 'risers' are fixed on the upper surface of the board at one end and at each side. The lack of a riser at the other end provides the hive entrance, known as a full width entrance.

Some beekeepers use a fourth riser that has a cut-out to provide an entrance of a lesser width. The risers provide the 'bee space' between the floor and the bottom of the frames of the bottom box. On a standard board, the rises are 10 mm high and 19–20 mm wide.

Risers of 44 mm high are used for deep bottom boards. Deep boards provide more space between the floor and the bottom of the frames of the box above. They are preferred by some beekeepers as bees can hang in the deep space when the hive is being moved to another apiary site. Deep bottom boards also encourage bees to fully draw out combs near the bottoms bars of frames in the bottom box, which is not always the case using the standard depth. A removable grate of wooden slats neatly fitted in the bottom below the frames will overcome the problem of bees building excessive burr comb in the deep space below the frames.

A bottom board of the same length as the hive has no platform for returning foragers to land on. The bees land on the front of the hive and walk to the entrance. Bottom boards that are 13–30 mm longer than the hive box provide a platform for bees to land. This longer board also supports the entrance closer. It also assists in keeping grass from the entrance and allows air flow between hives when they are being moved.

The bottom board should be well painted to protect it from weather outside the hive and condensation inside the hive.

Some beekeepers nail the bottom board to the bottom box and the result is known as a 'fixed' bottom board. This arrangement is useful when hives are moved because the bottom board cannot skew from the bottom box. Loose bottom boards, more commonly used by commercial and semi commercial beekeepers, are those not nailed to a box. They permit the interchange of boxes of combs on the hive.

Screened bottom boards are used by a few beekeepers. The insect-proof mesh provides greater air flow into the hive. The Rural Industries Research and Development Corporation's report *Screened bottom boards* provides information on this subject (See *Online publications* in chapter 20. *Additional information*).



Left: Deep bottom board with removable grate. Right: standard bottom board.

Hive covers

The migratory cover (or lid) sits on the top box of the hive. The durability of a hive and the health of the colony largely depend on the effectiveness of the cover to provide protection from the weather, especially moisture. A poorly fitting cover may allow robbing bees, mice, ants, insects and beetles to enter the hive.

The inner part of the migratory cover is usually made from weather-proofed hardboard cut to the external dimensions of the hive. The hardboard, with the smooth side down, is nailed to a wooden rim, also of the same dimensions. The rim has four risers, 19–20 mm wide and 44 mm high. After rounding the corners of the rim with an emery disc or rasp, the entire rim, the edges of the hardboard and the underside of the hardboard are painted. The metal cover is then placed over the hardboard (rough side up) and is nailed to the sides of the rim using 15 mm clouts or flat head nails. Apply weather-proof silicon or solder to the joins of the folded metal at the corners of the cover to prevent entry of moisture. The folded metal protects the hardboard and the upper part of the rim from the weather. Good heat reflection is obtained if the cover is painted a light colour. Silver paint is not as cool as gloss white.

Migratory covers allow space for bees to cluster when hives are being transported and they aid air circulation inside the hive during hot weather. A flat cover without a rim, does not provide this space.

Beekeepers are divided on whether or not hive covers should be ventilated. If covers are ventilated, two ventilation holes are pre-cut in each end of the rim by the manufacturer. Mesh or plastic ventilation grids supplied with the cover are used to prevent bees leaving the hive through the ventilation holes. It is the bee colony that ultimately decides if the cover is to be ventilated or not, because bees sometimes seal the ventilation grids with propolis or wax.

Hive mat

The mat is placed only on top of the frames in the top box of the hive. It helps to conserve heat generated from the bee cluster, especially in winter, and prevents condensation from the cover dripping onto the bees. In most cases, the mat discourages bees building burr comb in the space of the migratory cover. Without a mat in place, bees on a heavy honey flow and with little room to store honey will fill the space with burr comb. It is a matter of choice whether a hive mat is used or not. For all the reasons above, a mat is good management for some, while others consider a cover filled with burr comb honey excellent stores for the hive.



Hive mats conserve heat and help prevent excessive burr comb in the space under the cover.



The early stage of burr comb construction on the top bars of the top super.



Drone pupae in cells built above the top bars of frames. This can indicate that the expanding bee colony needs additional room.

Hive mats may be made from any durable material such as floor vinyl, plastic and plywood. Avoid carpet, hessian and similar material that bees can shred and get rid of through the hive entrance. For mats to be worthwhile, cut them about 16 mm less each way than the inner dimensions of the hive. This gap allows the bees to circulate air freely in the hive.

Protecting hive components

Timber hive components are usually made with pine and are subject to decay, particularly at the joints, if not protected from moisture. It is not necessary to protect frames as they are not exposed to the weather. If apiary registration numbers are to be fire branded on boxes, covers and bottoms, do this before applying any preservative or paint to hive material.

Apply a good coat of primer or undercoat when hive components are first assembled. Alternatively, prime or coat the joints with waterproof glue, and then assemble and nail components while still tacky. Apply the primer or undercoat on the inside and outside surfaces and well into the timber. Pay particular attention to the frame rest areas inside the box where condensation can accumulate. Follow up with two coats of finishing paint.

Acrylic paints are commonly used on hives, but oil based paints may also be used. Buy quality paint that will last for many years. Light coloured paint, such as white, will reflect light and help to keep the hive cool. Some pastel colours, for example light green, will help the hive to blend in with the environment and this camouflage may prevent theft.

Painted surfaces need regular maintenance. This is especially true on hive corners where use of the hive tool to prise supers apart may damage the corner of the box. Damage may also occur when adjacent hives rub together when being transported. Unless these areas are maintained, moisture will enter the timber and cause decay. Cracked paint surfaces allow moisture to penetrate the timber, where it is largely trapped under the layer of paint resulting in decay. Remove peeling paint and sand the area smooth before repainting.

Beekeepers can purchase hot wax dipped wooden hive components. The wax treatment helps to make the components water repellent. There are a few outlets that offer a wax dipping service. Ideally, painting the dipped material while still hot can provide further protection and it will help to keep the hive cool in hot weather if a light coloured paint is used.

Branding hive components

Beekeepers are given a number, or brand, when they register as a beekeeper with their state or territory Department of Primary Industries (or equivalent). The primary purpose of the brand is to enable apiary inspectors to identify hive ownership. The brand must be placed on each hive. Beekeepers should check with their Department to find out the size of the letters/numbers required and where the brand should be located on the outside of the hive.

The brand may be painted or stencilled on the hive, but a thief can easily hide it with a quick coat of paint. A fire brand, burnt into the wood is almost permanent. It is not easily removed and this can help deter theft. The branding iron, made at home in the workshop, or ordered from a beekeeping equipment supplier, can be kept hot with a blow torch or in a fire bucket of hot coals. While it is not

a legal requirement, it is a good idea to fire brand all hive components, including the top bars of wooden and even plastic frames. This helps to deter theft. Fire brand the items before painting them.



Newly assembled frames branded to help deter theft.

When second-hand hives are purchased, the new owner must brand them with his/her own registered number. Beekeepers should check with their Department of Primary Industries apiary officers to determine the requirements concerning cancelling the previous owner's brand that is on the hive.

Entrance closures

One day it may be necessary to shift your hives and an entrance closure will be required to lock the bees inside as they often don't take kindly to being picked up and shifted around. Investigate the many types of closures available to see which type is best for your hives. Whatever type is chosen, it must be bee proof and easily worked to ensure bees cannot leak from the hive when being moved. Strips of foam rubber or folded insect screen pushed firmly into the entrance may be used for the odd move, but they are considered a poor alternative when hives are frequently moved.

Frames

During its long working life, a frame can be subjected to all sorts of treatment, so care should be taken with its assembly. Frame joints can be strengthened with quick setting woodworking glue applied to the joints before nailing or stapling.



The frame comprises top bar with groove (top), bottom bar (third from top) and two end bars.

When assembling a wooden frame, the top bar is placed on the work bench with the groove for foundation upwards. The end bars are pushed onto the frame lugs of the bottom bar after the glue has been applied. Glue is then applied to the upper cut out portions of the end bars and the bottom bar is inserted into the two end bars.

Nail the bottom bar using one 25 mm x 1.4 mm galvanised nail. If glue is not used, use two nails. The frame is then turned so that the top bar is uppermost. Nail the top bar to the end bars with two 30 mm x 1.4 mm galvanised nails at each end. Check that the nailed frame is square and not twisted. Place it in a super to allow the glue to set. The use of a staple gun and glue to fix frames is gaining popularity especially when larger numbers of frames are to be assembled.

The weakest parts of the frame are the lugs found at each end of the top bar. A full depth comb contains about 2.2 kg to 2.75 kg of honey when full. This weight is carried by the lugs that sit in the frame rest area (or rabbeted area) at the ends of the box. Lugs can break if the frame is handled roughly, especially if it is dropped or bumped on the ground to dislodge bees from the comb. Lugs can be weakened if more than two nails are used at each end to fix the top bar to the end bar.

The end bars of full depth frames have four evenly spaced holes through which frame wire is threaded. When nailing the frames, avoid driving the nails so they fill these holes.



Nail the bottom bar first using one nail.



Nail the top bar next using two nails.



Assembling the frame.



The assembled frame. After checking to ensure it is square, place it in a box until the glue has set.



Glue all frame joints before nailing.



Staples are an alternative to nails.

Wiring frames

The frame holds the sheet of foundation beeswax on which bees build their cells. The foundation is fixed to four horizontal strands of wire that keeps the foundation perfectly straight and vertical. The wires also help to strengthen the newly constructed comb. Combs well supported by wire seldom break in the extractor or during transport. Suitable galvanised and stainless steel frame wire is available from beekeeping equipment suppliers. Pre-wired frames are also available from some outlets.

Frames have end bars already drilled for the wires. Methods commonly used to prevent the wire cutting into the grain of the wood when tightened and so losing tension are:

- placement of an eyelet in each wire hole
- counter sink holes with a centre punch to harden the wood
- placement of a staple on the tension side of each hole.



Three methods to prevent wire cutting into the grain of the wood. Note the small staple driven through the end bar into the top bar as indicated by the red circles. This will prevent detachment of the top bar when the frame is prised out of the box using the hive tool.

To wire a frame correctly, a home-made frame wiring board, or one available from a bee equipment supplier, will make the task of wiring frames relatively easy and the end result will be tight wires.

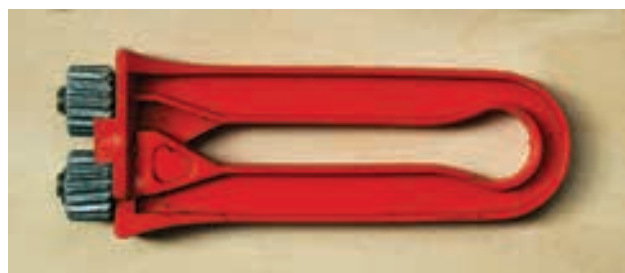


Homemade wiring board with wired frame. Note the position of the two gimp tacks on the left end bar indicated by the arrows.

After the glue has set, place the assembled frame in the wiring board. A small nail or 10 mm gimp tack is *partly* driven into the edge of one end bar, near the first and fourth hole. The wiring board has a clamp and this is used to slightly push

the centre of one end bar towards the centre of the frame. The frame wire, in one continuous strand, is threaded through the holes of both end bars in turn. The wire is then wound around the gimp tack four to five times. The tack is then hammered well into the wood so it is flush with the surface. Twist the small length of excess wire at the nail to break it off cleanly. Cutting the wire will leave a little stub that can prick the fingers when the frame is next handled.

Each span of wire is pulled tight in turn with the fingers, or by using a pair of long-nosed pliers. Any slack is wound onto the spool of the wiring board. The last span of wire, while still being held tight is wound around the second tack. This tack is hammered flush and the wire twisted off as described above. The clamp is released to further tension the wires. It is important to have the wires as tight as possible so that the comb is well supported. Any slack wires can be tightened using a hand-held wire crimper, available from beekeeping equipment suppliers.



A crimper for tightening frame wire.

The comb can be given more strength. A vertical wire in the centre of the frame looped around the horizontal wires at the intersections and fastened to the top and bottom bars will prevent sagging of the comb. To fit the vertical wire, drive a fine nail through the centre of the top bar and bend it over to form a hook. Drive another nail and form a hook, this time upwards through the bottom bar.

Ensure that the heads of both nails are pulled into the wood to prevent damage to the uncapping knife when burr comb is being scraped off. The nail turned back into the wood cannot work out and project, even if the wire breaks. Fasten the wire to the top hook and turn it around each horizontal wire, keeping it taut. Pass the end through the bottom bar hook, pull it up tight and fasten it off as close as possible.

Instead of a vertical wire, some beekeepers use a vertical centre wood post to give added strength to the frame. The post is glued to the frame top and bottom bar.



A well-fitted centre post glued between the top and bottom bars will give the frame added strength.

Comb foundation

Comb foundation is a thin sheet of beeswax impressed on both sides with the pattern of worker cells that make up the comb. Bees construct the cells using this pattern. The foundation is suspended from the top bar of the frame and is firmly supported by the horizontal frame wires which are embedded in each sheet by the beekeeper. When the comb is fully constructed it is known as 'drawn comb'.

Perfectly straight combs will result if foundation is properly fitted in the frame and drawn out by bees under favourable conditions including access to nectar and pollen. Bees are mostly reluctant to draw comb foundation and will gnaw holes in it when nectar and pollen are scarce. They generally don't secrete wax during the cold months of winter, but there are some exceptions when they work certain nectar flows in warm districts. Weak colonies are not able to draw as much foundation as strong colonies can.

Foundation should not be fixed in frames too early before the expected time of placement in the hive because it may warp. This in turn results in a warped comb that is difficult to remove from the hive.

Nature has determined that drones are needed and with a good sheet of foundation wax the only place the bees are able to build drone comb is in small spaces. Such spaces occur between the foundation and the end and bottom bars of the frame, or where the comb has been damaged. Although drones are part of a healthy colony in spring, summer and autumn most beekeepers believe that large numbers of them do not add to the productivity of the bee colony.

Embedding wire

The only satisfactory method of embedding the horizontal wires into the foundation wax sheet is with an electric embedder and its electric transformer, available from a bee equipment supplier. The embedder consists of a wooden holder with four or more studs with flattened ends for pressing onto the wire. The two end studs are terminals through which the low-voltage current runs.



Electric embedder and 6-volt power source.

To embed the wires it is necessary to have an embedding board made from 20 mm thick board, cut slightly smaller than the inner dimensions of the frame. Dampen the surface of the board with water to prevent the foundation sticking to

it. Position the foundation in the groove in the frame top bar. Then place the sheet of foundation, still in the groove, with wires uppermost over the embedding board on the bench. In this position, the frame is supported by the wires with the end bars clear of the 20 mm board.

Apply gentle pressure by placing all the studs of the embedder on each strand of wire in turn. Press the switch at the end of the embedder to allow the low voltage current to run through the strand of wire nearest the top bar of the frame first. Stop the current as soon as molten wax is seen around the wire, but only remove the embedder after the wax has solidified around the wire. A little practice is needed because the wire becomes hot and easily sinks right through the foundation sheet cutting it into strips. Continue with the other wires in turn.



Electric embedder in use. Place all five studs of the embedder on the wire and carefully apply gentle pressure. Too much force may cause each heated wire to cut through the sheet of foundation.

The cost of foundation justifies the patience and time needed to embed foundation properly. The result will be a firm flat sheet on which the bees will construct a good even comb.



Spur wheel embedder.

A spur wheel embedder may be used if only a few foundation sheets are to be prepared, but it is not as good as the electric embedder. Heat the embedder by immersing the wheel in boiling water. 'Wheel' it quickly along the wire. Don't have it too hot, or press too hard, as it may cause holes in the wax.



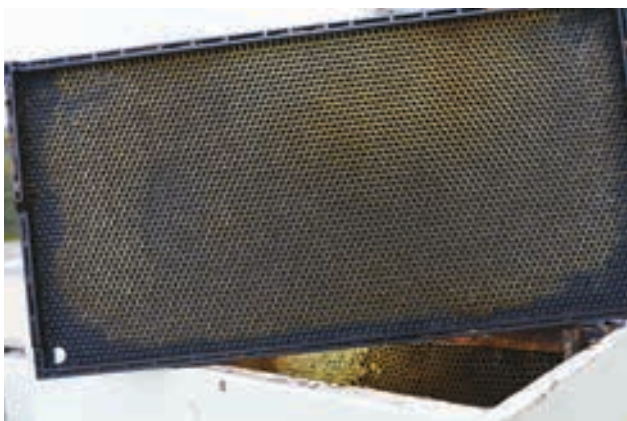
Frame with wire embedded in the sheet of foundation.

Plastic frames and foundation

Moulded plastic frames with fixed plastic foundation do not require wiring. This also applies to plastic foundation sheets inserted into wooden frames with grooved top and bottom bars. In both cases, molten beeswax is painted or rolled on both sides of the plastic foundation to encourage acceptance by bees. Make sure the plastic foundation sheets are well rolled with beeswax, otherwise the bees will be very unwilling to accept them, unless they are on a very good nectar flow. Some beekeepers prefer to place the wax coated plastic foundation in the super rather than the brood nest. The building of comb appears to be better in the super compared to the brood nest. Beginner beekeepers starting with their first hive do not have this choice.



Rolling beeswax on the plastic foundation.



Partly drawn comb on plastic foundation.

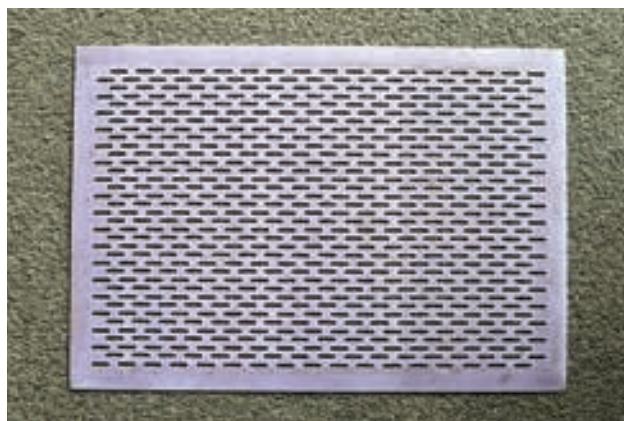
An advantage of plastic foundation is that if the constructed comb deteriorates with age or is physically damaged, including damage by wax moth larvae, it can be scraped clean, re-rolled with beeswax and returned to the hive.

Queen excluder

The queen excluder is a barrier used to confine the queen (and drones) to the brood box. Worker bees are able to pass through the excluder to enter the honey supers. Confinement of the queen below the excluder means that there will be no brood in the honey section of the hive. As a result, full combs of honey without brood can be taken from the hive for extracting.

The most commonly used excluders are the metal bound welded wire grid, perforated metal sheet and perforated plastic sheet. The bound wire excluder provides less obstruction to ventilation and is considered to do less damage to bees as they pass through the grid when compared to the plastic version. However, plastic excluders are light, cheap, easy to clean and are readily accepted by the bees.

The use of queen excluders is now well established in the management of bees. Beekeepers need to be aware that it is very necessary to remove the excluder and inspect brood for signs of disease.



Queen excluders (from top) bound welded wire excluder, perforated metal sheet and perforated plastic sheet.

Hive fastener

When a hive is to be moved, steps should be taken to ensure the various hive components are not able to separate from the hive during transit. It is best to use the one type of fastener on all hives to allow interchange of material during normal hive management.

The most common fastener used today is the 'Emlock' fastener used in combination with galvanised or stainless steel strap. The Emlock normally sits on the hive cover. The strap is cut to a length to allow it to be fastened to the Emlock and wrap around the bottom board between the cleats, at least three hive boxes, queen excluder and cover. The lever on the Emlock is used to tighten the strap. If an item is removed from the hive, any surplus strap is wound around the Emlock thereby allowing the fastener to do its task on a shorter hive. Plastic straps with ratchets are similar to the Emlock and are available from beekeeping equipment suppliers.

Another fastener, the Reade wire and stud type is placed at each joint of a loose bottom board, each super and the cover at each end of the hive. There is little or no flexibility to accommodate the extra thickness of a wooden framed welded wire queen excluder, division board or escape board.

3. Handling bees and beekeeping safety

Bee stings

All beekeepers will get stung at some stage despite wearing the best personal protective equipment available. There are no exceptions.

The following information about the effects of stings was supplied by the Australasian Society of Clinical Immunology and Allergy. *“Most people are not allergic to stings. The normal reaction is for some local pain for about ten minutes and some local swelling for a day or two. Occasionally the person stung may be sensitive to stings. Extensive swelling or redness may occur over a localised area; a generalised rash may also develop. In extreme cases, breathing may become difficult and the person may become very weak. This is an emergency and urgent medical treatment is required. Even if the reaction is self-limited, people should seek medical advice regarding future stings.”*

Most beekeepers have found that the first few stings will cause a ‘local reaction’ of swelling and discomfort. Usually, this reaction becomes less as more stings are received over time. Eventually, the stings cause little or no local reaction apart from pain. However, this is not true for everyone. For some people, the reaction increases as more stings are received. These people should not keep bees without medical advice.

When beginning in beekeeping, it is important to have another person present to watch for any indication of an adverse reaction to stings. The person should be able to get medical help for you if it is needed. Joining a beekeeping club where beginners are able to open hives and handle bees under guidance of an experienced beekeeper is recommended. Attendance at beekeeping field days and short courses is also a good idea.

The sting of the bee is located at the tip of the abdomen. When the bee stings, the abdomen is bent and thrust downwards and the shaft of the sting enters the victim. The barbs on the shaft prevent the bee from withdrawing the sting. After a brief struggle it tears itself free of the sting mechanism and flies away.



After successfully inserting its sting this bee has not yet broken free.

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Muscles in the detached sting continue to drive the sting deeper into the skin and at the same time more venom is pumped from the poison sac into the victim. Remove the sting as quickly as possible. A delay in removing the sting will increase the amount of venom injected.

Research reported in the medical journal, *The Lancet*, in 1996, pointed out that the method used to remove the sting did not seem to affect the quantity of venom received. It was more important to get the sting out as quickly as possible in order to minimise the amount of venom. It was previously believed that squeezing the poison sac would cause most, if not all, of the poison to be received by the victim.

A sting may be removed by scraping it out using a finger nail or by rubbing it off on one’s clothing.

The best approach is to avoid stings. There are indications that some beekeepers with long term excessive stinging may have become dangerously allergic to bee venom.

Personal protective equipment

Effective bee-proof personal protective equipment helps beekeepers, especially beginners, to have confidence when approaching and opening hives. Bees always, sooner or later, find holes in veils and clothing, so it is good idea to repair these before visiting the apiary. Regardless of what others say or think, there is absolutely no need to project the image of being a hero by being stung.

Wear clean, light coloured and smooth clothing. Bees dislike dark and woolly clothing including felt hats, woolly socks and some types of leather gloves that have a rough surface. Bees can panic and are likely to sting when they are caught in hair and fibres of clothing.

Bees dislike a number of odours. Avoid contamination on yourself or your clothing by oil, diesel fuel, dog and horse odours and build-up of excessive perspiration. Don’t use hair spray.

The bee veil protects the face, head and neck. It sits on a sun helmet, or smooth broad brim hat, and is held in place by a band of elastic. It is made of dark mesh because this coloured mesh is easy to see through.



Tapered square folding wire veil, ventilated sun helmet and vinyl gloves with attached gauntlets.

The tapered square folding wire veil is rigid and provides good separation between the face and the wire mesh and is very popular with beekeepers. When buying this veil, ask the seller to demonstrate the correct way of tying the cord. It is important to tie this veil correctly so that it is totally bee-proof.

The black net veil is held in place on the helmet by elastic. The lower portion of the veil is tucked under the coveralls, or shirt, around the beekeeper's upper chest and back. This flexible veil can pull out of the clothing providing an opportunity for bees to find their way inside the veil. Strong winds may cause the veil to touch the face or neck, providing bees an opportunity to sting through it. Beginner beekeepers will have more confidence in handling bees when protected by a folding wire veil or bee suit that has a built-in veil.



Soft black net veil and hat.

If a bee gets inside the veil, keep calm and don't panic. Never take the veil off in the apiary or close to hives. Often, if a bee gets in the veil it is because it isn't happy and there may be other numerous bees also trying to get in. Even when walking well away from the hive or group of hives, bees may still follow you and taking off the veil will mean trouble. If there aren't too many bees following, aim a few puffs of smoke around the face and head and then get into your vehicle with the veil still on. Drive some distance away allowing any bees in the vehicle to fly out through open windows. When all followers have gone, take off the bee veil.

An alternative faster and more efficient way of dealing with a bee in the veil is to simply squash it before it has a chance to sting you. Do this without hesitation, because if it is done slowly the bee may have time to sting your hand or fingers.

Bee gloves with attached arm gauntlets protect the hands and prevent bees from crawling up the arm inside the sleeve. A bee that crawls inside the sleeve may sting if squashed by the movement of the fabric. Vinyl gloves and leather gloves are available at beekeeping equipment suppliers. Leather gloves with a rough surface may annoy bees and are not as easily cleaned as the smooth vinyl version.

Bee suits, with zip-up front and zip-on hood incorporating a veil, are available from beekeeping equipment suppliers. They are ideal for beginners. A half suit version, with veil, is also available.

Standard white or khaki drill coveralls can be modified by inserting elastic in the leg cuffs so they fit snugly around the ankles. Insert elastic in the wrist cuffs of coveralls to prevent bees crawling up the arms when working without gloves and gauntlets. A full-length zip fastener may be inserted at the front, or alternatively, place two extra press studs between the existing press-studs to close the spaces. The side pocket access openings may also be closed.

Attach strong elastic stirrups to the cuffs to pass under the boot instep. These hold the cuffs down to prevent them riding up over the tops of the boots. Stings in the lower legs or ankles are painful and the effects are long-lasting. Elastic-sided riding boots are ideal.



The beekeeper is well protected by veil, hat, coveralls and vinyl gloves with gauntlets. Note the elastic stirrups used to hold the leg cuffs down and protect the ankles.



Gaiters give additional protection around the ankles.



When conditions are ideal, experienced beekeepers can manage docile colonies with little protective clothing. Note that the veil remains on the hat just in case the beekeeper's face requires protection. Good weather, good nectar flow, adequate use of the smoker and steady handling of frames is required.

As experience and confidence in handling bees grows, the beekeeper can try working bees without gloves and with sleeves rolled up. It is important to choose a hive with docile bees. Also choose a time when bees are foraging happily such as late morning on a balmy spring day. Avoid times when the temperature is cooling in the afternoon and when taking off honey at the end of the nectar flow later in the season. Remember to take off any wrist watch because any accumulated perspiration under the band is objectionable to bees and may cause them to sting.

Equipment

Another necessary item is a hive tool for prising apart and lifting the frames out of the box. Various types of hive tools are available. The hook end pattern hive tool is widely used and is well designed for prising supers and frames apart. Some beekeepers prefer the 'American' hive tool. A screwdriver can be used as a temporary substitute but the specially designed hive tool is more efficient.



Smoker (100 mm barrel) and some hive tools. Hook end pattern hive tool (front), American style hive tool (centre) and substitute tool when the hive tool cannot be found.

The smoker and safe operation

Effect of smoke on bees

The smoker is a necessary item for all beekeepers. Without smoke, bees are ready to defend themselves. They are difficult to manage and often become a danger to close neighbours and passers-by. Smoke is the only language that bees understand. Regardless of what some beekeepers say, it is not possible to responsibly work bees without smoke.

Smoke causes bees to gorge honey. The guard bees stop guarding the hive entrance and move to the combs to gorge honey. Bees are much easier to handle after they have filled their honey crops.

The amount of smoke needed to subdue bees varies according to the colony's temperament, weather conditions, availability of nectar and pollen, and most importantly the beekeeper's ability to handle bees gently. Hives in shade will generally require more smoke than those in sunlight.

Too much smoke will unduly distress or excite the bees. Too little smoke will mean the beekeeper has little control over the bees and this may lead to reduced confidence for the beginner. A good smoker capable of delivering a large volume of cool smoke instantly when needed is always a beekeeper's best friend.

The smoker

The smoker consists of a barrel (or cylindrical firebox) that holds the burning fuel that creates smoke. A grate keeps the fuel off the base of the smoker. When squeezed, the bellows direct air through a hole into the barrel at its base. The air fans the fire and drives smoke through the nozzle in the lid of the smoker.

Smokers with double vents in the bellows are preferred because they prevent hot ash from being sucked out of the firebox. With the single vented smoker, hot ash may be sucked out, possibly causing a fire risk.

Always choose a smoker with a 100 mm diameter barrel and off-set nozzle. Resist the temptation to purchase a cheaper smoker with a smaller diameter barrel because you have only a few hives. These smaller versions may not deliver the volume of smoke required at the time you need it. Keep the nozzle and barrel clear of tar and rubbish. Some build-up of tar between the barrel and the lid helps to seal the gap thereby ensuring that smoke only exits from the nozzle. On the other hand, excessive tar build up will stop the lid from closing properly.

Dry, brown, pine needles are an excellent smoker fuel. Other fuels include dry bark (preferably stringy type), dry eucalypt leaves (not coarse), bracken fern, and clean hessian bags that have not held chemicals. Don't use cream or green baler twine as these may contain preservative chemicals harmful to bees and the beekeeper.

Lighting a smoker

Place the smoker in a fireproof container, such as a tall metal bucket, before lighting it. The bucket will contain any burning fuel that might accidentally fall out of the smoker and become a fire risk. It is preferable that the height of the container is higher than the height of the smoker. Lighting the smoker should always be done in an area cleared of flammable vegetation.

Put a small amount of fuel inside the barrel of the smoker. Use a flame lighter (gas stove lighter with a flame) to light the fuel. Using this type of lighter enables the beekeeper to apply flame to the fuel resting on the grate in the barrel. Doing this keeps the flame within the smoker barrel. As soon as the fuel begins to burn, gently work the bellows to keep it burning. While still gently working the bellows, place some more fuel in the barrel. When the added fuel is burning well, fill the barrel with more fuel while puffing the smoker. Pack the fuel, but not too tightly as to smother the fire. Close the smoker lid and continue to work the bellows to ensure a good volume of cool smoke. The fire will usually stay alight when the base of the barrel feels warm.

Never fill the smoker barrel with fuel and then light the top surface of the fuel. The fire will not establish and will very quickly go out. You will not have the smoke you need when opening a hive and working the bees.

The smoker should always be well charged with fuel and should provide a dense stream of cool smoke. Hot smoke accompanied by sparks, and even flames, is a sure sign that more fuel needs to be added. It is also a fire risk. To avoid hot smoke, add more fuel to the smoker from time to time during use.

Smoker, fire risk and regulations

The smoker must not be used on a Total Fire Ban day unless the beekeeper has obtained an official written permit that authorises its use. Even if a permit is granted, the smoker should not be used unless special circumstances apply, such as a road accident involving transport of hives.

Beekeepers should also enquire with their state/territory fire agency about regulations controlling use of smokers and other beekeeping activities during the declared Fire Danger Period. The date of declaration and length of the period will vary according to district and seasonal conditions. Inquiries should also be made about use of smokers in forests and public land outside the declared Fire Danger Period. An example of legal regulations that apply in Victoria concerning use of smokers is provided in the following paragraph.

Beekeepers who have hives in Victorian forests must comply with the Victorian Forests (Fire Protection) Regulations 2014 Version No. 001 S.R. No. 52/2014 – Version as at 28 June 2014. These are quoted in full immediately below:

12. Bee farming

1. The written authority of an authorised officer is not required for a fire within a smoker used in connection with a bee farming operation if the person in charge of the bee farming operation:
 - (a) uses the smoker on an area of ground which is clear of all inflammable material for a distance of 1.5 metres from the outer perimeter and uppermost point of each beehive; and
 - (b) places the smoker in a fireproof receptacle when not in use; and
 - (c) if the weather conditions in the area are such that there is a danger of the spread of fire, has available for immediate use at least:
 - (i) one knapsack spray pump with a tank capacity of not less than nine litres which is fully charged with water, is in proper working order and complies with AS 1687–1991; and
 - (ii) one rake-hoe or similar implement capable of removing grass, shrubs, vegetation and other inflammable material from the area of the fire.
2. For the purposes of sub-regulation (1)(a), inflammable material does not include a standing tree or the beehive to which the smoker is being applied.



Knapsack, fire rake-hoe and fireproof container for the smoker.

When the smoker is not in use

Place the smoker in the fireproof container when you are not using it to smoke a hive. Never place or rest a lit smoker on the ground because a hot smoker can scorch vegetation and cause a fire. An additional safety measure is to place a grate or some small stones in the fireproof container to prevent the hot smoker from heating the base of the fireproof container.

When the smoker is no longer required, the fire should be extinguished. This can be done by pouring water into the smoker to thoroughly wet the fuel. An alternative method is to stop the air flow through the smoker. Plug the smoker's outlet nozzle with very tightly rolled wet material. The smoker should then be placed in the metal container described above. Never travel from apiary to apiary with a lit smoker.

Emptying ash and unburnt fuel from the smoker onto the ground is a fire hazard and could contravene fire regulations. Emptying ash and unburnt fuel into a container of water can also be a fire hazard because wind may carry sparks and burning fuel.

How to handle frames and combs

Both sides of the comb must be examined when looking for brood disease and queens.

A comb should always be turned on a vertical axis. Combs fractured or strained through handling them the wrong way can break down in the extractor. Although bees repair partly damaged combs when they are returned to the hive, the damaged cells become elongated, and are often large enough for drone brood, several rows of which may be found across the comb where it was fractured. Combs so damaged are also likely to break down in hot weather and when hives are moved.



The correct method of turning a comb (a)



(b)



(c)



(d)

Combs handled the right way will not be damaged. The first position is shown in photo (a) above. To turn the frame upside down without damaging the comb, bring the top bar of the frame into a vertical position as shown in photo (b); and by swinging the frame halfway round (like a door on its hinges), photograph (c); and then bringing the top bar into a horizontal line, the frame is completely reversed as shown in photograph (d).

Examining the hive

Always work at the side of the hive and not at the front where you will be in the flight path of the bees. Bees dislike obstructions to their flight path, especially close to the hive entrance.

Place the nozzle of the smoker at the hive entrance and work the bellows five or six times, directing smoke well into the hive. Wait for one minute before opening the hive. This will give time for the smoke to work through the hive, stimulating bees to gorge honey. Give a few more puffs at the entrance. Remove the cover while directing a few puffs of smoke underneath it. With a few more puffs, remove the hive mat and place it on the upturned cover near the front of the hive. Place the smoker safely to one side in the fire bucket within easy reach.



Apply several good puffs of smoke into the hive entrance.



Blowing smoke across the entrance may be insufficient to control bees under poor conditions.



Wait one full minute before gently lifting the cover and sending some more smoke inside.



Remove the hive mat without jerking or hurrying. Have the smoker ready.



Apply smoke over the frame top bars and some down between the frames. Do this before removing any frames.

Using the hive tool, separate the frames near the wall of the hive. Take out the frame, second from the wall, lifting it slowly and vertically. Stand it on its end against the hive, preferably near the opposite front corner so that it will not obstruct forager bees using the entrance. In this position, any bees, including the queen, that crawl off the comb will be able to find their way into the hive. The removal of this frame leaves room in the hive for manipulation of the remaining frames without crushing bees. The frame next to the hive wall can now be prised away, breaking any brace comb at the same time. Lifting out this frame first may have caused brace comb to damage the comb surface nearest the hive wall, or worse still squash or roll the queen.

If the queen is seen on the first comb or any other comb taken from the hive, gently direct her, using a finger, back in to the hive rather than allow the frame to stand on the ground where she may get lost in the grass, trodden on, or even take flight.

Ensure frames and combs are vertical when they are lifted out of a box. Combs lifted on an angle to the vertical can cause rolling and squashing of bees, including the queen. This poor treatment of bees can make them more likely to sting.

When opening the hive, stand preferably with the sun shining over the shoulder which will give good light for comb examination. Shake the bees from the combs and back in to the hive if examining brood, looking for queen cells, or brood disease. To do this, hold the frame at each end by the lugs and give it a sharp downward flick of the wrist movement with an abrupt stop. After practice, one becomes very efficient in this movement. If necessary, the remaining bees are easily removed by gentle sweeps with a damp bee brush. Never 'dump' the end bar of the frame on the ground or hive to remove the bees as this can damage the frame lugs and comb and is a sure way to agitate the bees.

The effect of smoke will soon wear off. Keep an eye out for bees building up on the frame top bars. This can indicate that an offensive against the bare hands of the beekeeper is imminent unless control measures are quickly enforced. A few puffs of smoke over the top bars will restore order. It is a

good idea to apply a little smoke to removed supers or other places where bees may also be gathering.

Remember to work the bees confidently but gently. Use deliberate and smooth movements. Avoid quick, jerky movements and bumping hive components. The rougher you are with bees, the rougher they'll be with you. Some bees may circle and dart around the operator. Take no notice of them. Striking at them is a useless form of defence and can incite others to join the attackers.

Don't shake bees from the frames in front of the hives in cold or wet weather or late in the evening, as they may become chilled. Don't shake them onto hot ground in hot weather as they may be scorched, or into long grass in front of the hive where the queen could be lost. Removing two frames from the box leaves ample space to conveniently shake bees, and queen, back into the hive without scattering them in all directions.

If the hive has two or more boxes, place the cover upside down in a convenient position near the front of the hive, but not directly in front of the entrance. Using the hive tool, prise an end of the super up off the bottom box, about ten to 20 mm, and direct a few puffs of smoke between the boxes. Remove the super and place it on the upturned cover. Conduct any comb manipulation in the bottom box first. Work on the combs in the super may be done while it is on the upturned cover or after it has been replaced on the bottom box.

Before replacing the super, remove any burr comb from the frame top bars of the brood box and bottom bars of the super. Burr comb should be placed in a container, not left on the ground to attract robber bees and possibly risk spreading disease. Apply a little smoke to the brood box and the bottom of the super to direct bees away to prevent injury by squashing them. Place the super on the bottom box with the four corners of the bottom box just visible before twisting the super into its correct position.

Ideal conditions for examining the hive

A good time for beginners to open hives is when bees are happily foraging. Bees generally begin foraging well when the temperature is 16°C or above, cloud cover is less than 7/10ths, it is not raining, the wind is relatively light, and pollen and nectar are being gathered by the bees. Often, these conditions don't all happen at once, but when several are present beginners can work bees. A suggested good time is mid-morning to mid-afternoon. This period avoids the cool part of the early morning and the decline in temperature following mid-afternoon in spring and autumn. The latter part of the afternoon in these seasons is sometimes accompanied by a reduction in the supply of nectar and pollen. This is when the bees by being a little more aggressive tell you it is about time to cease hive manipulation for the day.

As it is not always possible to work bees in ideal conditions, attention to adequate protective clothing and correct use of smoke will usually enable the beekeeper to complete the hive inspection. Because of the potential adverse effect on

the colony, there should be little or no need to open a hive during the cold of winter.

Where possible, avoid robbing hives when there is no nectar flow, as this may incite robber bees and angry bees. Working bees for other reasons when nectar is in short supply can similarly result in aggressive bees. If robber bees become bad, working the hives will need to stop until conditions improve. If there are any rogue hives in the apiary, work them last.

Don't tolerate cross bees in your apiary. Some bee colonies are very easy to control, while others are virtually uncontrollable, especially in the hands of a beginner. You may hear from other beekeepers that defensive or savage bees produce more honey. However, there is no connection between the temperament of bees and their potential productivity. Requeen unfriendly colonies with a queen of a docile strain purchased from a professional queen breeder.

Safety and beekeeping operations

Many beekeepers travel long distances to reach their apiary or search for suitable flora and apiary sites. They often work alone in isolated areas. It is important that beekeepers are aware of the following points for their health and wellbeing.

Long journeys may occur after a period of hard work in the apiary. Beekeepers are encouraged to be aware of fatigue and take power naps and break of journey every two hours, or even stay overnight before commencing a long journey home.

Always have an effective means of communication when working in isolation. It is important to be able to effectively communicate with the outside world and seek help in an emergency. In addition, before leaving home, a beekeeper should advise family members, or an appropriate person, of the apiary location and expected time of returning home.

A working mobile or satellite phone and a radio should be part of the beekeeper's safety equipment. These will allow the beekeeper to receive information about emergencies including wild fires and to seek assistance in medical and other emergencies. Beekeepers should also carry first aid kits and have a basic understanding of first aid.

Take special care when working with bees on hot days. Wearing protective clothing and working hives in full sunlight can easily result in the human body becoming over heated and dehydrated. Ensure an ample supply of cool fluids for frequent drinks. Be aware of the early signs of heat stress and dehydration. Better still, it is best to avoid working bees on very hot days and during the hottest part of the day in summer. This will be good for you and the bees.

Beekeepers lift supers and entire hives in their beekeeping operations. An 8-frame super with all combs full of honey may weigh around 32 kg. To avoid back injuries, beekeepers are encouraged to adopt correct manual handling techniques and use mechanical lifting equipment when moving hives. Information on suitable lifting equipment is available from beekeeping supply shops and beekeeping journals.

Lifting a heavy super from a hive, or off the ground onto a hive, may cause back strain. Bending over to inspect combs in bottom boxes and supers placed on the ground can also result in back problems. Supers removed from a hive can be placed on an empty super or bottom box on the ground thereby reducing the amount of bending and lifting. Alternatively a metal stand can be constructed for the same purpose.

It is a good idea to wear gloves when lifting hives to move them to another site. Spiders, including red-back spiders, may nest under the bottom boards of hives. Occasionally, snakes may hide under the bottom board.

4. How to get bees and increase numbers of colonies

For best results, starting a colony is best done in spring and early summer. Colonies started later than this may require additional management to ensure they are established with adequate numbers of bees, and sufficient stores of honey and pollen to survive winter. There is usually a good supply of nectar and pollen in many localities in spring and early summer provided there has been sufficient rainfall. These conditions are ideal for colony build-up and are often the best conditions for beginner beekeepers start handling bees.

Established bee colonies

Colonies established in hives are available for purchase from time to time and may come in various sizes of one or more boxes. The saying “buyer beware” applies here and the following notes will help purchasers avoid trouble.

A second-hand hive should contain a colony of bees with a good temperament. The colony should not be considered weak for the time of the year it is offered for sale. At the very least, combs that contain brood should be well covered with bees, and brood of all stages should be present. The queen should be laying and the brood pattern should be even and not scattered like a pepper box pattern. There should be combs containing honey and pollen to provide sufficient food for the colony in the short term.

Ideally, the hive components should be in good condition and of standard dimension. Check for rot in the timber as well as for broken frames and combs.

It is extremely important that hives to be purchased are free of disease. Inspect the brood combs for signs of brood disease before any sale is completed. If disease is present, or if there is any doubt, the sale should not proceed. Hives should not be purchased in late autumn or winter because brood may not be present. If brood is absent, the tell-tale signs of brood disease may not be evident. Also, even if brood is present, it is poor management to break a winter cluster of bees to inspect for disease.

The cost of second hand hives can vary considerably and there are a number of factors to consider. Calculating the cost of buying and assembling a new hive of the same size will enable potential buyers to make an approximate comparison. Don't forget to add the purchase price of package bees or a nucleus colony to obtain the comparative total cost. The queen may be nearing the end of her productive egg-laying potential and may need to be replaced.

A supply of water should be in place before the bees are moved to your apiary, because if they first start watering somewhere else it is almost impossible to get them to change to the new watering site.

Transport the hive when all the forager bees have returned to the hive after dusk. Moving hives when bees are foraging will mean that approximately half of the bees will be left behind. Movement of hives can be done in daylight hours in cool weather when there is no bee flight, such as in winter (see *Moving hives* in chapter 7. *Summer Operations*).

The purchased hive is placed on its permanent site in the apiary. Apply smoke to the hive entrance and slowly open it to let the bees fly. Wear protective clothing when doing this because the bees may be a little agitated. Let the bees settle down for several days before opening the hive to inspect the bees and brood.

The benefit of buying secondhand working hives is that there is no requirement to assemble hive components. Painting will only be necessary if the existing coat is damaged or flaking from the timber. Hives with good populations of adult bees are ready to forage as soon as they are placed in the buyer's apiary. If the nectar flow is reasonable, the bees may produce a good honey crop.

Nucleus colonies

A nucleus (sometimes called *nuc*) is a small colony of bees in a box with either three, four or five combs, containing brood in all stages, as well as honey and pollen. It has a laying queen and sufficient bees to cover the combs. Nucs may be obtained from bee equipment supply firms and beekeepers offering them for sale.



Nucleus hives. Left: 4-frame. Right: 5-frame

Follow the notes under the section *Established bee colonies* (above) for advice on transporting and placing the nucleus in the apiary.

Allow several days after locating the nuc in the apiary for the bees to settle and orientate to their new environment. After this, if the nuc has plenty of bees and needs more room, transfer it to an eight- or ten-frame hive so it can develop into a productive colony. Delay the transfer if the nuc is weak and doesn't immediately require additional room. Placing a weak nuc in a larger box may retard its development for a while.

Apply some smoke to the entrance of the nuc and move it a little to the side. The hive to receive the nuc is placed on the site where the nuc was. Take the frames, with bees, out of the nuc and place them in the centre of the hive in the same order. Place frames of beeswax foundation, or drawn comb if available, in the hive on both sides to fill in the gaps. If available, include a frame or two of honey taken from a

healthy hive. Place these adjacent to each hive wall. Check inside the nuc to see if the queen is there, and if she is, gently guide her into the hive using a finger. Then, shake or gently brush any remaining bees left in the nuc into the hive. Check the ground around the nuc just in case the queen has fallen from a comb.

In most areas of Australia, spring is the best season to establish nucs. Under favourable conditions, the colony will build up quickly and may even produce a good crop of honey in its first season. Nucs obtained later in the year, for example in early autumn, may require special care to ensure they have enough adult bees to survive through winter. Sufficient time is also necessary for the bees to forage and build up their honey and pollen stores as little foraging, if any, is possible in the cold winter months in most districts.

Package bees

A package of bees consists of a cage containing a given weight of bees, usually one or two kilograms. It also includes a queen and escort bees (workers) in a second smaller cage and a feeder to provide food for the bees in transit. On arrival at the apiary, the package bees are transferred to a hive that has been assembled to house the bees.



A bank of packages being filled with bees prior to delivery to a customer.

Packages are usually available from mid-spring to mid-autumn. Like nucleus colonies, package bees should be obtained early in the season to allow sufficient build-up time before winter. Instructions for installation of the bees are usually supplied with the package.

Catching honey bee swarms

Usually, a swarm consists of a queen bee and many thousands of workers. Swarms mostly leave managed hives and feral bee nests between mid-morning and mid-afternoon in spring and early summer.

Swarms occur in towns and cities, as well as rural areas, and may be obtained at no cost. Many people are willing to pay to have a swarm removed from the place where they

have settled. Swarms usually settle around 100 m to 200 m from the parent hive, and any swarm hanging near an apiary owned by another beekeeper probably belongs to that beekeeper. That beekeeper may take a dim view of your swarm catching box with his or her bees inside, so access the situation before catching the swarm.

While most swarms are quiet and easy to handle, approach them quietly and always wear a veil. If the swarm has been disturbed previously or perhaps has used its engorged honey that it carried from the hive it issued from, its behaviour could be unpredictable when handled.



A swarm that will make a nice productive colony when hived.

As soon as a flying swarm has settled and clustered, it can be collected. Do this as soon as possible because there is no set time that a swarm will remain clustered and stay in that position. The swarm will move as soon as the scout bees have chosen a suitable nesting site.



A swarm on farm machinery. Gently brush the swarm into a box.



This swarm is relatively low to the ground and can be collected by placing a hive box underneath. As the swarm is spread out, some gentle brushing or a little gentle smoking will encourage the bees to move to the hive.

Swarms can be placed directly in a hive, but this is not always possible for several reasons. The cluster may be in a position where a box cannot be placed directly under the swarm to shake the bees into it. The hive may be too heavy to hold under the swarm, or an empty hive box is just not available.

Any clean empty cardboard box, free of chemicals and odours objectionable to bees, can be used. Where a swarm is on a shrub, place the box immediately under the swarm and shake the branch to dislodge the cluster. The shaking should not be half-hearted but more like a sudden jolt so that the cluster falls from the branch as one unit. Better still, if the branch is not too thick, gently cut it off with most of the bees still on it. Place the branch and bees in the box. In other cases, brush, scoop, or gently use a little smoke to guide the bees into the box.

When most of the bees are in, place the box on the ground in a shaded position as near as possible to the site where the swarm was clustered. Do not fully close the box, but leave an entrance so that any bees that took flight can re-join the swarm. Never shut the bees in because this will probably result in their flying away when let out.

If your swarm catch box with the swarm inside is in the vicinity of a walkway (etc.) keep it well back from the passing public. Alternatively, erect a barricade or hang warning tape (etc.) to keep people away. Never take the captured swarm away as soon as you have caught it because the returning scout and field bees can be quite angry if the swarm has been moved. It is very poor management to remove the catch box immediately. Apart from the potential angry bee problem the person hiving the swarm could be leaving a large number of their valuable forager bees behind.

After dusk, or when all the bees have stopped flying and are in the box, move the box containing the swarm to your apiary. Place it on the spot that the frame hive is to occupy. The bees can be put in the hive the next day, or a day later.

Most importantly, some swarms prefer to cluster for a while after they have been placed in a hive. A hive box with its

full quota of frames containing comb or foundation will not allow the bees to form an unbroken cluster. The swarm may choose to leave the hive, but it may be recaptured when it clusters again. However, there is always a risk that the swarm may fly out of reach.

The problem may be overcome by placing an empty hive body underneath the one containing combs or foundation. This enables the swarm to hang in a cluster under the frames and occupy the combs above, as they wish. The simplest method of hiving the swarm is to shake it into the empty hive body and immediately place the super of combs with a cover on top. The empty hive body may be removed or filled with combs, depending on the size of the swarm and honey flow conditions. This can be done towards evening when the swarm has settled down, or the next day. If the box is left empty without frames too long, the bees will build comb in it, creating an illegal box hive.

For small swarms, clustering space may be provided in a single hive box by temporarily removing half of the frames from the centre of the box. These can be placed in the box the next day.



A very small swarm. This is best united with another swarm.

If a swarm absconds repeatedly after being hived the bees may be induced to stay by giving them a comb containing unsealed brood from another hive. Before doing this, closely inspect the brood of the donor hive for signs of brood disease. If disease is found choose another donor hive. Some swarms don't like the odour of a newly painted box. A little molten beeswax painted on the internal surfaces of a new box will help to reduce absconding.

Swarms may carry disease organisms, so it is best to place hived swarms in a separate apiary for at least three months where the bees and brood can be regularly checked for signs of disease. It is a good idea to place the swarm in old box until its health has been established. An old box is preferred because if American foulbrood disease occurs the hive will need to be destroyed by burning.

The age of the queen in the swarm is not known. If her egg-laying is poor, replace her with a young queen to ensure continued good egg-laying capability. Wait until unsealed brood is present in the hive before attempting to introduce a new queen. Requeening with a known docile strain is a good idea when hived swarms are bad-tempered (See chapter 12. *Requeening colonies and rearing queen bees*).



The beekeeper has shaken the branch and caused this very large swarm to fall into two boxes of combs, which will be combined later. It will make an excellent honey producing colony.

Collecting swarms is probably the easiest and cheapest way of establishing an apiary or increasing the number of colonies. Anyone wanting swarms can supply their name, telephone number and the areas in which they wish to operate to local government, police and beekeeper clubs. It is a good idea to have some experience in handling bees before taking on a role of a swarm collector.

Increasing the number of colonies

‘Splitting off’ nucleus colonies

Nuclei (or nucs) can be taken from colonies during spring to reduce their potential to swarm. Where a colony is very strong, with large numbers of adult bees, more than one nucleus may be obtained. It is possible to divide entire colonies to form multiple nuclei.

It is necessary to first find the queen. The queen, and the comb she is on, is temporarily placed in a separate box for safe keeping. For a 4-frame nuc, remove four combs covered with bees from the parent hive: a comb of honey, a comb containing larvae, a comb of sealed brood and a comb containing pollen and honey. The queen and comb she is on are then returned to the parent hive. If the queen cannot be found, place the combs that will make up the nuc into a super over a queen excluder, after having first shaken and brushed all the bees off them into the bottom box. When bees have moved through the excluder in sufficient numbers to cover the combs, place the combs in the nucleus hive. This procedure avoids the need to look for a queen in the hive from which nuclei will be taken.

If the nuc is to remain in the same apiary, field bees in the nuc will return to the parent colony, potentially leaving the colony too weak. One way to make up this loss is to have a fifth comb above the excluder, the bees on this comb are shaken into the nuc. Alternatively, close the nuc and move

it to another site at least five kilometres away. The bees will orientate to the new site and stay with the nuc.

The nuc can be left to raise a queen from the comb of unsealed brood, provided there are eggs or newly hatched larvae present. However, this queen is likely to be of poor quality because it was reared under the emergency impulse (see chapter 12. *Requeening colonies and rearing queen bees*). Alternatively, if there is a well-built queen cell present in the parent hive, the comb containing it can be placed in the nuc. This queen will be far better than the one raised under the emergency impulse situation but she may mate with undesirable drones.

The best approach is to introduce a queen bought from a queen breeder. This queen can be introduced to the nuc a few hours after it was split from the parent hive, or the morning after. If the beekeeper has allowed the nuc to raise its queen, it is best to requeen the nuc at a later time with a well-bred docile queen. This can be done when the nuc has unsealed brood and recently emerged bees present.

Where nuc boxes are not available, a single nucleus may be placed in an 8- or 10-frame box.

Swarm catch boxes (bait hives) and swarms

Swarms readily occupy hive boxes that have previously housed bees and have some beeswax and propolis on the internal walls. Catch boxes must only contain frames with foundation. Combs must not be placed in catch boxes because robber bees may transfer any disease organisms present to their own colonies. New boxes are not normally attractive to swarms. However, in addition to the frames of foundation, they can be made attractive by painting the internal walls with molten beeswax. Bait hives are more likely to be successful when they are raised at least one metre off ground level. As bee swarms occur mostly in spring, attempts to use this method of obtaining colonies in other seasons of the year will be largely unsuccessful.

When placing catch boxes on site, ensure that the hive entrance is open. Each box must be branded with the beekeeper’s brand. If the box is positioned on property where the beekeeper does not live, it must be labelled with the beekeeper’s name and telephone number in characters of at least 25 mm.



A swarm moving into a box of combs on a trailer.

Place occupied bait hives in a separate apiary and monitor the brood for three to six months for signs of disease.

Secondhand hive components and empty hives

Pre-used hive material not housing bees can be purchased at reduced cost and sometimes obtained at no cost. There is a real danger that bee disease organisms may be present, especially the notifiable brood disease, American foulbrood (See chapter 13. *Brood diseases of bees*).

Unfortunately, there is no effective way to determine if used hive components are carrying disease organisms. It is not until bees are placed in the hives that disease, if present, may develop and show symptoms in the brood or adult bees.

Secondhand items not containing bees are best sterilised by gamma-irradiation to make them disease free before use. If the material is not irradiated, the hives should be placed in a separate apiary and monitored frequently for at least twelve months for signs of disease. If disease does occur it is then confined to the one apiary.



Acquiring neglected and poorly managed hives can be a disease risk.

5. Apiary sites and flora

A well-chosen site for hives will help to ensure good honey production and assist with colony well-being and disease management.

Migratory beekeepers are able to select apiary sites that provide the ideal environment for each season of the year. Hives are moved from site to site as plants begin to flower. This type of beekeeping is largely learnt by experience with some good outcomes and unfortunately some failures.

A hobby beekeeper who keeps hives in a stationary position on his/her property may not be able to provide an apiary site with all the features described in this chapter. The hobbyist must choose a position that gives the bees the best possible environment all year. Careful placement of hives near a deciduous tree will provide some shade during the hottest part of the day in summer and permit the hives to have as much winter sunlight as possible. Ideally, the district in which the site is located will provide nectar and pollen for the greater part of the active beekeeping season.

Beekeepers should conform to any regulations and requirements of Codes of Practice that, apart from other requirements, specify where hives may be located on a property. If hives are kept in a backyard, position the hives so that the bees are not a nuisance to family members, adjacent and nearby landholders, the public and pets.

If a site does not have a natural source of water nearby during all seasons, a supply of water on the property must be provided and maintained by the beekeeper throughout the year. This is a legal requirement in some Australian states.

The water should be in place before locating the hives on the property. If not, the bees will collect water elsewhere, where they may become a nuisance. It is then almost impossible to change their behaviour and have them use the water supplied by the beekeeper.

The shorter the distance bees have to fly to forage for nectar and pollen, the less energy they use, and they are able to store more surplus honey. Where colonies are located to forage on a particular plant species, it is best to place them within the stand of flora in flower, or immediately beside it.

If a mobile extracting plant is to be used, locate the extracting plant at the lower end of the apiary for easy wheeling of full boxes of honey.

Winter site

In southern Australia, the ideal winter site will be on a gentle northerly downwards slope that extends for some distance, levelling out to plains rather than to rising ground. Good air drainage is important so that the very cold, damp air can drain away. Avoid locating the apiary at the bottom of a slope where cold, damp, stagnant air and fog can occur. Damp stagnant air affects bees and can reduce the life of hive material, especially if it is not well maintained. Avoid low lying areas where flash flooding may result in loss of bees and hives.

If a slight downward gradient from the back of the hive to the entrance is not available, place a brick, flat stone or piece of wood under the rear cleat of the hive bottom board to achieve the desired slope. This allows condensation and storm water to drain out the entrance rather than stay trapped on the bottom board at the back of the hive.

The site should be sheltered by windbreaks to give protection from southerly and westerly winds. Protection from cold wind will help to minimise incidence of nosema (*Nosema apis*), a serious adult bee disease.



A commercial apiary on a good wintering site that provides some shelter from wind, relatively clear ground and good air drainage, and minimal shade.

Ideally, the hive will face north-east to east which allows the early sun to shine on the hive entrance. The site will have maximum sunlight and no shade. Grass and other vegetation around the hive should be cut regularly so the hive receives full sunlight and bee flight is not impeded. Colonies in good sunlight may forage on relatively warm winter days and collect some pollen.



A poor wintering site with too much shade and poor air drainage. The hive should be raised at the back to allow condensation to flow freely out of the hive entrance.

Good vehicle access is important so that hives and equipment can be moved to and from the site at any time. A bogged vehicle in a farm paddock is an unpleasant experience. Similarly, hives that cannot be moved to another nectar flow or to fulfil a pollination contract cannot provide income for the owner.

Summer site

Helping colonies to control temperature in their hives is sound economy. It is essential for colony well-being and maximum production of honey. Man-made hives provide the bee colony with only relatively thin timber for protection. A colony in its natural environment usually nests in a tree or rock crevice, with several inches of wood or stone surrounding it, thereby providing protection from the extremes of weather.

The ideal summer site will provide broken shade over the hives, particularly at the time of day when the temperature exceeds 30°C, as this helps the bees cool their hives. Shade from the west is particularly helpful in the late afternoon and dusk. Avoid dense or total shade for the entire day. Early morning sunlight on the apiary is desirable.

There is a big difference in the effort required by bees to maintain a normal temperature in a white hive compared to that necessary in a hive painted with any other colour, including silver.

Extreme summer temperatures of recent years have resulted in some colonies being heat-stressed. In these conditions, some adult bees and brood have perished, queens have stopped egg-laying or their future egg-laying potential is markedly reduced, and combs have melted. Observations made by a very small number of beekeepers seem to suggest that hives placed on sites where there is very little or no air movement during these extreme heat events may accentuate the effect of heat.

Be aware of the danger of bushfires to hives. Obtain approval of the landholder, owner or manager to clear the site of all inflammable material such as grass and leaves. Clearing a substantial fire break around the apiary will at least give the apiary some chance in the path of an approaching fire. It will also minimise the chance of the beekeeper's use of the smoker being the cause of a fire.



A cleared summer site with some shade.

Private land sites

There are no designated apiary sites on private or freehold property.

After determining the potential of a district for nectar and pollen yield, the beekeeper need simply request permission of the owner or landholder of freehold land to locate hives on a particular spot on the property. The value of the bees for crop pollination may help to obtain permission. On the other hand, consider the potential for damage to bees by application of agricultural chemicals on the crop and nearby crops. Placement of hives out of view of the public and away from roads can help reduce the risk of theft and vandalism.

Beekeepers rarely pay money for private sites, preferring to give the landholder honey instead. An ongoing, good working relationship will usually ensure that you can return to the site in following years. Leave your name and contact details so that the landholder can contact you in an emergency, such as hive damage or intended use of agricultural chemicals. It is also an idea to leave these details on a sign or hive in the apiary in case the initial contact details are mislaid.

Comply with all requirements of the owner. Keep the site and immediate surrounds in a clean and tidy condition. Close gates if you find them closed. Keep vehicles to agreed tracks and advise the landholder of your intention to visit the property, especially when moving hives at night. Seek permission to fence the site to prevent damage of hives by stock, such as sheep and cattle. Be aware of the flight path of the bees, so don't locate the apiary too close to gates, lanes between paddocks, water troughs, hay stacks or anywhere where the owner or staff are likely to be working.

There is no set distance between private land sites. Too many hives in an area may result in poor honey crops, and in adverse conditions, none at all. A check with locals to find out where other bees are usually placed will guard against a beekeeper placing his or her hives in an over-stocked area, especially if the nectar flow does not come up to expectations. Simply 'dumping' bees on a site without regard to other nearby apiaries will result in the beekeeper getting offside with fellow beekeepers.

Public land apiary sites

The availability of apiary sites (bee sites) on public land varies according to the current policy of the individual state or territory. Designated sites may be available in state forests, some national parks and in other areas of public land. However, there are few vacant public land sites and anyone commencing a beekeeping business will mostly have difficulty in obtaining them. Most beekeepers who hold sites pay the due fee to retain use of the site even though useful flowering may not occur every year.

Enquiries about vacant sites, licence fees and conditions of use, including clearing of flammable material and should be directed to the government agency or manager responsible for the land.

Nectar and pollen flora

Most beekeepers who keep hives in towns and cities, on the one site all year, do not need to be concerned about flora. This is because, good supplies of nectar and pollen are usually available, especially from early spring to late autumn. However, there may be periods, especially in years of low rainfall, when nectar and pollen may be in light supply. When this happens, some feeding of hives may be necessary. The honey produced in towns and cities is often referred to as 'garden honey'. This natural blend of nectars results in honeys of various flavours and colours.

A good supply of pollen is important for brood rearing, as well as honey bee nutrition and health. An apiary site that offers a mix of pollens from a number of plant species is preferred to a site where only one pollen is available. This because pollens from different plant species vary in their nutritional value. A mix of pollens will help to provide bees with a balanced diet. However, any pollen, no matter what the quality, is better than having no pollen at all.

Beekeepers with just a few hives can plant nectar and pollen yielding flora as windbreaks or beautification plants around the home or farm buildings. Choose species to flower at times of the year when there is a dearth of nectar and pollen. In cool areas of southern Australia, avoid planting winter flowering species because bees do not generally forage much at this time. Some winter flowering species yield thin nectar which is stored in combs but is not ripened by the bees. It can ferment and predispose the bees to dysentery.

Semi-commercial and commercial beekeepers must be prepared to locate hives in rural areas. They move hives to utilise the wide range of nectar and pollen producing flora to make beekeeping a paying occupation.

The distribution and value of nectar and pollen flora is influenced by factors such as soil, climate, latitude, topography and man. Combining experience and local knowledge, the beekeeper will soon learn that because of these factors, the pollen and nectar yield is not uniform. The same flora can show difference in yield when growing in different localities and just because the flora yields this year doesn't mean it will yield next year. In general, the older mature healthy Eucalypts are considered by beekeepers to be the best yielders of nectar, when compared to younger trees of the same species.

Periods of cold, wet weather can confine bees to their hives especially during the southern spring. Although there may be copious flowers available, only small amounts of nectar and pollen will be collected by bees during the brief breaks of suitable foraging weather. Colonies should be checked regularly for stores and feed given when required to prevent starvation.

Some ground flora plants, such as white clover, require warm, humid weather and good soil moisture for a good yield of nectar. In dry years, the nectar flow may be very low or non-existent.

Up to 80% of Australia's honey crop is derived from Eucalyptus and Corymbia species. (Corymbia species, such as spotted gum, were previously known as Eucalypts but have been classified by botanists into a separate group). Some species flower annually and others may flower every second year, while others range up to seven years between regular flowerings. Factors such as drought can affect the flowering cycle. The extent of flowering of a species can vary from district to district. A heavy budding may be followed by one or more periods of light budding. These are known as 'on' and 'off' years.



An excellent heavy flowering of yellow box.

Eucalypts generally set buds after a spurt of foliage growth. In general, there is then a period of several months to 24 months before the buds open to release the flowers, depending on the particular species. Survey the new locality before moving the hives to ensure that prospects are good and that the flowers are secreting nectar.

The quantity of buds can vary greatly from tree to tree. The extent of budding and potential for a nectar flow should not be based on looking at only one or two trees of the same species. Inspect trees at several spots around the apiary site and within the bee's immediate flight range. Look for signs of disease and pests that may affect tree health and potential for a good nectar flow.



A poor set of buds.



A good set of buds.

Beekeepers can increase their knowledge of pollen and nectar yielding plants by keeping a record of budding and flowering times and consulting with other beekeepers. There are a number of books that will assist beekeepers identify native plants.

Move colonies on site as soon as possible at the commencement of the nectar flow. A lengthy delay may mean that the peak of flowering has past and little honey will be produced.

When to move the hives to a site can be determined by placing and observing one or two test hives. The presence of fresh nectar can be determined by gently shaking a broodnest comb containing unsealed brood and empty cells. Hold the comb above the brood box in a horizontal position and gently shake it. If nectar falls out, a flow is in progress. The appearance of freshly drawn comb and white wax on the walls of honey cells, especially near the frame top bar, is another useful sign that nectar is being gathered. Nectar in the blossom is also a favourable sign. It can be seen with the naked eye when the blossom is turned towards the sun. Get information from a dependable local apiarist as to whether bees are doing well in the area.

Even if there is a very good show of buds and nectar in the flowers, moths, beetles, nectar feeding birds, thunderstorms, extreme heat waves and a sudden drop of buds can all influence the nectar flow.

On occasions, some sites may offer little or no pollen. When pollen is not available from flowers, the bees will consume the pollen they have stored in the hive. There are a number of pollen supplement products available on the market. These may assist bees maintain body protein and continued brood rearing. Further information is contained in the publication *Fat bees, skinny bees* (see chapter 20. *Additional information*). Information on sugar feeding is presented in chapter 6. *Spring management*.

Nectar fermentation

Under certain conditions yeasts may cause nectar in flowers to ferment. The alcohol produced by the fermentation can affect forager bees. They fall from the flowers to the ground where they crawl or stagger around, appearing drunk and confused, and unable to fly. Most eventually die. Those that are able to return to their hive are found dead at the hive entrance. Bee faeces may be seen on hives.

The fermentation may be triggered by rainfall and increased humidity, as reported by researchers, Melanie Birtchnell and Maria Gibson (see chapter 20. *Additional information*). Losses of bees foraging on Grey box (*Eucalyptus microcarpa*) have been seen following the first major autumn rainfall, whereas losses of bees were not evident prior to the rain event. There have been reports of 'drunk' bees foraging on species such as Robinia, Common bottle-brush (*Callistemon longifolia*), Banksia species, Lemon-scented Gum (*Corymbia citriodora*), Red Ironbark (*Eucalyptus tricarpa*), Red Bloodwood and Wandoo.

These events also occur in cities and suburbs and usually occur from January to May. European wasps and other insects may be similarly affected by the fermenting nectar.

Pests that affect flora

Certain pests can have an indirect effect on the well-being of honey bee colonies and honey production by injuring or destroying the flora from which the bees obtain nectar and pollen. When evaluating a stand of flora as a potential source of nectar and pollen, consider plant health and the presence of any plant pests, as well as the numbers of buds on the plants.

The leaf-lerp is an insect which attacks leaves. It is similar to a scale insect and is protected by a small waxy scale cover. Red gum (*Eucalyptus camaldulensis*) seems to be especially effected by this pest, and from time to time, large stands of this tree can be seen completely defoliated, and in some cases killed.

Phasmids or stick insects can defoliate trees when their populations are high. Most damage occurs in summer when the insect is most active. It is hard to detect in its natural environment because its shape and general appearance resembles a twig of a tree, giving perfect camouflage.

The larvae of gum moths may occasionally reach plague numbers in isolated patches of country and can damage eucalypt foliage. The bud weevil lays its egg in or on the bud, and then cuts the bud from the tree, causing it to fall to the ground. The damage caused by large numbers of this insect can virtually de-bud trees. It infests a number of eucalypts, including Red gum and Long-leaf box.

A number of Eucalypt species are affected by galls which are defined as an abnormal growth of plant tissue. The bud gall is especially prevalent on Red gum (*Eucalyptus camaldulensis*) in Victoria and damages the young growing flower bud.

The Bogong moth (*Agrotis infusa*), is a dark brown or blackish moth which in some seasons occurs in plague proportions. The moths breed during winter in the Darling Downs, Queensland and dry inland areas of New South Wales and Victoria, and migrate to the alpine areas during spring. Bees will not visit flowers that have been visited by Bogong moths. In some years, plagues have virtually wiped out the honey crop from yellow gum in western Victoria and have occasionally affected other later honey crops. Bees placed in cherry orchards for pollination have neglected the flowers because they were first visited by these moths.

The Rutherglen Bug (*Nysius vinitor*) attacks plants by piercing the skin of leaf, stem and fruit, and by sucking sap. It is a small grey insect and may build up to plague proportions in summer. It is not certain how the insect affects the plant with regard to nectar flow. From the beekeeper's point of view, problems associated with this insect are spasmodic.

A number of other insects affect honey production either directly or indirectly through attacks on the foliage of nectar plants and infestation of eucalypt bus and flowers. However, problems from these insects are fortunately relatively rare and generally do not cause great concern.

Hive stocking rates

There is no set formula to provide a guide as to how many hives can be placed on a site. Overstocking can reduce the amount of honey each hive produces thereby reducing the profitability of the beekeeping enterprise. A check with locals to find out where other bees are usually placed will help to guard against a beekeeper finding his/her hives in an overstocked area.

Drifting bees and placement of hives

Drifting occurs when bees enter other hives in the apiary instead of entering their own hives. It can occur when bees are unable to identify their hive in amongst all the other hives.

A lack of landmarks is a major cause, especially in windswept areas when there are many hives in several rows. Drifting is much less of a problem on a bushy or forest site where natural landmarks are plentiful. Place hives near or between landmarks such as trees, stumps, clumps of grass, or bushes. In open plain country, distribute boughs of trees throughout the apiary as temporary landmarks. Do this before the bees are released from their hives after a move.



Shade cloth positioned to provide an added land mark to minimise risk of drift.

Sometimes bees will drift with strong wind to one side of the apiary following release from hives relocated to an apiary site. It is an advantage if bees can be released before daylight in hot weather, particularly on heavy flows. When they are released in daylight, always direct a few puffs of smoke over the hive entrances as they are opened. Slowing down the outward rush will help to make them take notice of the new location.

Many bees may be attracted to sections of the apiary where there is the most activity once drifting starts. This can result in some hives collecting huge numbers of bees, while others become so depleted of bees that they are too weak for production of honey for some time. Hives which have accumulated large numbers of bees do not benefit greatly by their extra numbers. The bees do not settle down to work. At times they will cluster all over the hives for days. Sometimes the influx of strange bees can cause fighting and loss of queens.

Hives should be spaced about one to two metres apart with rows about three to four metres apart, or more, to allow vehicle access. Some apiarists conserve space by placing hives in distinct groups of three within the rows, with their entrances facing slightly different directions. The hives are closer together, with little more than a normal space between groups.



The entrances of these hives face slightly different directions to help minimise drift.

Painting hives different colours is of doubtful value in reducing drift. Observations show that bees identify shapes more readily than colours.

Fire Precautions

Fire is always a serious threat to the security and productivity of a beekeeping enterprise. Bush fires can destroy hives and mobile extracting plants. Bush fires can wipe out the nectar and pollen potential of a forest site for many years.

Apiary sites should be made as fire-safe as possible. Clear the site and, if possible, the surrounding area by raking all flammable material such as fallen leaves, sticks and branches. Before doing this, obtain permission of the landholder or land manager because there may be vegetation planning controls that make it an offence to disturb the site and/or remove plants.

Hives on a cleared site will have a much better chance of survival in the event of a fire. The cleared site will also minimise the risk of the beekeeper's own operations being the cause of a fire. In addition, a site cleared of obstructions will help the beekeeper's quick getaway in the event of an approaching fire. Refer to chapter 3. *Handling bees and beekeeping safety* for notes on the safe use of a smoker and mandatory fire fighting equipment that must be carried by the beekeeper.

Identification of apiaries

There is a growing trend for beekeepers to provide their contact details on a legible sign at each apiary site where they do not reside. This allows nearby farmers and other local people to contact the beekeeper in case of an emergency such as flood, bushfire, intended application of agricultural chemicals, vandalism and theft. The information may be provided on a stand-alone sign or on one or more hives in the apiary.



Supers with beekeeper contact details.

6. Spring management

Colonies that successfully live through winter generally have low numbers of adult bees and little brood. In some districts, there may be no brood at all. The aim of spring management is to increase the size of colonies as strong colonies are necessary for good honey production. More honey can be obtained from one colony that contains 50,000 adult bees than from two colonies each containing 25,000 bees.

In early spring, (sometimes late winter depending on seasonal conditions and district), the rate of brood rearing increases, which in turn results in more adult bees. Although this is good for honey production, the expansion of the colony can stimulate the swarming impulse that causes colonies to naturally split to reproduce. This causes the original colony to be weakened for some time.

As soon as colonies begin to expand their brood nests, usually in early to mid-September, inspect the brood for signs (symptoms) of American foulbrood disease (AFB) and other brood diseases. Do this on a relatively warm day when bees are flying well. If AFB is found, or is suspected, reassemble the hive and reduce the entrance to about 50 mm to safeguard against robber bees. Notify an apiary officer of your state/territory Department of Primary Industries straight away as AFB is a notifiable bee disease.

Stores and feeding bees

The amount of honey in the hive can be very low in the late winter-spring period. The expansion of brood at this time of the year will use much of this honey, particularly if nectar is in short supply or unavailable. Bees require one comb of honey, as well as an amount of pollen, to produce one comb of brood. In addition, the colony will now have many young bees emerging that do not gather nectar but still have to be fed. If bad weather interrupts the nectar flow, or prevents foragers from gathering nectar, the entire colony may suddenly collapse from starvation.

A colony with less than two well-filled combs of honey could soon be threatened with starvation when brood is being raised.

It is important to frequently check the amount of honey in the hive, but opening the hive too early in spring and breaking up the bee cluster by removing combs can stress the bees. The stress may trigger European foulbrood and nosema disease. The best compromise for beginners is to open the hive for a quick look, but where possible avoid break-up of the bee cluster. Experienced beekeepers can check stores by lifting the back of hives and judging the amount of stores by weight.

Starvation of colonies can be prevented by moving the hives to areas where plants are yielding nectar and preferably pollen, or by feeding them white table sugar, or syrup made with white sugar. Bee colonies can be kept alive for long periods by feeding white sugar. Raw, brown and dark brown sugar, and molasses, should not be used as these may cause dysentery in bees.



One of the symptoms of starvation. An empty dry comb with dead adult bees in empty cells.



The colony in this hive died due to starvation. Monitoring stores in the hive can prevent this.

Placement of sugar syrup or dry sugar in hives is best done towards evening to minimise any tendency for bees to rob the hives that are fed.

Beekeepers operating a small number of hives should place sugar inside the hive, so that colonies needing the feed get the feed. If sugar is placed in containers in the open, weak colonies with low numbers of foragers may be unable to gather sufficient quantities. Some, and probably most, of the sugar in the open may be taken by another beekeeper's bees, feral bees, ants, or animals.

Some beekeepers prefer a ratio of one part of sugar to one part of water, measured by weight (known as 1:1). Others prefer a thicker syrup of two parts of sugar to one part of water (known as 2:1). Generally, 1:1 syrup is used to supplement honey stores, stimulate colonies to rear brood and encourage drawing of comb foundation particularly in spring. The stronger syrup is used to provide food when honey stores are low. Measuring the sugar and water by weight or volume is alright because there is no need to be 100% exact about the sugar concentration. Bees fed syrup reduce its water content and store it in the combs as if it were ripened honey.

To make the syrup, heat the water in a container large enough to hold both the water and sugar. When the water has begun to boil gently, remove the container from the heat

source. Pour in the desired amount of sugar and stir until the sugar is dissolved. Never boil the mixture as the sugars may caramelise and may be partially indigestible and toxic to bees.

Let the syrup cool to room temperature before feeding it using a method described below. Whatever feeder is used, a medium to strong colony will usually empty it in a matter of days.

To use the plastic bag feeder method, pour the cooled syrup into a plastic freezer bag, to about half full. Gently squeeze the bag to expel all the air. Tie the neck of the bag using an elastic band. Place the bag on the top bars of the frames in the top box of the hive, under the hive cover. Alternatively, remove one of the wall frames in the hive and gently slide in the plastic bag into the space. Use a brad or very small diameter nail to punch about six to eight small holes into the upper surface of the bag. The bees will suck the syrup through the holes. Never put the holes on the under surface of the bag as the syrup can leak out faster than the bees can gather it. The syrup may flow outside the hive and cause bees to rob. Ensure there is a bee space between the upper surface of the bag and the under surface of the hive lid so bees can gain access to the syrup. A small wooden riser frame of the dimensions of the hive may be used to raise the lid.



Sugar syrup in a plastic bag. A temporary riser is used to give a bee space clearance between the top of the bag and the underside of the hive lid.

To use the shallow tray method place the sugar syrup in trays, such as aluminium foil trays, under the hive lid. Provide floats in the form of wood, corks, polystyrene or shade cloth cut to the size of the tray so that bees can reach the syrup without falling into the liquid and drowning. The hives should be on level ground to prevent loss of syrup. A riser may need to be used if the tray under the hive lid is not shallow.

The frame feeder, available from beekeeping supply outlets, is the size of a full-depth Langstroth frame, and holds approximately three litres of syrup. It has an open top and sits in the super as a normal frame does. The feeder requires flotation material, as described above, to allow bees to reach the syrup without drowning.



Sugar syrup in a tray. The shade cloth prevents the bees from falling into the syrup and drowning. A pollen supplement cake is provided in front of the tray. An empty super is placed on the existing box followed by the hive lid.



A plastic feeder tray with shade cloth float. Bees enter the feeder from the hive through the central opening.

A less frequently used feeder is the Boardman or front feeder. The device sits in the hive entrance and contains an inverted jar or bottle in which the syrup is placed. The bees enter the device to access the syrup without leaving the hive. The level of syrup can be monitored without opening the hive. It is essential that there is sufficient space at the hive entrance for normal foraging activity.



A boardman feeder placed in the hive entrance.

For colonies with virtually no stored honey and no incoming nectar, the initial feed will be largely determined by the amount of brood and the size of the colony. As a guide, small colonies may be given an initial feed of about one litre and strong colonies may be given up to three litres. While it is safer to over-feed a colony than to skimp and cause the death of the colony, small colonies should not be given more than they can collect and store in the combs within a few days. A guide as to whether follow-up feeding is required can be obtained by checking the combs to see how much syrup has been stored. Feeding can be stopped when nectar becomes available.

Colonies with insufficient stores of honey for winter can be given syrup to boost the amount of stores. This should be done before the cold weather of autumn sets in so that the syrup can be fully ripened. Syrup that is not ripened will ferment and adversely affect bees.

Medium to strong colonies can also be fed dry white table sugar placed on hive mats or in trays under the hive lid. Bees require water for liquefying the sugar crystals. They will obtain water from outside sources and sometimes use condensation that may occur in the hive. Weak colonies may be incapable of gathering sufficient water and feeding of dry sugar to them is not recommended. Feeding dry sugar works best during autumn and spring when humidity is relatively high. The hot, dry conditions of summer make it hard for bees to dissolve sugar crystals into a liquid.



Feeding dry white sugar in a feeder tray.



Dry sugar can be placed directly on the hive mat under the cover.

It may be preferable for a colony at starvation level to be first fed with a comb of sealed honey. If this is not available, feed with sugar syrup before dry sugar is given. This will give the bees immediate food without the need to liquefy crystals. Bees will usually stop using the dry sugar when they are able to collect sufficient nectar. The sugar will remain in the hive and in some cases may be deposited by the bees outside the hive entrance. A small amount of dry sugar may be converted to liquid and stored in the cells.

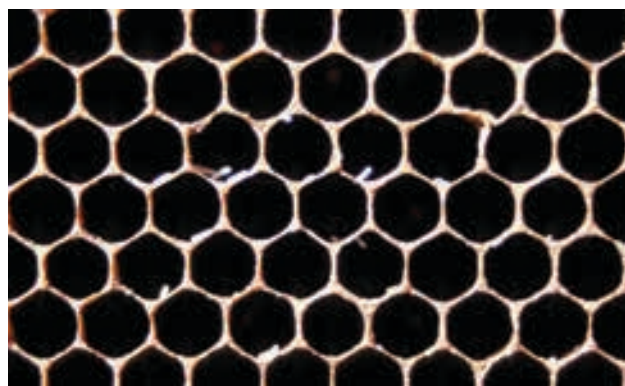
Combs of honey may be taken from hives that have excess supplies and given to others which need stores. Be sure that the donor and recipient hives are free from all brood diseases before doing this. Combs of fully sealed honey that were taken from your own disease free hives and set aside in a pest and vermin proof environment at the end of the previous beekeeping season may be given.

Never feed extracted honey to bees. Honey purchased from outlets such as supermarkets or farmers markets, or obtained from friends, may contain spores of American foulbrood disease and may cause infection in your hives. In addition, a natural compound in honey, hydroxymethylfurfural (HMF), may increase with age of the honey and heat treatment applied during extracting to levels that are toxic to bees.

Queens

It is important to check the egg-laying performance of queens as early as possible in spring. It is not necessary to see the queen because a uniform brood pattern of eggs, larvae and sealed brood is enough evidence that the queen is performing well. If a queen is of doubtful quality, mark the hive and check her performance during the next inspection. If she is still doing poorly, introduce a new queen to the hive as soon as a young queen can be obtained.

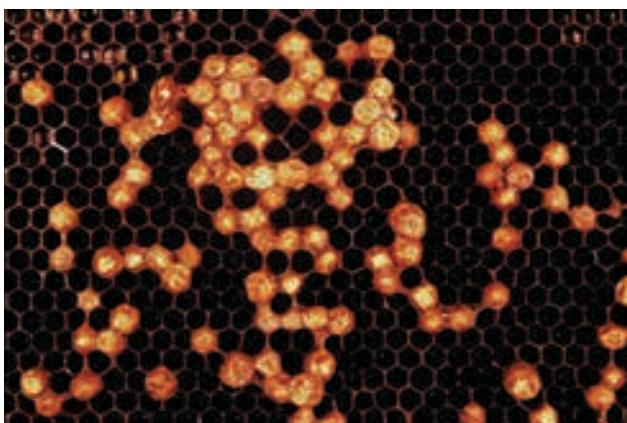
Sometimes a queen that has just commenced laying will lay more than one egg in a cell. This behaviour usually occurs for a short period and the beekeeper should then see the normal pattern of one egg in a cell.



Eggs laid in abnormal positions in cells. It is possible that in this case the queen has a blocked sting chamber. Eggs are discharged at the base of the queen's sting chamber.

Drone layer queen

A drone layer occurs when a queen becomes infertile and has no more sperm to fertilise eggs. The condition may result from a poor mating or old age. Infertile eggs are laid in worker cells but they only develop into drones, not workers. The cappings over the worker cells containing the drone pupae are bullet shaped, unlike those over worker brood which are slightly convex. The drone layer may be tolerated by the colony for months, but the number of workers steadily declines and the colony will eventually die.



Typical brood pattern of a drone layer.

A colony that is weak as a result of a drone laying queen is best united with another colony after first removing and destroying the drone layer. Requeening weak drone layer colonies is unlikely to be successful. This is because there is very little brood, no unsealed worker brood and no young adult bees present. If requeening is to be tried, give the colony at least two frames of disease-free emerging brood from another hive a few days before introduction of the queen. This will provide a some young adult bees. Then find the queen and destroy her before introducing a caged laying queen or a mature queen cell a few hours or a day later.

Laying workers

When a colony becomes queenless and has not raised a new queen, the ovaries of some workers will develop. The eggs laid by these workers are always infertile and develop into drones that are raised in worker cells. Many eggs may be laid in one cell, sometimes on the cell walls, but usually not near the cell entrance. The bees appear nervous and beekeepers will often hear a distressed roar caused by the workers fanning their wings as the hive is opened. Colonies with laying workers cannot be successfully requeened and should be united with a queen-right colony.

Robber bees

Robber bees steal, or attempt to steal, honey from hives, honey extracting equipment and facilities, exposed sticky hive components and especially extracted combs which are particularly attractive. Robbers hover around the hive entrance, joints between supers and at ventilation grids in the cover. They appear nervous and their legs protrude behind them.

Robbing begins when honey, or the aroma of honey, attracts bees from other hives in the apiary and from nearby managed and feral colonies. It is seldom a problem when bees gather plenty of nectar. When nectar is in very short supply or the nectar flow stops abruptly, robbing can be initiated when hives are opened. When robbing occurs, the beekeeper may have to cease all operations in the apiary until it stops.

Robber bees target weak colonies that are unable to fully defend themselves. The guard bees are overthrown and in severe cases the hive will be robbed of all the honey, leaving the colony to starve. Many bees may be killed. Robbing can spread quickly in the apiary. Robbers are aggressive and may attack nearby people and animals.



Robber bees try to gain entry to a hive to steal honey.

Prevention is better than cure. When robbing is likely to occur, carry out hive management, feeding and return of extracted sticky combs to hives in the late afternoon so that if robbing starts it will soon stop with the onset of cool temperatures and darkness. Avoid exposure of combs, wax scraps and other sticky items in the open. Cover supers temporarily removed from hives during routine management and combs of honey taken from hives for extracting. Reduce the width of the entrance of hives under attack. Do this with discretion according to the prevailing outside temperature and the strength of each colony to avoid smothering the bees. Never close hives completely.



Robber bees attacking hives on a pallet.

Avoid using the smoker, or use very little smoke, when robbers are active as this disturbs the guards and they are unable to defend their hive. If severe robbing occurs, it may be necessary to move the hives to another area where nectar and pollen are available.

Comb replacement

During early spring, some bottom box combs may be either empty or almost empty. This is a good time to remove old, thick, heavily gnawed, and broken combs from the hive. Combs with excessive amounts of drone cells may also be culled or placed above the excluder for storage of the honey crop. Drawn comb, foundation or a combination of both are then placed in the bottom box. Good combs are essential for maximum worker brood.

Never force expansion of the brood nest by spreading the brood, that is, by placing empty combs in the centre of the brood nest. The insulating shell of the cluster of bees can be stretched only to a certain amount and loss of brood through chilling may result. It is better to place good, clean, empty combs or foundation *beside* the brood to give the queen ample room to lay eggs.

Adding a super to a single box hive

A super of drawn comb or foundation may be added when an eight-frame single hive has about seven combs of bees and brood, and some nectar is being stored. A rule of thumb may be used: when the hive cover is removed and bees virtually bubble over the sides of the box, a super is most likely necessary. Lift the two combs containing honey adjacent to the hive walls of the bottom box into the centre of the super. This is done to encourage the bees to occupy the super as bees are mostly reluctant to work a super containing entirely foundation and sometimes even drawn combs. The gaps in the bottom box may be filled with drawn worker combs, or foundation if drawn comb is unavailable.



The colony in this single hive is expanding and requires a super.

There is no fixed time as to when a super of combs or foundation should be added to a single-box hive after winter. If it is done too soon, especially in very cold spring conditions, it may cause a set-back to the expansion of the colony. Similarly, a delay will hold back expansion of the colony and any congestion may cause the colony to swarm.

Swarming

Swarming is the way bee colonies reproduce. A swarm comprises, on average, about half of the adult bees and usually the old queen. The swarm leaves the hive in a whirring mass and temporarily clusters on a shrub, tree branch, post or building usually up to 200 metres from the parent hive. The swarm, once settled, will normally remain there until scout bees decide on a suitable permanent nesting cavity.



A honey bee swarm that has settled on a branch.

Lose a swarm and about half your nectar gathering field force is gone. So, prevention of swarming is a necessary part of good beekeeping management. Prevention is also responsible beekeeping, because neighbours do not usually appreciate a swarm lodging on their property.

The impulse to swarm is strongest in spring and early summer, and is stronger in some seasons than in others. Few swarms occur after the summer solstice.

Swarms often leave the hive on sunny mornings when the first queen cells are sealed, but this is not fixed. Swarming can be delayed by bad weather, and then again, the impulse may be so strong that the swarm will go out, leaving very young queen cells or even just eggs in cell cups in the hives.

The old queen goes with the first swarm which is known as the 'prime' swarm. Occasionally, smaller secondary swarms (called 'after swarms') may leave as young queens emerge from queen cells left in the hive. This usually happens several days after the 'prime' swarm.

After the swarm has left the hive, a virgin queen will emerge from her cell and will kill any rivals still in their cells. She leaves the hive to take orientation flights and then mating flights. Some days later, she will begin egg-laying in the original hive, but this can be delayed for up to 20 days from the time the swarm departed if poor weather delays mating flights.

After a colony has swarmed, carefully examine all the combs that the queen has had access to and destroy all but two of the largest queen cells. This ensures that the colony will have the best possible replacement queen. Two cells are left just in case one is defective.

Swarming can have a harmful effect on colonies. It causes a major loss of adult bees and a break in the brood rearing cycle until the new queen begins to lay. The colonies may be too weakened to be of much value for honey production and pollination for about half the honey season. When there are both prime and after swarms, colonies may become seriously depleted of adult bees and eventually die. Beekeepers can take steps to prevent and control swarming (as described later) in order to minimise these losses.

Some Australian states have codes of practice for beekeeping. These require beekeepers to prevent swarming and if a swarm leaves the apiary, the beekeeper should collect it so that neighbours and members of the public are not inconvenienced. Swarms can sometimes fly into the vicinity of the apiary from nearby hives and feral honey bee nests.

Signs of swarming

- Queen cells under construction, usually on the lower and side edges of combs. This is in contrast to queen cells constructed using modified worker cells on the surface of brood comb during an emergency response following loss of a queen.
- Queen cell cups (the foundation of queen cells) under construction. On occasions, these may be built and later removed. Their presence does not necessarily indicate imminent swarming. However, swarming will soon occur if cups contain eggs or larvae.

The signs of swarm preparation, as described above, will usually be accompanied by lack of comb space for brood rearing and a high worker and drone population. The presence of capped queen cells and removal of wax from the tip of queen cells exposing the cocoon are sure signs that swarming will occur very soon or almost immediately.



A capped swarm cell and cell cup (top).

Barry Cooper



Two empty queen cells. The slightly rough edges at the opening of the cells indicate that the new queens have emerged or have been removed by worker bees.

Causes of swarming

Year to year variations in spring and the availability of nectar and pollen can influence the amount of swarming. Colonies are usually more inclined to swarm when they are on build-up flora (a good pollen flow and a light nectar flow) than when they are placed on an abundant nectar flow and are storing honey. This is why swarming can be a problem in urban areas where there is a light supply of nectar and pollen available from a wide variety of flora. In some years, bees are more inclined to swarm when foraging on certain flora, for example, lupins, cape weed and particularly canola.

Congestion in the hive is a major cause of swarming. Adding a super to a single box hive will remove the impulse to swarm for some time and delay swarming until congestion builds up in the double hive. It is then necessary to divide the double to prevent it swarming, especially if queen cell cups begin to appear. Just placing more supers or foundation on a hive will not always prevent the impulse to swarm.

Colonies in single and nucleus boxes will swarm when they run out of room, unless the beekeeper takes action.



A very strong colony in a two storey hive in spring. Good management will include monitoring the hive for preparation for swarming and taking steps to prevent it.

Reducing the impulse to swarm

Some of the methods under this heading may reduce the impulse to swarm and delay swarming for a while. Eventually, more drastic action such as division of colonies will be necessary to control the bees.

Minimising the number of drones

It is natural for bees to raise a large number of drones in spring, but too many drones in the hive can be a strong inducement to swarm. Keep their numbers to a minimum by placing full sheets of comb foundation and combs with worker cells in the brood nest.

Remove combs with large patches of drone cells from the hive and render them down for wax. If this is not practical owing to a shortage of combs, at least move them from the brood nest into the honey super above a queen excluder so that the queen cannot lay in them. Cutting out patches of drone comb, or destroying drone cells with a hive tool, may lessen and slow the swarming impulse, but is of little use, as the bees only restore the damaged drone comb.

Destroying queen cells

At best, removal of queen cells can only delay the swarming impulse and is a stop-gap procedure. Examine hives every seven to eight days and destroy all queen cells and queen cell cups. Shake the bees off the combs to ensure that no cell or cup is missed. Be particularly careful because if one cell is missed, the swarm will leave the hive. Look at every comb that the queen has access to, as sometimes queen cells are almost hidden. If the swarming impulse is very strong, the bees may leave before the replacement queen cells are capped.

Queens

Young, vigorous queens play a major role in reducing swarming as they secrete more pheromones than old or failing queens do. The pheromones help to inhibit the construction of queen cells.

It is ideal to requeen colonies with young queens early in spring before swarming becomes a problem. However, at this time of the year, it can be hard to rear or buy young queens. The alternative is to requeen in autumn when queens are more likely to be available from queen breeders. A temporary measure to retard swarming is to kill the old queen and introduce a mature cell queen from another hive until a queen of better quality can be introduced. Bees inherit the swarming impulse, so don't rear queens from stock which tends to swarm excessively.

After requeening, it is essential that adequate brood rearing and honey storage space be added to the hive. Swarming may still occur under some conditions if this is not done.

Congestion in the hive

An important principle of delaying swarming is to eliminate congestion in the brood nest and the honey storage area. Placing a super of combs or foundation on a hive will relieve

congestion. However, in most situations the colony will continue to expand and will soon need to be weakened or divided to control swarming.

Remove surplus honey and give as much comb foundation as the bees can work if there is a good honey flow. A heavy honey flow keeps the bees contented and working and plays a big part in swarm prevention if the honey is extracted as soon as it is sealed.

Relieve congestion in the brood nest by taking combs of sealed brood and give them to weaker colonies. Fill the gaps in the brood nest with good empty worker combs. This helps to equalize the numbers of bees in hives in the apiary. Excess combs of honey can also be given to hives short of stores. Before transferring combs to other hives, make sure the brood is healthy as you don't want to spread disease throughout the apiary. Avoid transferring much unsealed brood to very weak colonies because they may be unable to feed the larvae and keep the brood warm.



A comb containing sealed brood, honey and pollen suitable for giving to a weak colony to assist its development, but first check that disease is not present in the donor and receiving hives.

Some combs of sealed brood may be transferred from the brood chamber to the super. This distributes the young bees throughout the hive, and most importantly, gives the queen additional egg-laying room in the brood chamber. The gaps in the chamber are filled with good empty worker combs or foundation. Avoid transferring combs with eggs and young larvae above a queen excluder as this can stimulate the superseding impulse to raise queen cells in the super which will then lead to swarming.

Give strong colonies some relief by swapping their position with weaker colonies. This serves a dual purpose of reducing the number of bees in the strong colonies and building up the weaker ones. The field bees from the stronger colonies return to the original site and enter the hives containing the weaker colonies. It is advisable that this method is only practised during a nectar flow. Examine the weaker colonies to determine the reason for their condition. Make sure the brood is healthy. Mark weaker hives for requeening if the queen is not laying well as compared to other queens in the apiary.

In most cases these actions will only delay swarming and it will become necessary to divide the colony.

Division of colonies or artificial swarming

Methods known as 'artificial swarming' are used by beekeepers to divide the colony in a way that the impulse to swarm is removed. The aim is to weaken the parent colony by separating much of the brood and many young nurse bees from the queen and the older bees. The division should be done when the first signs of preparation for swarming are observed in the hive.

The bees, brood and comb split from the parent hive can be used to increase the number of hives kept. If additional colonies are not required, the parent colony and the division may be united after the swarming season has ended. This will create a good populous honey gathering colony.

The methods described below require the beekeeper to find the queen. Notes on this are found in chapter 12. *Requeening colonies and rearing queen bees.*

Dividing, or weakening the parent colony, can be achieved by splitting off one or more nucleus colonies. A young queen or a queen cell is given to each nucleus. Alternatively, each nucleus is allowed to raise its own queen. Notes on splitting nuclei are found in chapter 4. *How to get bees and increase numbers of colonies.*

In a second method, the parent hive is moved a little to one side. A single deck hive containing a full set of combs is put in its place. One of the empty combs from the single hive is interchanged with a comb containing mostly unsealed brood, and some honey, from the parent hive. The queen is also transferred to the single hive. Some bees on some combs of the parent hive are then shaken in front of the new hive, allowing them to run in. If the combs are shaken gently, sufficient bees, chiefly young ones, will be left in the parent hive to care for the brood. This should be done with discretion according to weather conditions because, if the weather is cold, some of the brood may become chilled if insufficient bees remain.

The new hive now contains most of the field bees and the queen (which normally constitute a swarm) plus a comb of unsealed brood (with some honey) to induce them to remain. Keep an eye on this hive as it may require a super as the colony expands and fully occupies the box.

The two hives are left together, at slight angles, so that the entrances face slightly different directions. They may be re-united after the swarming season is over. If increase is desired, the parent hive may be removed to another part of the apiary.

The parent hive is now queenless. Introduce a new queen or allow the bees to raise a queen. If a new queen is not to be introduced and queen cells are present at the time of division, choose two well-formed queen cells and destroy the remaining cells. Take care not to shake or jar the comb and damage these cells and developing queens. Later, inspect the hive to see that a new queen has started to lay normally.

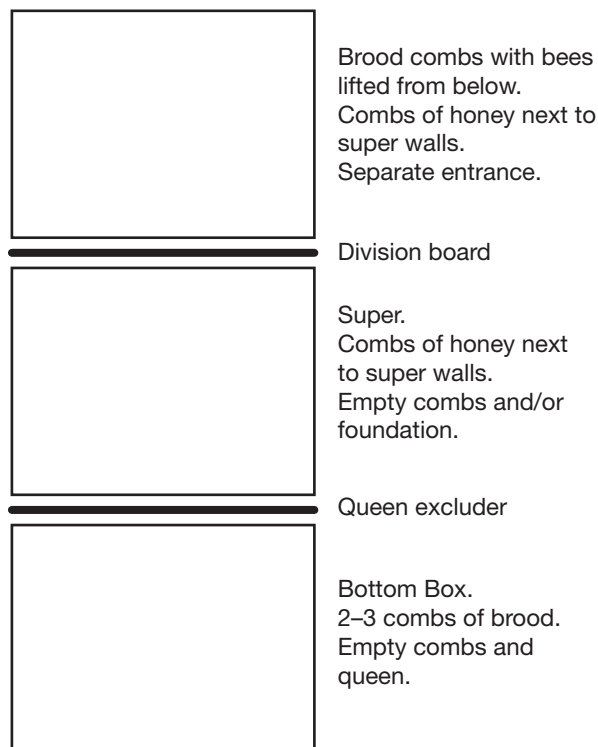


Figure 5. A method of swarm prevention. Division of a two-storey colony and introduction of a third box, queen excluder and division board.

The third method, probably the best, involves splitting a two-storey hive that has a queen excluder (Figure 5). Leave two or three combs of brood in the bottom box. Place all the other combs from the bottom box, with bees on them, in a spare super. Fill the gaps in the bottom box with empty combs and foundation, and then put the excluder on the box. Make sure the queen is in the bottom box. Place a super containing combs of honey, empty combs and some foundation on top of the excluder.

Next put a division board with its entrance at the rear or side on top of what is now a two-storey hive. Place the super that contains the remaining brood and bees above this board and introduce a capped queen cell or caged laying queen immediately. Inspect the super seven to ten days after introduction of a laying queen or 12 days after a queen cell was introduced to see if a laying queen is present. Check that there are adequate honey stores, and feed if necessary.

Later still, after the swarming season, if desired, the two colonies can be united as described below under the heading *Uniting colonies and splits*, or managed as two separate hives.

The method is particularly useful for suburban beekeepers who can only keep a certain number of hives as it allows division of colonies without increasing the number of hives kept.



A division board with ventilation holes and entrance.

A fourth method is to take all but one of the combs containing brood away from the colony. Gently shake the bees and queen from these combs into the hive. Replace the combs with empty drawn comb, or with frames containing foundation. The one comb of brood left should preferably contain mostly unsealed brood. The combs of brood removed may be used to strengthen weaker colonies.

In areas, such as some urban areas, that have good supplies of pollen with a light nectar flow, the bees can rear a large amount of brood. In these conditions, the splits taken from hives may need to be given a super to prevent them from swarming. In fact, it is a good idea to monitor both the parent colonies and splits to determine any potential swarming tendencies.

Some beekeepers use the Demaree method, or a variation of it. The method is described on several internet sites and is not fully described in this book. Essentially, brood and young bees are separated from the queen and the brood box, but are retained in the hive. As such the colony is not weakened and may later swarm. To prevent this, the process is repeated, or bees and brood are removed to form another colony or a number of nucleus colonies.

Uniting colonies and splits

If increase of the number of colonies is not required, the parent colony and split can be united to form a populous honey producing unit. The time to do this is after the swarming season ends and will vary according to the district. In areas where there is no strong nectar flow, but good nectar and pollen supplies to support substantial brood rearing, uniting may need to be delayed until the summer solstice. These conditions can occur in urban areas and the urban fringe. Uniting too early can cause the bees to prepare for another round of swarming.

Colonies have their own distinct odour and will fight if suddenly joined together. The newspaper method of uniting allows bees to gradually become acquainted and mix without fighting. It is usual for the weaker colony to be placed on the stronger colony.

To unite the two hives, remove the lid of the hive containing the strongest colony and place a single or double thickness of newspaper over the frame top bars and box edges. Make several small perforations in the paper with a small nail or the sharp tip of the hive tool. If it is windy, place a hive tool on the paper on the windward corner or edge of the box to keep the paper in place. Take the box containing the other colony off its bottom board and place it on the newspaper with its lid intact. Gently withdraw the hive tool.



The first step in uniting two colonies. Two sheets of newspaper are placed on the hive.



If a nucleus colony is to be united with a hive, place an empty super on the newspaper and transfer the combs from the nuc into the super and fill the spaces with comb or foundation.



The final step of uniting is completed.

Delay uniting of colonies if the weather is very hot because there will be little if any airflow in the top box and the bees may suffocate. It is best to wait until a cool day or a cool evening. If this is not possible, use a small stick to lift the top box a little at one end to provide ventilation until the bees chew through the paper.

When quite an amount of gnawed newspaper is seen at the entrance of the hive, it is usually safe to assume the two colonies have united. The two queens in the united hive will fight until one dies. If the beekeeper prefers one queen over the other, the queen not required should be found and destroyed before uniting the colonies.

Care needs to be taken when uniting hives. Foragers returning from the field and not finding their hive because it has been moved and united with another will enter any nearby hives in the apiary. If there are no other hives, the foragers may become a nuisance to nearby people. To prevent this, move the two hives to be united a little closer to each other each day until they are almost touching, then unite them.

7. Summer operations

The majority of honey flows (*nectar flows*) occur in the warmer months of the year. For many districts, this occurs from mid spring to the time of preparation of colonies for winter. The contents of this chapter apply to this longer period.

Apart from the enjoyment and wonder of keeping bees, one of the aims is to have a sequence of honey flows, but this is not always possible. Perhaps two or three decades ago it was thinkable, but now because of many factors in nature it is not.

Hobby beekeepers who keep a small number of hives in, or adjacent to, towns and cities often find that there is sufficient flora to sustain their colonies and to provide enough honey for their needs. They do not need to move hives. On the other hand, commercial and semi-commercial beekeepers practice migratory beekeeping. This type of beekeeping is the movement of hives from one district to another, to make the most of nectar and pollen flows.

Some plants yield both nectar and pollen, others yield nectar but no pollen, or vice versa. The migratory beekeeper needs a thorough knowledge of plants, their flowering habits, and their nectar and pollen yield potential. Hobby beekeepers in cities and towns should also be aware what flowering plants are in their own particular locality.

The majority of Australian honey, about 85%, is produced from Eucalypts and some members of the genus *Corymbia* that until the mid-1990s were classified as Eucalypts. Different species flower at different times of the year. Many are sporadic in their flowering habits, and intervals between useful flowerings may be several years. There may be plenty of blossom in a district but it may not yield any nectar. While in another district, the same species may flower and yield nectar freely. These variations may be caused by factors such as soil type and rainfall.

For both the commercial and hobby beekeeper who are intending to move hives to a potential honey flow, a delay of a day or so can result in a part of the nectar yield not being collected. Careful planning and frequent monitoring of flower buds and plant health are necessary.

Preparing hives for transport

Extract surplus honey from the supers to reduce hive weight, but be aware that sometimes honey flows, for a number of reasons, fizzle out quickly or don't even happen. Be prepared to leave the bees enough honey stores, just in case the honey flow fails. Preparing for transport should be done a few days before the move, especially if sticky, extracted combs are to be placed back on the hives. Give the bees time to remove honey from sticky combs and store it in cells.

If frames are loose, push them to one side of the box and wedge them firmly with a small wedge of wood. Frames bumping around during transport can easily squash bees and even worse, the queen. If colonies are strong, remove the hive mats to let the bees cluster in the migratory cover.

Ensure hive fasteners are in place to securely fasten together the bottom board, all boxes and the hive lid to prevent them from twisting and coming apart. Use masking tape, or similar, to block any holes and cracks in hive material that will permit bees to escape. During a shift many angry bees can escape from a hive even if they only emerge one at a time.

When it is time to load the hives, that is when the bees have stopped flying, close the hives with the fixed entrance closure. If there is no fixed closure, use strips of foam rubber or folded insect screen pushed firmly into the entrance so that they do not become loose during transport.

Transport of hives

Movement of bees is carried out almost entirely at night when foragers have returned to their hive. Moving hives when bees are foraging will leave a large number of bees behind thereby weakening the colony. Bees left behind may become ill-tempered and a nuisance.

The length of time that bees can be safely confined to a hive depends on the strength of the colony and weather. Bees get excited when the hive is closed and can generate considerable heat as they panic and attempt to get out. Colonies may smother if kept in a closed hive for too long in hot weather. If the night is very hot, postpone the move. If possible, wait until a cool change has arrived. Do not transport very strong hives for long distances in hot weather, either by day or night, except at the discretion of an experienced beekeeper.

Hives develop what is known as a 'sappy' condition when brood rearing conditions are good. This condition is caused by heat generated by brood, a steamy atmosphere created by the feeding of larva, and by ripening of nectar and storage of honey. Bees travel much better if they are allowed to ripen nectar before hives are moved. Unripened nectar can splash out of the cells and onto bees during movement of hives, causing excited bees, generation of more heat and drowned or smothered bees. Many beekeepers prefer to close their hives in the early morning before daylight while it is still cool and the nectar has been ripened. The damaging effects of having to 'smoke' bees into the hives can be greatly reduced.

Close up the hives after the bees stop flying, or on cold days when bees are not foraging. It is best to load closed hives across the trailer or truck, parallel to the axle and, if possible, in layers of even height so the draught can pass across the covers of the bottom layer of hives from front to back of the load. Contrary to this, mechanical loading has accelerated a trend towards loading hives in the direction of travel.

Loading bees onto a hot truck or trailer is like putting them onto a hot plate. Park the vehicle in the shade. If the tray of the vehicle is still hot when time to load arrives, throw some water on it to cool it down.



Sappy conditions smothered most of the bees in this hive during transit. Originally a populous 3-box hive, it was quickly reduced to a 4-frame nucleus. Note the dead bees on the bottom board.

Secure the hives on the vehicle with approved restraints that conform to Australian standards. State and territory road transport authorities have on-line information about securing loads. It is an offence to have unsecured loads. Bees in hives that fall from vehicles become agitated and are a danger to the public.

If a long distance is to be travelled, a supplementary water ration, about one cupful per hive, may be given through the ventilation holes (if present) in the hive cover after the hive has been closed. A spray knapsack is useful for this purpose but make sure it has not been used for applying agricultural chemicals. If the night is moderately hot, quickly hose the load, or if this is not possible, douse with a few buckets of water. This plus the draught travelling through the load will help keep the bees cooler.

Get under way quickly once the closed hives are loaded, regardless of the time at which they are being transported. Do not stop the vehicle once on the road. Movement and vibration cause bees to cluster, but once vibration ceases, they break cluster and start to 'race' and become overheated. This is usually when the damage occurs. Colonies may completely smother and combs may collapse very quickly. If a short stop cannot be avoided, keep the motor of the truck running to maintain enough vibration to prevent the bees from breaking cluster.

At the destination, park the vehicle in the shade where practical. Unload the hives and release the bees as quickly as possible. Use a little smoke when opening each entrance to keep the bees calm. Stand at the side of the hive as it is opened because bees will come out with a rush if the colony is strong. Splash a cup of water on the front of the hive and over the released bees in hot weather or if bees seem distressed. This gives them an immediate supply of water and helps them to return to normal quickly. Before you leave the apiary, check that all hive entrances have been opened.

Beekeepers who intend to shift hives should ensure that vehicles and trailers are in good condition. A break down could leave hives standing in the sun and this will do more damage to the bees than if they were left standing at night.

Moving bees with open entrances

Moving hives without closing the entrance is done by many commercial beekeepers, but only during the hours of complete darkness. It allows bees to circulate fresh air into and throughout the hive and remain relatively cool.

Loading hives on the vehicle should start two or three hours before sundown. All returning field bees fly onto the load and into hives. The front row of hives is placed so that the hive entrances face to the rear of the vehicle. The back row should have their entrances facing towards the front. After dark, the hives are transported to the new site arriving prior to sunrise with unloading done in early light. Bees tend to be aggressive when unloaded in darkness.

There is a danger that the vehicle loaded with open entrance hives may break down in towns, near houses or on busy roads. If this happens, the truck or trailer must be towed to a safe place before daylight to prevent bees becoming a nuisance to other people. Responsible transport of hives with open entrances requires the use of a bee-proof net made from knitted shade cloth that will cover the entire load. This will minimise the risk of escaping bees. Take care when using nets in hot weather as bees may overheat. Hosing the load will help to reduce the temperature.

Carry enough fuel, food and drink for the entire journey to eliminate stops at service stations. Bees will be attracted to the lights, where they become a nuisance to customers and service station personnel. Vehicle stops must be made well away from street and other lights.

Moving hives with open entrance is not recommended to those who have not had a lot of experience in migratory beekeeping. The Australian Honey Bee Industry Council has developed a document *Best management practice for the transportation of open entrance beehives*. The document is available on AHBIC's website (see chapter 20. *Additional information* for website details).

Loading bees

Make sure the equipment you use conforms to work health and safety laws. Consult your WorkSafe or WorkCover authority in your state or territory. A Safe Work Method Statement may need to be developed for activities considered to be a safety risk, such as lifting hives. Details of laws applying to trailers and vehicles for towing should be ascertained before purchasing them.

Loading trolley and ramp

These are possibly sufficient for the beekeeper with few hives. Hives are wheeled up the ramp and can be placed in position on the tray of the vehicle or trailer without any more handling. Hive trolleys may be purchased at beekeeping equipment suppliers. There are various designs of trolleys and it is a good idea to consult beekeepers who use them. Trolleys should have large pneumatic wheels of around 45 centimetres diameter to cope with uneven ground and furrows.



Hand trolleys suitable for moving hives. Note the large diameter wheels.



The low height of the trailer makes wheeling hives onto the tray of the trailer reasonably easy.



This hive barrow is used to move heavy supers of honey in the honey extracting facility. It can also be used to move hives when used in the upright position.

Hydraulic or manual tail gate

This is another popular method of loading bees, supers and drums of honey. The tail gate on the transport vehicle is lowered to ground level, loaded with hives or honey and is raised hydraulically, electrically or manually to tray level. A trolley is then used to position the item on the vehicle. The tailgate is then folded away into the travelling position.



This manually operated tailgate lifting device easily lifts these hives.

Mechanical loaders for large operations

Forklifts, suitable for rough terrain, are a quick and efficient way of loading hives and other items in the apiary. They are equally useful in the honey extracting facility for moving supers of honey and containers of extracted honey.



Forklift loading a pallet of four triple storey hives.



Four triple storey hives on a pallet. Each pair of hives is fixed to the pallet by metal strap and Emlock fastener. Cleats on the upper side of the pallet also prevent movement of hives.

Boom loaders are a popular loading device used by commercial apiarists. They alleviate the back breaking lifting of heavy hives and honey supers and are ideal for one person operations.



Split boom loader. Note the careful use of tie down straps and ropes to secure the load.

Moving bees short distances

Field bees will drift back to their old location if hives are moved less than five kilometres from their present position. If a hive is to be moved to a site within the bees' present flight range, it should first be moved to a temporary site approximately ten kilometres away for about four weeks and then moved to the intended site. This will stop the majority of foraging bees from returning to the original hive site.

Where hives are to be moved a short distance, such as to a different position in a yard, this is done by moving the hive about one to two metres each day so that bees returning from foraging will be able to find the hive in its new position. The ideal time to do this is during the cooler months when the clustered bees are relatively inactive, but it may be done successfully at other times.

Water for bees

Bees require water for their diet, for production of larval food, to dilute honey and to maintain hive humidity.

In hot weather, bees may use more than one litre per day for cooling the hive. In some parts of the world in very hot, dry conditions, a very strong colony may use up to four to five litres per day. Small droplets of water are placed on the comb surface, in open cells and in depressions in the wax on frame top bars. The water is evaporated by bees fanning their wings. Water may be held in reserve in the crops of waiting 'reservoir' bees until it is required.

An inadequate supply of water can cause colonies to overheat and suffocate. There may be melt down of combs. Even if bees don't die, the brood may perish or not develop normally.

Bees prefer to collect water from moist sand or soil at the edge of the main body of water at creeks, rivers, dams and other similar natural sources where there is little or no risk of being drowned.



Bees collect water from damp surfaces at the edge of a body of water.

For large apiaries, a dam or alternative water source should be no closer than 30 metres from the nearest hives and preferably 100 metres away because a large concentration of bees at the water's edge may then cause confusion in the apiary. The water should not be further than 200 metres away as sometimes water carriers have to battle against strong winds and hot conditions. It can become impossible for them to cope in these conditions and they may be lost in the field if water is not reasonably close at hand.

In some states, beekeepers are required to supply water for their bees. Even if this is not required by law, or apiary codes of practice, it is responsible management.

Containers of water are best placed in shade and it is essential to provide floats for the bees to land on. This will minimise the risk of bees falling into the water and drowning. Pieces of cork, slats of wood, branches and interlocking foam floor mats attainable from hardware outlets are suitable. To prevent birds and animals taking water, especially in dry and desert areas where a natural water supply is not available, the tanks and other containers can be covered with weldmesh or similar material. Water and the containers should be kept clean.



Water supplied for a commercial apiary.

Locate the water so that the bees have a direct flight path from the hives to the water source. More time and energy will be spent by bees if they have to fly around obstacles such as buildings and hedges. This extra effort required of the bees can be critical in an extreme heat wave. A flight path through broken shade, especially during the hotter hours of the day will be helpful.

If the apiary is large and the surface of the water source is small in size, the activity of watering bees at the water's edge can become chaotic. If the water has been provided for farm animals, the concentration of bees can prevent animals from drinking.

For hobby apiaries of a few hives, the water can be placed about three to four metres from the hives. Alternatively, a boardman feeder, or a variation of it, can be used to supply water direct to the hive. This feeder consists of an inverted glass jar and tray contained in a wooden box that partially sits in the hive entrance (see feeding bees in chapter 6. *Spring management*). The entrance must be wide enough to accommodate the feeder and still have adequate space for foragers to come and go and for good airflow into the

hive to avoid overheating and smothering. The jar should not be exposed to lengthy periods of direct sunlight as this may make the water too hot. Bees prefer water that is below 32°C and will not collect it if it is hotter than 38°C. During hot weather, the jar will need to be refilled with water daily and most likely more frequently.



A method of supplying water at the hive entrance, similar to the Boardman feeder.

Steve Demchinsky

Water can also be provided in trays or pans. To prevent drowning, floats should be provided for the bees to land on (as described above). Water in a shallow tray is more likely to become hot than a deep body of water will.



A chicken watering device adapted for bees.

Maree Belcher



Bees watering in a tub of water. There is no need for floats as the bees land on the rocks.

Barry Cooper



Water with floats provided by hobby beekeeper.

Especially in a hobby backyard situation, water should be available in the apiary before hives are moved on site. If water is unavailable, the bees may 'lock-on' to another source and become a nuisance to nearby neighbours. When this happens it is difficult to make bees shift to the supply provided by the beekeeper.

A water supply should be available all year, otherwise bees will find water elsewhere. They will gather water from ponds, swimming pools, wet surrounds such as paths adjacent to pools, lawns and other foliage still wet from being watered, damp washing and water provided for animals. In these situations, bees can become a nuisance to neighbours.

Bees hanging out

On occasions, during warm to hot days, many bees may be seen clustered around the entrance and on the front of the bottom box and super(s). This natural event particularly occurs during the afternoon. If the front of the hive is exposed to full sunlight, the bees may move to a shaded side of the hive. They usually move back into the hive during the cool hours of the night and early morning.

The bees move outside the hive to enable the colony to better regulate the temperature of the hive. The behaviour may also be caused by some overcrowding of bees in the hive and shortage of comb for honey storage. Often, the addition of a super of combs will remedy the situation, especially if the bees are working a strong nectar flow. Extracting honey from capped combs and returning the empty combs to the hive will also give the bees more storage room. Deep bottom boards also allow bees to cluster inside the hive and away from combs.



Bees clustered on external surfaces of hives

The broodnest should also be examined to check that there is sufficient comb space for brood rearing. When there is no more honey storage space in the super(s), the bees will store honey in the broodnest combs. This will reduce the number of cells in which the queen can lay eggs. In extreme cases, there may only be one or two combs available for brood rearing. If this is allowed to continue, the number of bees will decrease and the colony will weaken. It will then be unproductive and may not survive the winter if there are insufficient bees. Excess combs of honey should be removed from the broodnest, extracted and returned to the hive for the queen to lay eggs.

Preparing bees for extreme heat

Shade over the hive is important in summer, particularly during the hottest part of the day from early to late afternoon. Even shade over the hive for a few hours at any time of the day is better than no shade.



Broken or mottled shade is essential during summer.

Ideally, hives should have some shade in the hot months of the year and full sunlight in the cool months. This is not easily done when a hive is permanently located in the one position. A deciduous tree can provide shade in summer and let sunlight reach the hive in winter.

Where hives are in full sunlight, the bees can be assisted to survive periods of extreme heat. Partial shade can be achieved by placing a spare hive cover on top of the existing hive cover. Similarly, the side of the hive exposed to the sun may be shaded by a sheet of hardboard or a car windscreen heat shield. The metal cover of a hive lid painted white will reflect more heat than an unpainted lid.

The effect of radiant heat from the hot ground around the hive can be reduced by placing the hive on bricks so that the hive is about 150 mm from the ground. Do this well before summer. Don't do it on a day of extreme heat as it will upset the water gathering bees' flight pattern and slow down the incoming supply of water.

In extreme heat, beekeepers can assist bees to cool their hives by gently spraying water on the external walls of the hive and on the ground surrounding the hive. The bees may also gather this water from around the hive entrance. This is particularly useful if the bees have stopped gathering water due to the very high air temperature.



A car windscreen heat shield is used to shade this hive.

Steve Demchinsky



Another hive prepared for extreme heat by shading the top and side of the hive that will be exposed to the sun at the hottest time of the day. The hives have also been raised from ground level.

Jason Burke

Bees keep the internal temperature of their hive at approximately 35°C. They do this by circulating air in the hive, evaporating water and expelling the hot air through the hive entrance. Lifting hive lids or skewing hive boxes sideways to allow more air into the hive will upset this process and simply allow entry of more hot air. Opening hives for routine management should be postponed on days of extreme heat.

Adding a super for honey production

A strong colony of bees with access to a good nectar flow can soon run out of comb space in which to store honey. As a result, part of the potential honey crop is not produced simply because there is no room to store it. In some cases, the colony may choose to swarm outside the normal swarming season due to the congestion in the hive. The solution is to add a super of combs or foundation. Many beekeepers prefer to 'under-super' by placing the added super under the box of honey. Doing this means that the bees have less distance to travel in the hive to store the honey.

Bees are sometimes reluctant to move into a super containing only foundation. Take a comb containing honey from a box below and place it in the centre of the super of foundation. This will act as a bait comb and encourage the bees to draw the foundation.

An alternative to adding a super is to extract some of the honey combs provided they have been capped by the bees. The empty, sticky combs are returned to the hive to be refilled.



A two-box hive in desperate need of a super.

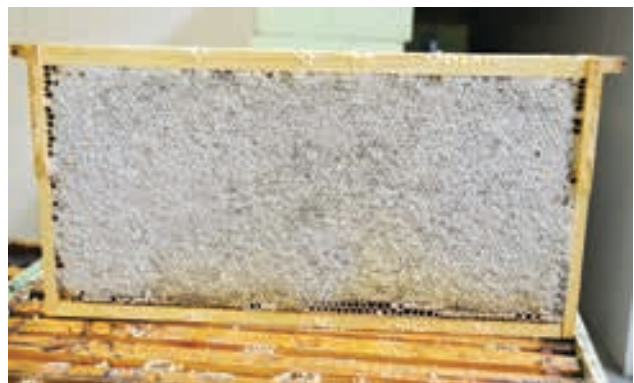
Harvesting honey

Before taking honey from a hive, ensure there is enough surplus honey to harvest. The amount to be left for the bees will vary according to the strength of the colony, time of the year and prospects for another nectar flow. It is essential that enough honey is left in hives for winter. If the season is good, honey can be taken from the hive on more than one occasion.

If a nectar flow is in progress and is expected to continue, then surplus honey may be taken. Even then, beekeepers should be taking honey on a shared basis with the bees. If eight combs are ready to be extracted, take four, extract them and return the sticky combs to the hive. If the bees fill them again, it will be safe to extract the other four combs left previously. Some beekeepers who manage triple box hives remove one box of combs for extracting and leave the other box of honey in case future nectar flows fail and for winter feed. Avoid taking honey when nectar is in short supply and robber bees are likely to rob honey.

Combs of honey that are fully capped contain ripened honey and are ready for extracting. Combs that are partially capped may be taken under certain conditions. Experienced beekeepers often extract combs that are $\frac{2}{3}$ to $\frac{3}{4}$ capped.

No fixed rule can be laid down as to when combs that are not fully capped may be taken for extracting. Much depends on the source of nectar and on atmospheric conditions at the time the nectar is gathered. More caution is required with ground flora honeys, such as clover and blackberry, as they generally have higher moisture content than some Eucalypt honeys. In hot, dry conditions, some dense Eucalypt honeys, such as red box and yellow box, are considered ripe when $\frac{1}{3}$ to $\frac{1}{2}$ of the comb is sealed. Other honeys may need to be capped more, and combs may have to be almost completely capped in cold climates or when the weather is cool, wet or very humid. When there is doubt, it is better to let the combs be sealed more than necessary rather than risk extracting the honey when it is not properly ripened.



A nice fully capped comb of honey suitable for extracting.

Usually, the more fully the combs are sealed, the better the quality of the honey. Unripened honey will have a high moisture content, and the density and flavour is inferior to that of ripened honey. It can granulate quickly and ferment.

Avoid extracting honey from combs that contain brood. Combs in bottom boxes are not usually extracted.

When taking honey from three-box hives, remove the combs of honey first from the top box and then the middle box, and replace them with empty combs in the reverse order. Work on the hive is then completed in the one operation.

Removal of bees from honey combs

There are several ways of removing bees from combs of honey before they are taken from the apiary for extracting.

Shake and brush

A simple and inexpensive way is to shake the bees from each comb back into the hive. Shaking bees is quite easy and effective, and for a hobby or sideline beekeeper this would be the preferred method.

Gently smoke the hive. Use the hive tool to gently prise the honey frames apart and lift one out, being careful not to roll or squash any bees. Stand this frame against the side of the hive near the entrance. There is now a gap between two of the remaining frames. The gap is made bigger by removing the next frame. Hold this frame firmly by the top bar lugs. A sharp downward flicking motion with a snap of the wrists into the gap in the honey super will remove most, if not all the bees. They will fall from the comb into the gap.

Any bees remaining can be removed using a soft bee brush, either nylon or hair type. Place each brushed comb into a spare super which is kept covered to prevent access by inquisitive or robber bees. Have a bucket of water on hand for washing the bee brush to keep it free of honey. Bees dislike being coated with honey by a sticky brush.

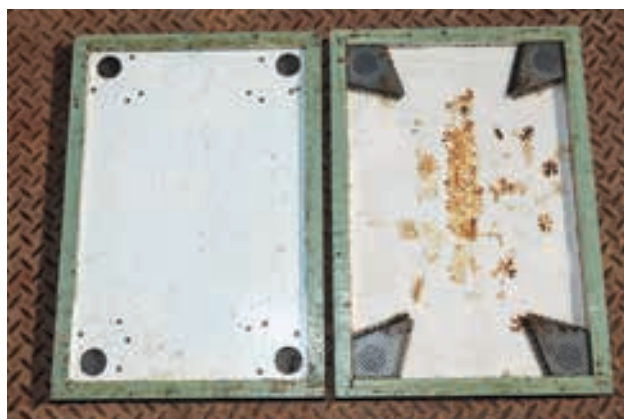


Bee brushes.

Escape or clearer boards

The bee escape is a one way device that allows bees to leave the honey super but not return to it. The common clearer board has four escape devices, one in each corner. Alternatively, a single 'Porter' bee escape is placed in the centre of a board. All these boards work better in cooler conditions rather than hot conditions.

In the late afternoon, temporarily remove the super of combs to be extracted from the hive. Then put a super of empty combs in its place above the brood nest. Place the clearer board on top of this super, making sure it is the right way up. Place the super of combs of honey back on the hive above the clearer board. Inspect the super containing the combs of honey after two days to see if the bees have left the combs. If only a few bees remain, the combs may be removed from the box and then brushed to remove the straggler bees. If only a few bees have left the super inspect why, and then provide more time for the process to work.



A clearer board. Left: upper side where bees enter the escape devices. Right: lower side where bees exit the devices.

Escape boards don't work when brood is present in the honey super because the bees will not leave the brood. The super and hive cover above the clearer board must be in good condition, and most importantly, must be bee-proof. If not bee-proof, robbing bees can enter the super and steal the honey.

Take care when using this method during hot weather as the colony cannot control the temperature in the supers above the escape board. This could result in melt down of combs.

Mechanical bee blowers

Bee blowers used by commercial beekeepers provide a fast, efficient means of removing bees uninjured from supers. The blower consists of a motor driven impeller that generates a stream of air that is directed along a flexible plastic hose and nozzle and then between the combs. It works like a vacuum cleaner in reverse. A disadvantage of this procedure is that if a queen has gained access to a honey super, she could be blown out and lost to the hive.

Blowers may be petrol or electric driven. A generator is necessary to power an electric a blower used in an out apiary. Blowers may be fitted to trolleys with wheels and moved around the apiary.



Two types of bee blower, electric (front) and petrol (back).

The super of combs to be extracted is placed on its end on top of the hive. A frame is removed and the remaining frames are prised apart using the nozzle of the blower as the bees are blown out. The bees generally fly when they

are blown from the super, but care should be taken not to squash bees that are blown onto the ground in front of the hive.

Robber bees can be quickly attracted to supers of honey standing on hives prior to blowing and immediately afterwards. Cover the supers from which bees have been removed to prevent robbing. Better still, honey should not be removed in this way if there are robber bees in the apiary.

Comb Honey

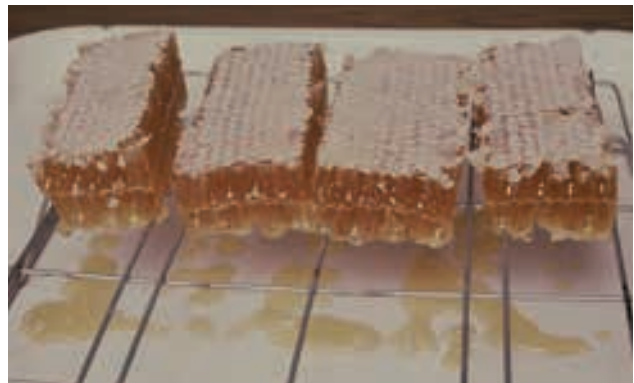
The sight of white, or almost white, comb honey is attractive and appealing to the average consumer. In fact, many people enjoy eating comb honey.

Production of comb honey is not difficult, but good planning will help to ensure an attractive product is achieved. Strong healthy bee colonies are essential. It is extremely important to have an excellent nectar flow and an extended period of fine weather for bee foraging. These conditions will allow colonies to build uniform new comb, fill the cells with honey and cap them as quickly as possible.

For bees to produce an attractive product that is pleasing to the eye, the foundation and preferably the frames should be new. The honey produced should not candy quickly as most consumers want the comb to contain liquid honey.

When the comb is fully capped, take it out of the hive without delay to prevent staining by bees walking on the comb surface over a period of time. The comb should not contain brood or pollen. If brood is a problem in the production of comb honey an excluder may be used to confine the queen to the brood box.

Cut comb honey is produced by cutting the fully capped, white, comb of honey into squares or rectangles. It is first necessary to withdraw the wires from the comb. A warm, sharp knife is then used to cut the comb. The pieces are placed on a cake rack to allow the sticky edges to drain overnight before packaging them in clear, sealable, leak-proof, food grade plastic containers available from beekeeping equipment suppliers.



Draining cut comb honey.

Chunk honey is produced by cutting newly capped honey comb into suitable rectangular sizes using the method described above. There is no need to clean up the sticky edges as the pieces of comb are placed vertically into a jar which is then filled with extracted honey of the same floral type contained in the comb.

Comb honey, including combs to be cut for comb honey and chunk honey, can be frozen to kill all life-cycle stages of wax moth and small hive beetle (See chapter 15. *Pests and enemies of bees*). Larvae of these pests can quickly ruin comb and make comb honey products unsaleable and unusable. Freezing may cause some floral varieties of honey to candy. Avoid damage to product labels by fixing them to dry containers after thawing the product.

Cut comb honey and chunk honey for sale must be labelled. Consult your local government public health unit to determine the legal requirements about food safety, packaging and labelling of these products.

8. Extracting honey

Extract combs of honey taken from hives immediately. Larvae of the small hive beetle can quickly ruin the combs and the honey they contain. Beetle eggs and very small larvae are difficult to see. Although there may be no apparent sign of infestation when the combs are taken from the hives, it doesn't take long for major damage to occur (See chapter 15. *Pests and enemies of bees* for more information).

Uncapping the comb

The wax caps (cappings) over the honey cells must be removed before the honey can be spun out. A hand held uncapping knife is specially designed for the purpose. It is 200 mm to 300 mm long with two cutting edges bevelled from one side and with a straight or offset handle. The knife should be sharp and very hot to prevent damage to the delicate cell walls and to prevent cappings sticking to the blade.

Hot water knives are heated by placing the blade in simmering water. Ideally, two knives are used alternately because they lose heat. The blade of the knife not being used is heated in the simmering water. Uncapping with these knives is less practical and slower to use than other types because of the frequent need to swap knives. It is also good idea to have a clean cloth on hand to quickly dry-off the knife as it is removed from the water and prior to uncapping the comb. This will prevent residual water on the knife from mixing with the cappings.

The electrically heated knife is fitted with a heater element incorporated in the knife blade and can be used continuously, provided power is available. Although this knife is the most expensive option, in practical terms it is by far the best.

The steam heated knife is also designed for continuous use. A copper tube soldered to the back of the blade of the knife is connected to a steam source with a flexible rubber or plastic tube. The steam leaves the knife through a second flexible tube and is condensed in a container of cold water. A steam boiler is required for this knife, but suitable approved boilers were not available for hobby beekeepers at the time of writing. Larger boilers suitable for sideline and commercial beekeepers are available, but the beekeeper must determine what regulations apply to their use in the relevant state or territory (See below under heading *Steam*).



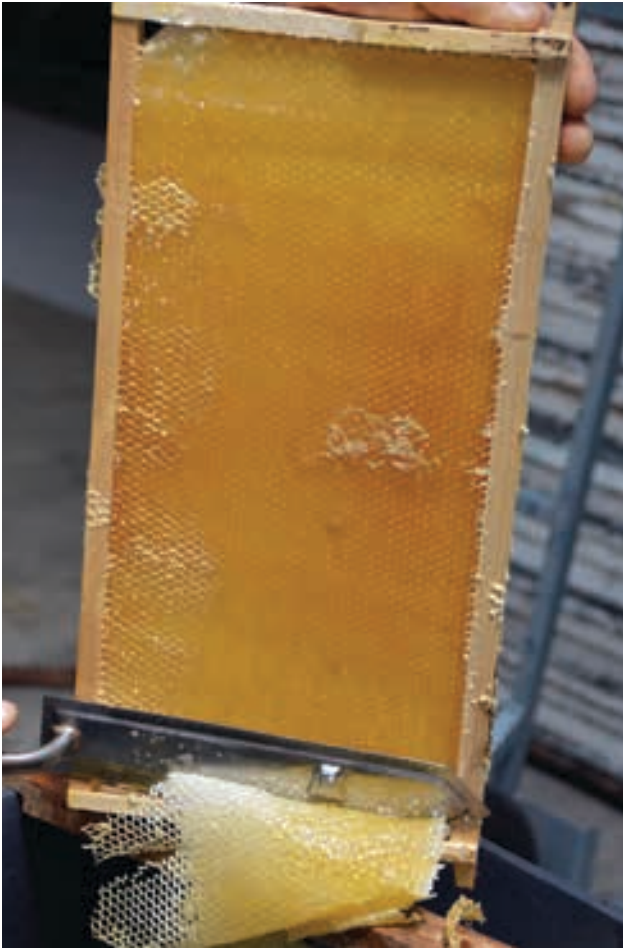
Uncapping knives. From top: steam, hot water and electric.

When uncapping with a hand held knife, rest the frame in a vertical position on an upward projecting stainless steel screw or spike protruding from a piece of wood that spans the gap over the cappings receptacle. The spike allows the frame to be rotated and reversed without lifting it. Grip the frame so that the thumb is lying along the end bar which is now uppermost.

Keep the bevelled edge of the knife towards the comb. Uncap a small part of the upper end of the comb with an upward cut. Next, uncap the whole side of the comb with a downward, slightly sawing motion. The depth of cut is guided by the top and bottom bars of the frame. Tilt the vertical comb slightly forward so that the cappings drop away from the comb surface as they are shaved off. Turn the frame and uncap the other side of the comb.



Uncapping with an electric knife. Keep the bevelled edge of the knife towards the comb.



The uncapped comb cut back to the top and bottom bar of the frame.



If upward cutting is preferred, keep your thumb, finger and arm back from the edge of the comb so that if the knife slips your hand is not accidentally cut.



Comb scratchers.



Comb scratcher in use.

Combs should always be cut back to the top and bottom bars of the frame as this keeps them an even thickness. Any patches of caps not removed can be cut away using the tip of the blade or a cappings scratcher designed for the purpose. Avoid uncapping any patches of sealed brood. Ideally, combs containing brood should not be taken from hives for extracting. Use the uncapping knife, or a clean paint scraper, to remove burr comb on the top and bottom bars of the frame so it can fit into the extractor basket.

The cappings scratcher is a small hand tool with multiple long prongs used to 'scratch' open cappings of honey cells. These are available from bee goods suppliers or a good home made version can be made from a shearer's comb. The scratcher is used by some beekeepers as an alternative to the uncapping knife. The caps are not totally removed, but the bees will later remove them and repair the comb. The scratcher will result in far more cappings in the extractor and strainer than when a clean cut is made with an uncapping knife.

Uncapped combs waiting to be extracted are best placed in a hive box sitting on a drip tray. This will help to keep the floor of the extracting area clean. They are essential if supers of combs are to be taken inside the house.



A drip tray for retaining honey drips. It may be placed on an empty super to minimise bending and lifting by the beekeeper.

Honey extractors

These consist of a drum, made from food grade plastic or stainless steel, with a honey gate at the bottom. A revolving reel on a vertical shaft inside the drum has a number of baskets that hold uncapped combs. The reel is turned by hand with a crank handle or by an electric motor. The centrifugal force generated draws (or flings) the honey out of the cells.



Hand operated 2-frame polygenic extractor on stand.



Interior view of 2-frame polygenic extractor.

For beekeepers with up to 50 hives, a 2-, 4-, or 8-frame tangential extractor is adequate. This type of extractor is efficient and quick, but as explained below the frame must be reversed during the process so that each side of the comb, in turn, is extracted. Beekeepers with more hives should consider extractors of a larger capacity.

Place the frames in the extractor baskets so that the bottom bars travel first in the direction that the extractor will spin. This allows honey to more freely leave the cells.

When the reel is in motion, the baskets move in a direction parallel to the wall of the extractor. The honey is only spun out of the cells on the side of the comb that faces the extractor wall. The extracted honey flows down the wall to the bottom. The comb is then lifted out, turned (reversed), so that the honey can be extracted from the second side. The bottom bar will travel first in this spin. The process can be speeded up by using an extractor with reversible baskets as the hinged baskets are simply turned to extract the second side of the comb.

Small extractors can fracture combs very easily, unless care is taken. As the first side of the comb is extracted, there is an initial quick flow of honey with the remainder taking longer to come out. With the weight of the other full side pressing on the partially empty side of the comb, breakages can result, especially in distorted and new combs. To overcome this problem, turn the extractor reel until about half the honey on one side of the comb has left the cells, then reverse the combs and turn until all the honey has left the second side. Reverse the combs again and complete extracting the first side. Breakage of combs can be prevented to some extent by the use of centre vertical wiring of frames or plastic foundation (see chapter 2. *The hive and its components*).

A quick inspection of the combs will determine if more turning of the extractor is necessary. Cold or dense honey is hard to extract and more turning will be required. A large amount of cold honey can remain in the cells even after considerable spinning of the extractor.

During cool weather, extract honey as soon as possible after the combs have been taken from the hive while they are still warm. Honey taken from hives late in the beekeeping season can be cold, especially if the bees have begun to form their winter cluster away from the honey supers. Similarly, combs of honey transported from an out-apiary for extracting can cool.



A 4-frame, stainless steel, electric driven extractor on stand.



Interior view of the 4-frame extractor. The hinged baskets allow the combs to be turned (reversed) for extracting the second side of the comb. Note that the cover and safety guards provided by the manufacturer have been temporarily removed for this photo to be taken.

Beekeepers with one or two supers of combs to extract could try warming and extracting them in a heated kitchen. A normal household blow heater may be used to direct warm air between the combs. There are some disadvantages of doing these activities in the house. During extracting, drips and spatter of honey and wax on walls and floor are unavoidable. Often wayward live bees, caught between the combs, are brought inside. A storage area is still required for the extractor, supers and honey. All this, along with the almost inevitable increase in the number of colonies kept, may soon convince the beekeeper and family that the enterprise has outgrown the home working area.

The following method of warming supers of combs of honey **should not** be used during the hot period of the year as too much heat will cause melt-down of combs. Stack supers, two or three high, outside in the sun for the day on bottom boards or upturned covers placed on the ground or on the tray of a ute (etc.). Ensure the boxes are properly covered and bee-proof to prevent robbing of the honey by robber bees. Extract the honey when the sun goes down. Wrapping them in black plastic will also increase the heat generated. Care must be taken when warming new combs as excessive heat may cause them to break during extracting.

In hot weather, combs will be soft and can break easily, but the honey being warm will extract freely and only gentle turning of a hand turned extractor will be needed.

Place uncapped combs in the baskets, taking care not to brush the combs against the wire screens of the baskets. This can burr the cells, damage the comb and prevent some of the honey from being released. Load combs of approximate similar weight, opposite each other to prevent extractor wobble and vibration.

The extractor should be placed on a frame, or stand, high enough to permit honey to flow from the outlet (the 'honey gate') of the extractor into a container. Some extractors are sold with legs fitted for this purpose. If the extractor is set up in a permanent position, the frame and the extractor can be fixed to the floor by bolts, anchor rods, cables or brackets to prevent extractor wobble.

Remember to monitor the level of honey in the extractor. If the build-up of honey touches the bottom of the baskets it will slow the extractor. Hobby beekeepers may drain honey into a clean bucket or other suitable container from time to time and pour it into a settling tank. Remember to never allow honey to flow into a container without keeping watch on it. Honey that overflows is a waste and is very difficult to clean-up.

Some beekeeping equipment suppliers have extractors for hire, suitable for hobby beekeepers. Don't rely on someone else to thoroughly clean the hired extractor. Do this yourself before use, to remove any potential for transfer of spores of American foulbrood disease to your own hives. The extractor doesn't need to be sterilised, but a good scrub with clean soapy water to remove all traces of wax, honey, propolis and dirt, followed by a clean water rinse will be sufficient. Ensure the extractor is dry before use.

The extracted sticky combs ('stickies') can be returned to the hives for the bees to store more honey, if there is a nectar flow. Alternatively, they can be stored for use at a later time. It is essential to protect stored combs from mice and ants, as well as infestation by small hive beetle and wax moth (See chapter 15. *Pests and enemies of bees*). Some beekeepers prefer to have sticky combs cleaned by the bees before winter storage. This is because honey on stored sticky combs can absorb moisture and begin to ferment. A super of sticky combs can be placed on a hive over a hive mat overnight. Do this late in the day to minimise any risk of robber bees attacking the hive. The bees will remove the honey overnight. Then, after shaking or brushing the bees off the combs, the super and combs can be stored.

Placing boxes of stickies in the open to have bees clean them up is illegal. It is a sure way of spreading disease organisms.

Processing the honey crop

Extracted honey contains small particles of beeswax, pollen grains, air bubbles and sometimes bee legs, wings, and the odd bee. These small particles can cause liquid honey to partly or wholly crystallise, which is not attractive to most consumers.

Use a coarse strainer to remove large particles and a fine strainer to remove small particles. Strainers and nylon (nytre) straining cloth are available at beekeeping equipment suppliers.



Polygenic settling tank, with lid, suitable for a beekeeper with a few hives.

Air bubbles and very small particles not removed by strainers are removed by a process known as 'settling'. The honey is placed in a tank, preferably with a honey gate positioned in the wall, slightly above the bottom of the tank. The air bubbles and fine particles rise to form a layer at the top. The clean and usually clear honey is then allowed to flow through the gate at the bottom into suitable containers. If a gate is not used, the layer of air bubbles and foreign matter is carefully skimmed off the top before honey is poured from the top of the container.

Plastic and stainless steel honey settling tanks are available in different sizes. These should have a well-fitting lid to prevent honey absorbing moisture from the air and being contaminated by insects and dust. When only a small amount of honey is extracted, a food-grade plastic honey bucket fitted with a honey gate will be ideal. These items are available at beekeeping equipment suppliers.

The period needed for settling is determined by the temperature and viscosity of the honey and generally requires a minimum of 12 hours to a few days.

Honey extracted in warm to hot weather and still retaining the warmth of the hive will usually flow through strainers with ease and settle well. Honey in combs which are cold is usually difficult to extract and strain. Cold honey will require more time to settle than warm honey. If only a few hives are kept, let the honey run from the extractor into pails or tins which may be left to stand in a hot water vat until the honey is heated to 35°C. The honey is then tipped through a strainer into a tank, covered, and allowed to settle.

Honey can be damaged by a combination of heat and the length of time it is exposed to heat. The duration of heating should be for the shortest time possible and should not exceed 45°C. Honey is a poor conductor of heat and it will take a long time for the honey in the centre of the container to be heated. Occasional gentle stirring of the honey in the pail will assist uniform heating. Never stand a container of honey directly over a gas flame or electric stove element as this will cause the honey nearest the heat source to be overheated and ruin.

Some beekeepers supply a market for 'cold extracted' honey. No heat is applied at any time during extraction, settling and packaging of this honey. The product is only partially cleared by natural settling.

Containers for honey

Honey can absorb moisture from the air and may ferment if it becomes diluted. Consequently, honey should be placed in air-tight containers. Glass jars, plus food-grade plastic jars, tubs, small buckets and pails with snap tight lids are suitable (see also *Packaging* in chapter 10. *Honey*). Jars that have held other products such as pickled onions and pasta sauce should not be used because of the residual smell and taste that may taint the honey. Jars should be dishwasher clean and allowed to dry in a warm oven before use. Dust in containers can cause honey to crystallise quickly. Large plastic food grade pails can be fitted with a honey gate for dispensing honey into small-sized containers.

Beekeepers who sell honey must only use new containers, never second-hand containers. Further information can be obtained from the Public Health Unit of your local government council.

Legal obligations when selling honey

Beekeepers who do not sell their honey don't have to comply with various regulations and quality assurance programs because the honey is for their own use. They can extract honey in the family kitchen, laundry or any other suitable bee-proof area.

However, the following points will apply if you are a hobby, sideline or commercial beekeeper who will sell honey.

First consult your Local Government Council Public Health Unit to find out the legal requirements that you should follow. Do this, before you design your extracting room, building or mobile extracting caravan, otherwise council may require costly alterations. Extracting facilities must incorporate current food safety requirements under relevant state/territory Health Acts and the Food Standards Code established by Food Standards Australia New Zealand.

No matter what type of extracting facility is chosen, it must be kept clean. An ample supply of water must be available for washing hands, equipment, floor and walls. Ideally, the central extracting plant should have a sloping concrete floor and a good drainage system, capable of removing washing down water.

The beekeeper should also seek advice from council's public health unit about a food safety and quality assurance program for his/her operation. Council can provide food safety program templates, but it is more convenient for beekeepers to use an audited quality assurance program specifically designed for the honey bee industry. These provide guidelines on extracting plant design, as well as production and extracting honey.

Council can also provide advice about the strict requirements for presentation of information on honey container labels. This will include the producer's name and address, name of product, weight and nutritional information.

Beekeepers are encouraged to seek reliable information and guidance from established sideline and full time beekeepers. There are occasions when extracting plants are open for inspection during beekeeping field days.

Separating cappings and honey

Process cappings without delay because larvae of small hive beetle and wax moth can ruin both the wax and honey. Although larvae may not be evident, any beetle and wax moth eggs present will soon hatch and the cappings will be ruined (See chapter 15. *Pests and enemies of bees*).

Cappings contain a substantial amount of honey which is as good as that from the extractor and is worth saving. The simplest way to get most of the honey from cappings is to allow it to drain from the wax. This is best done in a warm environment as the honey is less viscous. The layer

of cappings should be not too deep and should be turned occasionally to assist draining. After draining, the cappings can be rendered into wax blocks (See chapter 11. *Beeswax*).



Polygenic uncapping unit showing coarse mesh. The frame to be uncapped is placed on the upward projecting spike positioned at the centre of the timber support.

Polygenic uncapping units allow honey to be drained from cappings and are popular with hobby beekeepers. The rectangular units consist of two or three containers stacked on each other. The upper two containers have mesh bottoms and gauze inserts for coarse and fine straining. Combs are uncapped above the unit and the cappings fall directly onto the mesh screen in the top container. The honey drains from the cappings into the bottom tank and is removed through a honey gate. Allow two to three days for the honey to drain from the cappings. Shorten this period and render the wax immediately if small hive beetle larvae are seen as they have the potential to ruin the cappings and honey crop. Ensure the unit is protected from ants, insects and mice. The round polygenic uncapping units have less capacity and are suited to a beekeeper with a small number of hives.

A cappings bag will suit hobbyists with small amounts of cappings. These nylon mesh bags are loosely filled with cappings, closed shut and then placed in the extractor baskets. After a good spin most of the honey is removed leaving a reasonably dry sample of cappings ready to be melted down.

The process of rendering drained cappings is explained in chapter 11. *Beeswax* under the heading *Refining wax other than brood combs*.

Further notes for sideline beekeepers

Uncapping machines

Uncapping machines allow fast uncapping of about eight frames per minute. They relieve the physical demands of uncapping large numbers of combs by hand. The main body, chains and blades are stainless steel and have a relatively quiet, simple operation.

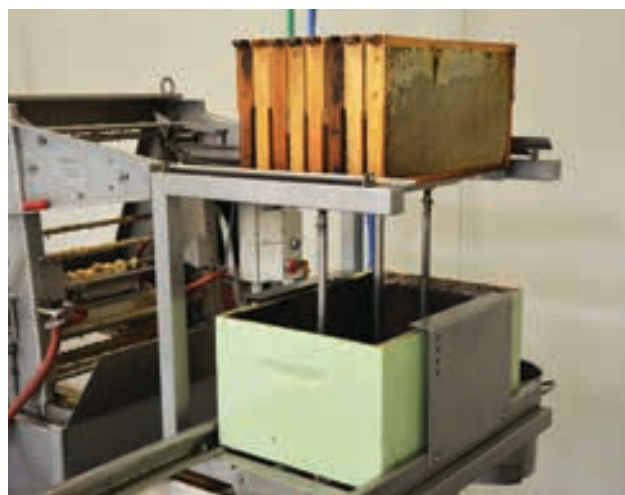


An uncapping machine. On the bottom right hand side of the photo an operator (not in view) uses a paint scraper to remove burr comb from the top bars of the uncapped frames and combs. The uncapped combs appear on the rack at the bottom of the photo.



The feed-in end of an uncapping machine showing the cutting blades.

The machines can be controlled forward and reverse, and the cutting depth is adjustable. Steam or hot water can be used to heat the two spring-loaded, vibrating cutting blades. A comb holder and chain conveyor moves each comb, in turn, down through the pair of heated blades, and transports the uncapped combs towards the extractor. The cappings drop down through the uncapping machine to the wax reducer below, or alternatively, they are sent to the cappings spinner. A de-boxer set up at the beginning of this process line lifts all the frames from a honey super in a single movement. The unit consists of a pneumatic jack operated by a foot operated valve.



A de-boxer in use. The frames are lifted from the box and pushed onto the uncapping machine guides.

Extractors

Radial extractors have a smooth initial slow speed, building up to a faster speed when the bulk of the honey has been removed. Combs are placed in the extractor like the spokes of a wheel, with the top bar of the frame furthest from the centre. This position takes advantage of the natural slope of

the comb cells. The honey is spun out of the cells on both sides of the comb at the one time. Some models, holding large numbers of combs, revolve on a horizontal shaft.

Semi-radial extractors hold nine, 12 or 21 frames and have hinged baskets that take up a position between that of radial and tangential extractors. The baskets are reversed to extract the second side of the comb.

The honey flows from the extractor to the honey sump through a coarse strainer and is then pumped through a fine strainer into a settling tank.



A 24-frame semi-radial stainless steel extractor.



A commercial honey extracting facility. Note the layout of uncapping machine (right, but mostly hidden by operator), GT extractor with hood raised (centre of photo). The uncapped combs are pushed into the extractor from the right hand side. After extracting, the empty combs are pushed from the extractor to the left hand side and loaded into supers. The GT extractor spins on a horizontal shaft.

Hot rooms and warming honey

Before extracting, combs may be warmed in purpose built hot rooms. Heat is generated through the walls or floor by means of hot water, steam, electric element or electric fan heaters. Air circulation provided by ceiling fans ensures even distribution of heat through the room. A thermostat is necessary to make sure the temperature does not exceed 32–35 °C. On average, the supers of combs need to be held in the hot room for 1½ to 2 days to warm the honey.

If a hot room is not used, the straining and settling process can be speeded up by gently heating the honey during extracting. A stainless steel tube is coiled twice around the inner extractor wall, just below the level of the baskets. The steam (or hot water) enters the upper end of the coil through the side of the extractor and leaves the extractor through the lower end of the coil, and is condensed. The extracted honey flows down the sides of the extractor and is warmed as it flows over the coil. Never let the level of extracted honey to rise so that it touches the steam coil.

Containers

Extracted honey is placed in approved food-grade 200 litre drums and 1,000 litre food-grade intermediate bulk containers (IBCs) for later packing by a commercial honey packing firm.



A stainless steel settling tank (top) and intermediate bulk container.

Steam

If steam is required in a semi-commercial or commercial operation, the installation of a boiler is necessary. Beekeepers should enquire with their relevant state or territory Workcover or Worksafe authority to ascertain the requirements, including training, that apply to people who operate boilers. In addition to this, if a gas fired boiler is chosen the beekeeper should also contact the relevant state or territory Energy Safe (for example, Energy Safe Victoria).

Cappings

Cappings spinners use centrifugal force to spin the honey from the cappings. The wax/honey centrifuge is similar to the spinner. Honey from the extractor and cappings from the uncapping machine are pumped together as a slurry through a heat exchanger to be warmed, and then into the centrifuge.

There are several types of cappings melters, including 100 or 200 litre stainless steel units with an electric heating element in the base, enclosed by a stainless steel cover. Water is added to completely cover the base. Cappings and other wax scraps are then added. The water is gently heated to slightly above 62–66°C, the melting point of wax. The molten wax naturally floats on the water and is held at this temperature for a few hours to allow contaminants to settle out. Water is then gently added to the melter to raise the layer of wax so it can flow through the outlet strainer into suitable moulds. If there is some dirt and scum floating on the wax, run this into a mould and put it through the melter again when another batch of cappings is processed.



A commercial wax reducer positioned below an uncapping machine.

Cappings reducers are made in various designs and sizes and are heated by hot water or steam from a boiler. During hand or machine uncapping, the cappings fall and melt on the heated reducer coils. The molten wax and honey run into a tank where the wax forms the upper layer. The two can be run-off through their different outlets. Alternatively, in

some models, the cool solidified wax can be lifted out as a solid block.

Reducers may spoil honey by excessive heat over an extensive period of time, especially if parts of brood cells and larval cocoons have been taken off by the uncapping knife. The heated honey becomes dark and may have a burnt or caramel flavour. This honey should never be mixed with extractor honey as it may darken and downgrade the entire crop.

Central extracting plant

The central plant is a permanent facility in a bee-proof building on the property where the beekeeper lives or on a nearby property, such as in an industrial area of town with electricity and water available. The full combs of honey to be extracted are brought to the plant from the out-apiaries. A spare set of supers and combs is necessary to replace combs that have been taken from the hives.

The central plant should be of a size to accommodate all the equipment needed from uncapping combs through to settling the honey and in some cases a vehicle, trailer or truck. There should be ample storage space for extracted honey. A built-in hot room to warm honey for extracting is an advantage. Ideally, the same room, or a separate room, should also be available as a refrigerated cool room to protect empty combs from damage by small hive beetle and wax moth. Robber bees and wasps will be troublesome if the plant is not bee proof. Allow extra room for any likely expansion resulting from an increase in the number of hives kept, which invariably happens.

It is a good idea to have a separate building for rendering wax, in case of a fire emergency. A workshop should be available for assembly and painting of hive material.

A building on land zoned as industrial or agricultural may be readily sold or rented should the beekeeper cease operations. A central plant building is almost a liability when located at the rear of a residence on residential land.

9. Winter management

As seasonal conditions vary throughout the various regions of Australia, hard and fast rules cannot be applied for wintering bees. However, there are basic requirements that can be followed for successful wintering. These include: the right locality, good apiary sites, adequate stores of honey and pollen, a good queen and colonies that are not weak. Weather-proof hive material that provides protection from cold winds and rain is also essential. Supers that are not required by the bees should be removed at the time the colonies are prepared (or 'packed-down') in mid-late autumn for winter.

Poor preparation for winter can result in seriously weakened colonies, and even loss of entire colonies, during winter and early spring. Any weak colonies that survive winter may be unfit for contract pollination and honey production in the following season until rehabilitated. Even with the best preparation some losses of colonies can and do occur during winter.

In districts that have a cold winter, very few bees leave the hive. Limited foraging will only occur during brief periods of fine weather when the temperature exceeds 12 °C, provided there is no wind chill factor.

Bees don't hibernate in winter. With the arrival of cold temperatures in late autumn, bees begin to form a winter cluster by grouping together to conserve heat. The tight cluster fills some of the gaps between the combs. A compact outer shell of bees helps to retain the heat generated by the bees within the cluster. In southern states, a small amount of brood rearing may continue through winter particularly in warmer districts near the coast and in warm desert areas. In colder inland areas, colonies are often broodless during winter.



The winter cluster. The hive mat has been temporarily removed for the photo to be taken.

Opening hives in the cold of winter can be harmful to bees. However, it is sometimes necessary to have a look in the hive to ensure enough honey stores are present. This opening of the hive should be very brief and the cluster of bees should not be broken up. Breaking the cluster by removing one or more frames will result in loss of heat and cooling of the cluster of bees. More honey is then consumed by the bees to restore the cluster temperature. Generally, good preparation before winter will ensure that colonies need not be disturbed until the bees are flying in the mild conditions of late winter and early spring. Even then, beekeepers should resist the temptation to open the hives for lengthy periods too early in spring.



The winter cluster in a hive without a hive mat. The bees have almost eaten all the honey in the burr comb.

Locality

There are only a few localities where well-prepared bees do not usually winter well. Low-lying, shady places where there is excess dampness should be avoided. Areas where winter flowering trees yield thin nectar should also be avoided because colonies can become sick and weak. In Victoria, white box (*Eucalyptus albens*) and red ironbark (*Eucalyptus tricarpa*) are two trees that yield thin nectar in winter.

Some of the most suitable localities for wintering bees are in the warm sandy country in coastal districts where some pollen is available to bees on good flying days, and brood rearing conditions are particularly good in spring. There is one danger here. Early brood stimulation, followed by bad weather will cause the bees to draw heavily on their food reserves. Check them regularly for stores and where necessary feed sugar well before they run out of honey.

In autumn, some beekeepers move their hives to the desert country in South Australia and in the west of Victoria. Bees continue to breed and store honey from desert banksia (*Banksia ornata*) and other plants. The colonies maintain their strength throughout winter. Continuous abnormal winter brood rearing may place strain on queens, necessitating more frequent requeening.

Stores

Honey is an energy-producing food. Bees eat it as their carbohydrate food and to create energy which helps maintain the desired temperature of the winter cluster.

The amount of honey a colony needs for winter depends largely on the strength of the colony and the locality in which the bees are to be wintered. Because of the amount they can consume, very strong colonies with many mouths to feed can be a liability rather than an asset in winter if adequate stores of honey are not available.

Don't leave unsealed honey in the hives for winter, unless it is in small quantities surrounded by sealed honey. Leave it well inside the cluster of bees. Combs of honey near the outside of the cluster should be completely sealed otherwise the unsealed honey will take up moisture and ferment.

Lack of food reserves in the hive is one of the most costly and common mistakes of beekeeping. Ensure that there is enough honey in the hive to carry the colony through winter and early spring. Leave at least 18 kg of honey for stores if the colony is strong enough to be wintered in 8-frame double hive. A Langstroth full-depth comb, full of sealed honey contains an average of 2.2 kg of honey. A single eight-frame hive with a good colony can hold about 14 kg of honey, which may not be enough to keep the bees alive for the entire winter, particularly if the district has long winters.

Two or three combs of fully sealed honey can be set aside for each colony as emergency feed in case stores become dangerously low in late winter and early spring. Place the combs in a sealed plastic bag and freeze them to kill all-cycle stages of wax moth and small hive beetle. Then keep these bagged combs in a dry, rodent-proof environment. Combs of unsealed honey should not be set aside as emergency stores because the honey will take up moisture from the air and become fermented and be detrimental to bees.

A problem of storing combs of honey is the strong possibility that the honey will crystallise in the combs. It is then a liability if it is not required as feed because the honey cannot be extracted. The combs are tied up until they are put back on the hive for the bees to eat the honey out.

A comb of honey is needed to produce a comb of brood. The greatest consumption of stores occurs with the rapid increase of brood rearing in late winter and early-spring. An expanding population of adult bees also demands more food. When not enough nectar is brought into the hive, the amount of stores will quickly decrease and feeding may be necessary. This is mainly true when bad weather slows down nectar gathering. Late winter and early spring is when bees usually starve. Hives should be monitored frequently and fed sugar well before there is no honey left (see *Stores and feeding bees* in chapter 6. *Spring management*).

Experienced beekeepers can obtain a good estimate of honey reserves by lifting the back of the hive to check its weight. Alternatively, the entire weight of the hive can be determined using a spring balance. A more accurate method for beginner beekeepers to check for stores is to briefly open the hive on a still, fine day when the bees are flying well. It is usually only necessary to check one or two combs adjacent to the cluster. The combs do not have to be entirely lifted out of the box.



A quick look down between the combs shows the amount of sealed honey stores available to the colony.

Pollen

Good quality pollen is valuable for successful wintering of bees. It should be as near to the centre of the cluster as possible. With suitable cluster temperatures, colonies in warm districts with pollen will maintain a low level of brood rearing. New emerging bees largely replace the old bees that die. This helps to lessen the effect of 'spring dwindle', when many of the old bees die and the number of bees in a colony markedly falls. There will be a vast difference in the results obtained from a colony coming into spring with 20,000 old bees, compared to another colony coming into spring with (for example) 10,000 old bees and 10,000 young bees. Typical spring dwindle and decline in the number of adult bees will be obvious in the first colony but may not be evident in the second. The second colony will, more than likely, produce more honey in the early part of the season, than the first colony.

During preparation of hives for winter, combs of pollen and honey may be taken from hives with excess quantities and given to hives that are short on supplies. It is important to make sure that both the donor hive and the hive to receive the combs are free of disease. Swapping combs from hive to hive is a sure way of transferring disease.

Winter cluster and space adjustment

The temperature inside the cluster is generated by movement of bees and consumption of honey. Bees at the core of the cluster are able to move about freely. Heat loss is largely prevented by the insulating outer shell of the clustered bees which are grouped tightly together. If the temperature is too high, the cluster will expand to allow heat to escape. If the temperature is too low, the cluster will contract and the outer shell will become more compact. In some districts, the temperature within the cluster will be high enough for some brood rearing to occur.

Removing surplus supers to consolidate the hive as much as possible will help the colony to control temperature variations. The space available inside the hive should be adjusted so that the bee cluster fills it without leaving open areas to cause loss of heat. This will also help to regulate the humidity and condensation in the hive. Free moisture in the hive is considered detrimental to good wintering.

When supers of empty combs are left on the hive, heat from the cluster rises into the unoccupied space. The bees may move to where it is warmest and establish their cluster between those empty combs. Some of the honey is carried up from the bottom box. This relocation causes increased activity accompanied by greater use of stores. Where queen excluders are fitted, the relocation can lead to partial isolation of the queen in the brood box. The queen excluder can be removed for good wintering as this allows the bees to move where they think it is the best for conservation of heat.

During wintering, and where possible, don't leave supers of empty or part-filled combs on the hives. Any unsealed honey in these combs can absorb moisture and may ferment. Unoccupied combs can become mouldy or soiled with faeces and this can aggravate dysentery and nosema disease.

Beekeepers have differing views on whether bees should be wintered in singles or double-box hives. The basic guide is that a colony should only be given enough space to accommodate it. The tighter they are clustered the better. There may seem to be too many bees, but it is surprising the number of bees which can get into a single if they have to. Research has shown that hives which were packed down tight for winter and were full, or nearly full, of honey had low numbers of nosema spores compared to hives that had surplus room.



A very small cluster at the end of winter. Weak colonies are best united with other colonies in autumn.



A colony successfully overwintered in a single box. Access to pollen enabled the colony to be reasonably strong in late winter.

It may be hard to confine colonies containing too much brood to singles if the operation is attempted too early in autumn. The space occupied by brood can prevent inclusion of enough stores in the one box, especially an eight-frame box. However, the colony may be 'packed down' into an eight-frame single if there are only three to four frames containing small patches of brood surrounded by honey. Place the brood combs in the centre of the bottom box and fill the box with fully-sealed combs of honey. Place combs containing unsealed honey against the brood combs well inside the cluster if there are not enough fully-sealed combs of honey. Place fully-sealed combs on the outside of the cluster.

After 'pack-down' of hives has been completed, extract combs of surplus sealed honey that are not needed as winter food reserves and store the combs in a dry, rodent proof environment. These sticky extracted combs (known as 'stickies') can be put back on the hives over a hive mat for a few days for the bees to clean them up before they are stored. This will prevent the honey from absorbing moisture from the air and fermenting.

Hive mats, entrances and moisture

Hive mats placed on the frames under the migratory lid are used by many beekeepers. They help to conserve heat in winter and prevent excess moisture that may occur on the underside of the cover dripping onto the bees (See chapter 2. *The hive and its components*).



Hive mat in position in overwintering hive. Mats help to conserve heat.

Some beekeepers reduce the hive entrance to a width of 50 mm or even less for winter to reduce entry of cold winds. Entrances must also be of a size to prevent entry of mice. They seek the warmth of the hive and can damage comb that is not covered by bees (See chapter 15. *Pests and enemies of bees*).

Most apiaries usually contain a number of 'wet' hives. These consistently have high amounts of moisture, irrespective of any type of ventilation, when most other hives are dry.

Slightly tilt the hive from back to front to allow any moisture and condensation to flow out through the entrance.

There is some debate about the use of air vents in migratory lids during winter. When the ventilator mesh is fixed to the inside of the vent hole some colonies will seal the mesh with

propolis, thereby restricting ventilation. Other colonies will choose not to seal the mesh, but we don't know the reason for this choice. On the other hand, when the ventilator mesh is fixed to the outside end of the vent hole, the bees don't seal the mesh.

Other winter tasks

In cool districts when colonies have been packed-down for overwinter, there is time to prepare for the next season. Tasks include repair and maintenance of extracting equipment, assembly of new hive components and repair and maintenance of existing hive material not currently in use.

10. Honey

Bees collect nectar from flowers and convert it into honey. Nectar is secreted by nectaries which are glands usually located near the base of the flower. The bee draws nectar up through its proboscis (the tongue and other mouth parts that form a tube) and carries it to the hive in its honey crop. Bees also collect pollen from flowers, but pollen is not used in the production of honey.

Nectar is a sweet liquid that contains water and sugars, namely sucrose, glucose and fructose. It also contains traces of other sugars, minerals, vitamins, pigments, aromatic substances, organic acids and nitrogen compounds. The concentration of sugar in nectar varies and is influenced by a number of variables including the type of plant and the district in which the plant grows, soil condition including availability of moisture, as well as ambient temperature and humidity of the day. An example of the variation of sugar content in nectar is illustrated by the fact that apple and pear nectar collected at the same time of day and in the same Australian orchard contained 23% and 7% total sugars respectively.

How bees make honey

The conversion of nectar into honey involves two processes. The sucrose in nectar is converted into glucose (dextrose) and fructose (levulose), and much of the naturally occurring water in nectar is removed. These processes are collectively known as nectar-ripening. The end product of these processes is known as 'ripe honey' (or honey) which is a highly concentrated sugar solution.

The enzyme invertase, a complex protein, is added to the nectar by bees as they forage and also by hive bees as they process nectar into honey. This enzyme accelerates the conversion of sucrose into glucose and fructose. Another enzyme, glucose oxidase is also added to the nectar. It acts on glucose to produce hydrogen peroxide and gluconolactone. Hydrogen peroxide has an antibacterial effect, but is found at very low concentrations in honey. A third enzyme, diastase, is a starch digesting enzyme whose function is unclear, but it may be involved in the partial digestion of starch grains in pollen. Very small amounts of other sugars occur in honey, but not in nectar.

Water is removed from nectar by evaporation. The process begins with forager bees transferring their nectar loads to hive bees. A bee that receives the nectar then exposes a small amount of the load, in turn, on the underside of its proboscis to the warm air of the hive. The process continues for about twenty minutes. The partially ripened honey is then placed in a cell where warm air circulating inside the hive results in more evaporation. At the completion of these processes, the sugar solution known as ripened honey will have a moisture content of about 14–18%, and on occasions up to 20%, according to the floral source.

Nectar may also be temporarily deposited in empty cells in the broodnest where conditions favour evaporation. Droplets of nectar may sometimes be seen hanging on the underside of the roof of brood cells that contain eggs or small bee larvae. This partially ripened nectar is later collected and when fully processed is stored in cells as honey.

When cells are full with ripened honey, they are covered (sealed) by the bees with a non-porous beeswax cap. Capped honey does not absorb moisture from the air.

Honey that is extracted by the beekeeper before a comb of honey has been fully capped may not be sufficiently ripened. It is likely to have a high moisture content and could ferment after it has been extracted. This is true for some ground flora honeys. On the other hand, some eucalypt honeys produced in the hot, dry conditions of summer can have a very low moisture content. Experienced beekeepers often extract combs that are $\frac{2}{3}$ to $\frac{3}{4}$ capped. The best advice for beginners is to be cautious and not extract honey before the comb is almost fully capped. The moisture content of honey can be determined using a refractometer designed for honey, but these are an added cost.

Properly ripened honey, packed in clean, dry, sealed containers, can be stored for years without deterioration. It may, however candy.

Honey stored in containers that are not air-tight will absorb moisture from the air. Once enough moisture has been absorbed to dilute all or part of the honey, the inhibition of sugar-tolerant yeasts is removed and fermentation occurs. These yeasts occur naturally in flowers, in soil found in and around apiaries, inside hives, on combs and in honey extracting and comb storage surroundings. Fermented honey should never be fed to bees because it can cause dysentery and heavy losses of bees.

Honey will not ferment when the moisture level remains below 17.1%. Honey with a moisture content more than 18% may be at risk of fermentation, but this depends on the number of yeast organisms present.

Partly ripened honey may ferment in combs in the hive when conditions are extremely humid, or when bees are gathering very watery nectar. Sometimes bees cannot ripen nectar collect in late autumn and winter. Yeasts growing in the honey produce alcohol and carbon dioxide gas, which can be readily detected by the alcoholic odour and frothing of the honey. Some beekeepers have shaken watery honey out of combs of affected hives to prevent bees having access to it. As it is an offence to expose honey in the open, it should never be shaken onto the ground. The honey should be shaken into a container or extracted in the extractor for later disposal.



A comb of capped honey.

Composition of honey

The composition of honey varies from one floral source to another. The average composition of Australian honey produced from native and exotic plants is: water 15.6%, fructose 42.5%, glucose 30.6%, sucrose 2.9%, minerals 0.16% and other constituents 8.24%.



A display of honey at an agricultural show. Colour and other unique characteristics of honeys are primarily determined by the floral source.

Viscosity of honey

Honey is a viscous solution because it flows slowly at room temperature. By comparison, water flows easily and is less viscous. Honey becomes less viscous and flows easily after it is heated. Caution must be taken when heating honey so that it is not spoiled (See *Filtration* below).

The floral source, moisture content and temperature determine the natural viscosity of individual honeys. Some ground flora honeys naturally have a high moisture content and relatively low viscosity. A special case of viscosity occurs in certain types of honey, such as that produced from some species of tea tree (*Leptospermum*). It can set like a jelly in the combs and is extremely hard to extract. Tea tree honey is great for bees but it can be difficult for the beekeeper. Such honeys are called 'thixotropic'.

Extraction of honey from combs is more easily done on days of warm to hot temperature because the honey leaves the cells more readily than on cold days (For details on warming combs of honey prior to extraction see chapter 8. *Extracting honey*).

Granulation of honey

The granulation or candying of honey is a natural process and its presence does not indicate adulteration of the product in any way. The natural glucose in honey is a major factor in granulation. It can form crystals in liquid honey and in time will form a solid layer. When partial granulation occurs, the rest of the honey, in liquid form, can have a high moisture content which may lead to microbial growth and fermentation.

The different floral honeys form crystals at varying rates and of different sizes ranging from fine to coarse. For example, yellow box (*Eucalyptus melliodora*) honey will candy very slowly and may not candy for two or more years. In

contrast, canola and white clover honeys candy very quickly, and may candy in the comb prior to extracting.

A temperature of 14°C favours granulation of honey. Temperatures below 10°C and above 14°C slow the rate of crystallization.

The presence of sugar crystals, very small particles of wax, dust and pollen in honey will accelerate granulation by acting as nuclei around which sugar crystals can form. This is the main reason why honey is heated and filtered before packaging. The heat applied dissolves any fine sugar crystals already present and filtration removes the particles. It is essential that honey containers are clean and free of dust before they are filled with liquid honey.

Creamed honey

Creamed honey is a very finely granulated honey that has a smooth texture. It is made by 'seeding' a naturally and rapidly granulating liquid honey with some very fine crystallized honey. Some creamed honey saved from a previous batch may be used as the 'seed'. The honey is then homogenised to mix in the 'seed honey'. The temperature of the honey to be seeded should not exceed 24°C. The containers of creamed honey are placed in a cool room at 10–14°C until the honey is set firm. The product should then be stored in a cool environment to prevent it losing its firm texture and reliquefying.

Effect of heat on honey

Hydroxymethylfurfural (HMF) is an organic compound derived from sugars. It occurs naturally in low amounts in honey and some other foods. In honey, HMF levels may increase with age (storage) and heat treatment of the product. Detection of high levels of HMF by laboratory analysis may indicate overheating and the honey may not conform to standards set by importing countries. To prevent acceleration of naturally occurring HMF levels, drums and other containers of honey should be stored under cover away from sunlight. Also, the heat applied to honey in the extracting and packing stages should be kept to a minimum, in both amount and duration. Too much heat can also decrease the level of the enzymes diastase and invertase.

Filtration

Honey is a natural food. Every effort must be made to maintain its natural qualities during processing and storage and to ensure it has a long shelf-life. It should receive minimum heat treatment. Granulation is minimised by removing sugar crystals, pollen, dust, wax particles and other debris from the honey. The honey is gently heated to enable it to be filtered and to dissolve any natural sugar crystals.

Commercial beekeepers deliver honey to packing plants in 200 litre drums or Intermediate Bulk Containers (IBCs). The containers of honey are held in a hot room at an air temperature of up to 60°C for a period of eight to 40 hours depending on the degree of granulation of the honey. When the honey has liquefied and reached a temperature of approximately 45°C it flows into a settling tank where the

wax particles and air bubbles rise to the surface. The honey is then pumped from the bottom of the tank and through a heat exchanger for a few seconds at a temperature of 55 °C before being pumped through a filter to a reservoir tank which feeds the bottling line.

For the smaller packer the process is similar. Honey may be heated to approximately 35–45 °C to lower its viscosity. The honey is then filtered and packaged. Heating honey above 45 °C will not improve its ability to flow through strainers and lines in extracting and packing facilities.

If honey has to be heated, place the container of honey in a heated water bath or in an environment with circulating hot air. Direct heat, such as a gas flame, or electric hot plate, should never be applied to a container of honey because the product will be ruined. The honey can be filtered through one or more fine mesh strainers before being placed directly into a settling tank. Once the honey has settled, usually about 24 to 48 hours, it can be packaged.

Packaging

Glass jars and food grade plastic tubs and pails, usually up to five kilogram capacity, are used as retail packs. Export honey may be packed in 200 litre drums, Intermediate Bulk Containers and retail packs. Clear containers allow the customers to see the product. Only new containers should be used.

Beekeepers who wish to package and sell honey should first contact their local government public health unit. There are strict laws regarding food handling in today's world and honey extracting and packaging are not exempt. It is far better to seek advice before designing a honey extracting plant, than having to carry out costly alterations so that the plant is approved. The public health unit can provide advice on the mandatory legal requirements for labelling your product.

Some beekeepers provide information to their retail customers about the granulation of honey and how to liquefy it should it set hard. It is important to point out that granulation or candying of honey is a natural process, and that the quality of the product is not affected at all, nor has it gone bad. Advise customers that candied honey may be reliquefied by placing the container in a hot water bath at preferably 35 °C but certainly no more than 45 °C.



A collection of containers suitable for retail honey packs. From left to right: Top row: 1.5 kg; 2 kg; 500 gram jar. Bottom row: 3 kg; 1 kg; 5 kg.

Honey standard

The Australia New Zealand Food Standards Code, Standard 2.8.2, Honey states: *Honey means the natural sweet substance produced by honey bees from the nectar of blossoms or from secretions of living parts of plants or excretions of plant sucking insects on the living parts of plants, which honey bees collect, transform and combine with specific substances of their own, store and leave in the honey comb to ripen and mature. In relation to the composition of honey, the Code states Honey must contain no less than 60% reducing sugars and no more than 21% moisture.*

The European Union Honey Directive 'Council Directive 2001/110/EC of 20 December 2001 relating to honey' states: *Honey consists essentially of different sugars, predominantly fructose and glucose as well as other substances such as organic acids, enzymes and solid particles derived from honey collection. The colour of honey varies from nearly colourless to dark brown. The consistency can be fluid, viscous or partly crystallised to entirely crystallised. The flavour and aroma vary, but are derived from the plant origin.*

11. Beeswax

Beeswax is produced by four pairs of wax glands in the abdomen of young adult worker bees of up to 17 days of age. Although when it is necessary, the glands of older bees can resume wax production but they tend to produce smaller quantities of wax.

Wax is secreted as a liquid which forms very small translucent white scales (flakes) when it contacts the bee's sternal plates on the underside of the abdomen. Using their hind legs, the bees transfer the flakes to their mandibles where they are moulded and added to comb under construction. The surface oil of some varieties of pollen can add colour to the wax.

Bees consume an average amount of 8.4 kg (range seven to nine kilograms) of honey to produce one kilogram of wax. They can also produce wax when feeding on sugar syrup. A good supply of pollen is important and without it bees secreting wax lose body protein. The impulse to produce wax is strongest when there is a shortage of comb for honey storage and when the honey crop of bees is full.

Bees involved in comb building form a cluster or curtain to maintain a temperature of 36 °C at the comb building site. Wax is very pliable at this temperature and is easily moulded and smoothed during comb construction. Wax is generally not produced during the cold months of winter. If wax is needed at this time, bees move wax from one position in the hive to another.



A selection of beeswax cakes and candles.

Properties of beeswax

The melting point of beeswax ranges from 61 °C to 66 °C. Beeswax is brittle at low temperatures, but is pliable at temperatures around 32 °C.

Beeswax is inflammable and has a flash point ranging from 254 °C to 274 °C and great care must be taken when heating it. At these temperatures, beeswax vapour can ignite. Beeswax does not need to be heated above melting point and must never be heated to these flash point temperatures. Several beekeepers have lost sheds and honey extracting facilities due to fire associated with beeswax. The wax is insoluble in water and floats on water.

Beeswax decreases in volume by 9.6% as it cools and changes from liquid to solid form. Beekeepers who prepare cakes of beeswax for show or sale, should allow the liquid wax to cool slowly in the mould to avoid cracks appearing as it solidifies. This can be done by allowing beeswax cakes to cool slowly in a warm oven after the heat source has been turned off.

Beeswax has a lower melting point and becomes softer if it is mixed with propolis. Foundation made from beeswax containing propolis is not as strong as foundation manufactured from pure beeswax. It is important to avoid propolis when scrapping beeswax from hive components.

Beeswax cakes and foundation may be covered with a natural whitish bloom which slowly increases with age. At first glance, it looks similar to a mould, but it is entirely natural and not harmful. Beeswax left to cool slowly, seems to have more bloom than wax that has cooled quickly. Bloom may be removed from candles and cakes by gentle rubbing with a very soft cloth. Gently warming the surface of these items can also remove the bloom, but it will reappear in time. Beeswax foundation sheets covered with bloom is readily drawn by bees.

Beeswax can absorb and become contaminated with a number of chemicals. Because of this, it should not be stored near chemicals, including agricultural chemicals.

Freshly constructed comb is generally white, or yellow to orange. With age, and the larval cocoons left in brood cells, the wax darkens in colour through tan, brown and then black.

Copper, zinc, brass, and to a lesser extent, galvanised iron will discolour wax. Stainless steel is the best material to use for melting wax as it doesn't discolour it. Aluminium, nickel and pure tin cause no discernible discolouration.



Blocks of clean beeswax produced by a commercial beekeeper.

Sources of beeswax

The uncapping of honey cells just prior to extracting is a major source of beeswax, usually in a ratio of one part of wax to 80 parts of extracted honey.

Another very important source of beeswax is the melting down of old and damaged combs. During the life of a brood

comb, each bee larva spins a cocoon, which remains on the cell wall after the young bee emerges. In addition, the faeces of each larva are enclosed in the cell by the cocoon and this adds more colour. After some years, the combs become dark, tough and leathery. It is good management to introduce some frames containing foundation to the hive every year and to remove some very dark, leathery, combs with thickened cell walls, as well as any broken combs. These can be set aside in a bee-proof area for later rendering into beeswax cakes or blocks. It is necessary to protect them from wax moth and small hive beetle damage.

Many beekeepers take their old combs and slum-gum to commercial wax processing plants. Using efficient equipment, the operators of these facilities are able to extract more wax than the average beekeeper can.

Routine apiary management, for hobbyists and commercial beekeepers, should include collection of wax scraps, including burr comb and broken comb, as well as any scrapings from frames. These can be collected and later rendered. Most beekeeping equipment suppliers will exchange blocks of clean beeswax for foundation or other items.

Wax moth and small hive beetle

Combs stored for later rendering, should be protected against infestation by wax moth and small hive beetle larvae (See chapter 15. *Pests and enemies of bees*). These larvae can chew through a considerable amount of wax in a very short time. Cappings and wax scraps should also be protected. Even though the wax may appear to be free of these pests, any eggs present will soon hatch into larvae.

Refining wax other than brood combs

The separation of cappings and honey during the extracting process is described in chapter 8. *Extracting honey*. The notes below describe the process of refining drained cappings, burr comb and pieces of comb that contain little foreign matter and no larval cocoons.

Never apply direct heat, or place the container over an open flame, when melting wax because of the fire hazard. Once wax catches fire it is very volatile and the fire is extremely hard to extinguish.

To melt wax, place it in water or in a vessel placed in a container of hot water. The presence of water between the heat source and the wax reduces the fire risk. It also prevents damage to the wax that can occur when direct heat is used.

Wax does not need to be heated above its melting point of from 61 °C to 66 °C, and certainly not above 76 °C as exceeding this temperature can discolour the wax. It is also uneconomical to heat wax to this temperature. Don't apply live steam direct to the wax and avoid boiling as these can cause saponification (a break-down of the fatty acids which make up beeswax) and softening of the wax.

Electric wax melters are a very clean, efficient way of rendering wax and are available from beekeeping equipment suppliers. They have a thermostat to maintain the correct temperature thereby eliminating fire risk and wastage of electricity. Clean water is added to cover the metal baffle over the electric element and the wax is then added to the tank. As the wax melts it rises to form a layer above the water. When all the wax is melted, hot water is then slowly and gently poured into the tank. The addition of water lifts the layer of molten wax which then flows through the strainers and the outlet at the top of the tank into moulds supplied by the beekeeper.



A commercially available beeswax melter suitable for cappings and burr comb.

Bill Winner



The inside of an electric melter.

An alternative is to heat the wax in water in a suitable tank or drum of a size to suit the beekeeper's operation. The tank should be fitted with a tap near the bottom for drainage of water. A strainer in the form of a mesh basket (22 gauge 16 mesh) almost the diameter of the tank, and with solid sides 150 mm deep is required.

The wax is added to the water and the strainer is inserted into the tank. As the wax melts, it passes through the mesh screen, leaving all but the smallest foreign matter below the strainer. The wax can then be removed with a dipper or similar container and poured into suitable moulds. Alternatively, it can be removed in solid form after it has cooled. The residue, known as slum gum, that remains in the tank can be allowed to set. It contains a considerable amount of wax and can be taken to a wax reclaiming plant to extract much of the remainder of the wax.

Beekeepers with only small amounts of wax can use cleaned milk cartons for moulds. When the wax has set, the carton can be simply peeled away. The larger operator may prefer to use large plastic moulds which are available from beekeeping equipment suppliers. Flared moulds are the easiest from which to remove wax.

Wax that has set in moulds may have a small layer of debris on the underside. This can be scraped off to make the block of wax look more attractive. Additional cleaning of the wax can be achieved by melting it and pouring it through very fine linen or similar material that will not add colour to the wax.

It is essential not to allow bees access to any cappings to clean them of honey. The danger of this practice is the potential spread of American foulbrood disease, the spores of which may be present in the honey.

Solar beeswax melter

Solar beeswax extractors are a cheap, efficient and safe way of melting beeswax scraps and drained cappings. Clear sunshine is required and it is best if the extractor is placed in an area sheltered from cool breezes and wind. Wheels can be fitted to enable the melter to be moved to receive maximum sunlight. These melters are not generally efficient for rendering dark brood combs.



A solar wax melter in operation. The molten wax flows into the metal mould on the left. (The glass lid has been temporarily removed for this photo).



The solidified wax in the mould.

A glass cover sits on the body of the extractor. The wax to be melted is placed on a metal tray. A small mould or pan is provided to hold the molten wax and any honey. A basket made of woven wire can be used when cappings are to be rendered. This prevents them from flowing into the mould before they are fully melted. An internet search will find a number of plans for building these extractors.

Uses of beeswax

Much of the beeswax produced in Australia returns to the honey bee industry in the form of foundation sheets. Refined beeswax has a variety of uses in industries. It is used as an ingredient of creams, ointments, lipsticks and other preparations. Church candles are usually made from pure beeswax or contain a high percentage of it. Beeswax is also used in dentistry, in the electrical industry, in adhesives and in polishes.

Further reading

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12. Requeening colonies and rearing queen bees

The queen is certainly the most important individual in the honey bee colony. For better or worse, the destiny of the colony rests on her, as it is her duty to maintain egg laying in response to the needs communicated to her by the workers.

Young queens are capable of laying more eggs than older queens. A high rate of egg-laying results in more worker bees and increased honey production provided other factors such as fine weather and good supplies of nectar and pollen are present.

When the queen is on a comb she is surrounded by a court of workers which generally comprises 6–11 bees. Members of the court feed, and touch and lick the queen. The queen has a number of glands that produce pheromones (chemical messages). Collectively, the pheromones are known by beekeepers as ‘queen substance’. Depending on the particular pheromone, they are distributed throughout the colony by workers touching, by air and by pheromone trails left on comb by the queen.

If enough queen substance is available to the workers, the colony functions normally. It inhibits the building of queen cell cups and queen cells, and ovary development in workers. But, as the queen ages, perhaps over two, three, or more years, the number of eggs she lays reduces and the amount of queen substance also dwindles. The colony decides that the queen should be replaced. This natural process is known as queen supersedure. The colony rears a new queen to replace the aging or failing queen.



Queen cell. The colony is raising a new queen.



Egg in queen cell.

Asls Sha'Non

New queens are also reared when the colony decides that swarming should take place. This usually occurs in spring when the amount of brood and adult bees increases rapidly and there is some overcrowding in the hive. Colonies with old or failing queens are more likely to swarm because they have less queen substance than colonies with young, vigorous queens (See notes on swarming in chapter 6. *Spring management*).

Requeening colonies

Requeening colonies is an important part of beekeeping. The old queen is removed from the hive and replaced by a younger one, either purchased or reared by the beekeeper.

Requeening can change characteristics of colony characteristics such as the potential to swarm and temperament. It can also introduce hygienic behaviour in which bees partially or totally remove diseased brood from the hive. Sometimes a colony may be less productive than others in the one apiary. If disease is not present, the difference in productivity may be due to variations in the strain of bee and the quality of the queen. Requeening with queens of a desirable strain will usually correct this.

Improvement of colony behaviour and docility by requeening is particularly important for colonies that are kept by hobby beekeepers in towns and cities. Swarming, temperament and aggressive stinging bees are probably the three most common problems that can lead to disputes with neighbours.

The Victorian *Apiary Code of Practice 2011* requires that colonies have young queens of a docile strain. Requeening annually or every two years will ensure a young queen is present. Commercial beekeepers generally requeen colonies every two years, but there is a growing trend for annual requeening.

Laying queens can be purchased from a queen breeder (rearer), or colonies can be allowed to requeen themselves through the natural process of supersedure. However, allowing colonies to requeen themselves is an ad-hoc approach as the new queen may mate with drones that have undesirable characteristics. The progeny may not be docile.

Hobby beekeepers can purchase untested or tested queens from a queen breeder, or beekeeping equipment supplier. Untested queens are mated and have begun to lay prior to being caged for sale. Tested queens are more expensive and are not offered for sale until their progeny has been verified by the queen breeder as being true to type. Most hobby beekeepers purchase untested queens. As there is usually a high demand for queens, beekeepers should consider placing an order well in advance of the time the queens are wanted. This may be several months or even before winter in readiness for the following year.

Preparation of colonies for requeening

Requeening is not a cheap exercise, so it needs to be done correctly to have any hope of success. It is best done when foraging bees are collecting some nectar and pollen. Requeening when these are scarce or unavailable can cause heavy losses of queens, unless feeding with a light sugar syrup is done at the time of introduction.

It is essential that the colony to be requeened has a good number of young bees. Colonies that have no brood, especially young larvae, or are weakened due to queenlessness or the presence of a drone layer, will rarely accept a new queen. These colonies consist of old bees and are not worth the risk of losing good queens through requeening attempts. Uniting these bees with queen-right colonies is the best management practice.

Prior to introducing a new queen, find and remove the old queen (See *Finding a queen* below). There are no real exceptions to this rule. She must be found and removed before a new queen is introduced. If this is not done, the new queen will be 'balled' by the hive bees and dumped outside the hive. Prior to an introduction the beekeeper must ensure any existing queen cells are found and destroyed.

If there is doubt as to the existence of a queen in the colony, introduce a test comb of very young larvae. If, after 24 hours or more, queen cells are started and there are no eggs in cells, it is almost certain that the colony is queenless. The presence of a non-laying queen is indicated if new queen cells are not started.

Finding a queen

Finding a queen in a colony is a necessary task when requeening and dividing colonies. It requires concentration and must be tackled methodically. The beekeeper should not be stressed or distracted. When opening the hive, disturb the bees as little as possible so they do not become excited. Excited bees tend to run over the combs, making it difficult to see the queen. Use extra care and gentleness in handling the combs and avoid jarring or shaking them. Look for the queen, and only look for the queen, because if other tasks are done at the same time it will be easy to miss her. Use only enough smoke to subdue bees gently without causing over-excitement, racing or clustering.

Where queen excluders are fitted to hives, it is only necessary to search the box, or boxes, under the excluder. At certain times, most queens are in the super, or at other times, mostly in the bottom box. If there is an obvious pattern after examining a few hives, examine those boxes first.

Take off the hive lid. After a quick look to make sure the queen is not in the lid, place it upside down on the ground near the hive. If the hive has a super, place it on the upturned cover. If there is a hive mat, place it on the super to exclude as much light as possible.

Take out the combs second from each wall of the brood box. Carefully examine them for the queen before placing them aside, or into a spare super. Then take the wall combs out carefully and gently. Move them away from the wall because brace comb between the wall of the hive and the comb being removed can roll and squash bees. Examine these combs and then place them aside, or into the spare super. Then move any combs containing honey away from those containing brood unless the brood is right across the box. Examine the comb nearest the brood, and then take out each brood comb in turn, returning it to the hive after examination. To deter the bees from running to the sides

of the box and possibly hiding the queen, keep the combs away from the walls of the hive.

Examine each comb thoroughly, but quickly, before passing on to the next one. Don't spend too much time on each one. Check the spaces between the comb and the bottom bar and the two end bars. As each comb is lifted out, a quick glance down the exposed face of the next comb may reveal the queen before she has time to hide. If a queen excluder is not used, follow the same procedure with the super if you don't find the queen in the bottom box. Search all honey and brood combs, bottom board, internal walls etc., before giving up and moving on to the next box.

The process may be repeated if the queen is not found during the first inspection of the hive. However, the bees will be a little more excited by this time. It is pointless to repeat the process a third time. Let the bees settle down and repeat the procedure later in the day, or better still, the next day. Before moving on from that hive, make sure the queen has not dropped off a comb onto the ground in front or at the side of the hive.

Some queen breeders will, on request, place a small colour dot or numbered disc on the queen's thorax. This makes finding the queen a much easier task. An additional fee is charged for marking queens. Some beekeeping supply outlets sell queen marking kits. A cage to hold the queen immobile on the comb for marking is also available. Never hold a queen by the abdomen as this will damage her.



A marked queen is relatively easy to find.

The queen may also be found by straining the bees through a queen excluder. The queen and any drones are unable to pass through an excluder.

Make a 'strainer box' by tacking a queen excluder to the bottom of a spare empty super. Gently smoke the hive and carefully place its super onto a spare bottom board. Remove all the combs with adhering bees from the bottom brood box and place them in another spare box. Carefully examine any bees left behind in the now empty bottom box to be sure the queen is not there. Next, place the 'strainer box' on top of the empty bottom box. Push the 'strainer box' far enough to one side to provide a gap on the side where the beekeeper is working. The gap should be large enough to allow each frame to be placed into the bottom box after it has been examined for the queen.

Remove a comb with adhering bees from the spare box and shake all the bees from it into the 'strainer box' now sitting above the empty bottom box. Make sure the queen is not clinging to the comb before placing it into the empty bottom box through the gap made by moving the 'strainer box' to one side. Use the hive tool to lever this comb in under the strainer box.

Repeat this procedure with all the combs in the spare box. All the bees will then be in the strainer box or they will be passing through the excluder to the brood combs pushed underneath. The queen will, in most cases, now be found running over the excluder trying to get to the brood below. If she isn't there, she must be in the super which was initially removed. Those combs must be treated the same way after adding an empty super between the brood box and the strainer box. This method is effective, tidy and safer than shaking the bees on the ground in front of the hive and looking for the queen.

An alternative method is to remove all the frames from the bottom box. Shake all the bees into the bottom box, place the excluder on this box, and then put a super above the excluder. Place the combs including those containing brood in this super. The bees will move from the bottom box into the super to attend to the brood. The queen will be in the bottom box or on the underside of the queen excluder.

Introducing queens in mailing cages

Purchased queens, each accompanied by six to ten escort worker bees, are mostly sent to purchasers in small mailing cages with candy in a compartment at one end of the cage. The candy is food for the bees during transit and as a retardant to ensure a slow introduction of the queen to the colony. The queen is not able to pass through the exit hole until worker bees either eat the candy or remove it.

When the mailing cage containing the queen and escort bees arrives by post, place a very small drop of water on the wire gauze for the bees to drink. The water must be placed at the end of the cage furthest away from the candy. Avoid getting the candy wet because the sugary solution will be spread by the movement of the bees throughout the cage. The now sticky bees and queen will soon be unable to move and will more than likely die.



Queen and escorts in mailing cage with insect screen cover. Thin paper covers the candy to help prevent it drying. Note the corks in the exit holes of the cages in the background.

Where it is not possible to introduce the new queen into the hive on the day of arrival, the queen in her cage may be kept in a cool to warm room, away from steam, direct heat and direct sunlight. Make sure there are no hazardous chemicals present and ensure no family member uses insecticides because these kill bees. The general rule is to introduce the queen as quickly as possible. If poor weather, or another reason prevents this, give the bees a drop of water each day and add some candy if the supply is low.

When transporting caged queens to the apiary, make sure they are not in direct sunlight. Never place them on the dashboard, seat or other positions of the vehicle where they could be exposed to sunlight. Ensure good ventilation in the vehicle. Bees in a hot cabin can very quickly overheat and die.



Queen mailing cages with plastic covers.

A colony of bees becomes hostile to a strange queen that is introduced incorrectly and suddenly appears in its midst. So the method of introduction must provide enough time for the new queen's pheromones to be distributed by the hive bees and recognised by the entire colony. The queen mailing cage or Miller introducing cage is used to prevent the queen from joining the colony too soon before the bees have recognised and accepted her.

Assuming the old queen has been found, the mailing cage containing the new queen may be immediately placed in the hive. Sometimes the mailing cage has a cork at both ends but often at just one end. If it has two corks, remove the cork from the candy end of the cage. Place the cage between the centre combs in the brood nest, near the frame top bars. The screen side of the cage must face downwards so that the hive bees and queen can become acquainted. Push the frames together to hold the cage in place to prevent it from falling to the hive floor. The exit hole at the candy end is placed slightly higher than its opposite end. This will prevent any dead escort bees in the cage from blocking the exit and preventing release of the queen. The queen will usually exit the cage in one or two days.

Some beekeepers prefer to add more candy to the cage before it is placed in the hive, especially if the escort bees have eaten much of the candy during transit from the queen rearer. Within reason, the longer the queen is in the cage when placed in the hive, the greater are her chances of survival.

The queen in the hive may be killed and the new queen introduced in one operation. However, some beekeepers prefer to remove the old queen from the hive and introduce the new queen the next day, 12 to 24 hours later. It is important that any queen cells raised during that interval are destroyed.

Carry out these operations with a minimum of disturbance to the colony and take care not to incite robbing. Colonies which have been very disturbed or angered by robber bees are not in a suitable mood to take kindly to a new queen. Don't place cages directly under the lid of the hive, especially in hot weather as this may 'cook' the queen. It is not advisable to extract hives just before requeening.

Only introduce laying queens. Virgin queens are harder to introduce successfully. A virgin may have taken orientation flights from her original hive, and may become lost if the mating flight takes place from a different hive. Virgins may be introduced, but this is best left to the discretion of an experienced beekeeper.

About 98% acceptance of queens will be achieved by quite simple methods of introduction at times when conditions are favourable, but beekeepers should expect some failures. Occasionally, some colonies are unwilling to accept a new queen, even under the best conditions. Relocation of hives to an area where better foraging conditions exist will usually improve the rate of acceptance. Do this before introduction.

Leave the requeened hive alone for at least seven days, and preferably ten days. Opening the hive before seven days may cause the queen to be 'balled' and be rejected by the colony.

Candy for queen cages

Commercially prepared queen candy may be purchased. Alternatively, candy is made by mixing honey and icing sugar in proportion to make dough, about the consistency of stiff putty so it can keep its position in the cage while in the warmth of the hive and in the post. Thorough kneading with very clean hands is necessary to ensure the ingredients are well mixed. It may need beating with a mallet to gain the texture needed in hot weather.

Use only honey from your own hives known to be free of disease. Use only pure icing sugar. Avoid icing mixtures as these may contain ingredients detrimental to the consistency of the candy and to the well-being of the bees.

Introducing a queen by uniting colonies

If it was not possible to find the unwanted queen in a colony to be requeened, the new queen may be temporarily introduced to a nucleus colony. The nucleus will be queenless and will have brood of all stages as well as plenty of young bees. If the nucleus is made up in the apiary, the older field bees will return to the parent hive leaving the young bees in the nucleus (See *'Splitting off' nucleus colonies* in chapter 4. *How to get bees and increase numbers of colonies*).

When the new introduced queen is laying well, the nucleus can be united with the original colony to be requeened. It is first necessary to remove the unwanted queen. The colony containing the queen to be kept should be on top of the

queenless colony, separated only by a single or double thickness of newspaper which is perforated here and there with a small nail or the sharp end of the hive tool.

The bees become acquainted and gradually mix as they gnaw away the paper. The new queen continues to lay eggs in her original box and gradually extends her activities to the combs below as she becomes more familiar to the other bees and they all acquire the one odour. Once quite an amount of gnawed newspaper is seen at the entrance of the hive, it is usually safe to assume the two colonies have been united.

Queen rearing

In nature, colonies rear queens in specially built queen cells. These cells are peanut-shaped, almost vertical and have an opening that faces downwards. They are built on the edges and/or on the surface of the comb. Queen cells are not always present in the hive because they are only built when required in the circumstances described below. Sometimes, previously occupied queen cells remain in the hive and some are torn down by the bees. Those cells not torn down are not reused and their presence does not indicate that the colony is preparing to raise queens in any of the three situations described below.

Queenlessness (emergency)

When the queen is accidentally killed by the beekeeper, or the colony loses its queen by natural causes, an emergency exists. Worker cells containing young larvae, sometimes as many as 40 cells, are modified by the bees to become queen cells.

Under the emergency, there is a tendency for the bees to hurry their work and the selected larvae may not be well fed. Also, they may have received worker diet before they were selected to become queens. This can result in the new queen having reduced egg-laying capacity. Despite this, if this is the only means of having the colony requeen itself the beekeeper should choose two of the largest queen cells and destroy the rest so that the emergency reared queen can be the best possible under the circumstances. Two cells are chosen in case one cell becomes damaged.

It is a good idea to replace this emergency reared queen with a better quality queen reared by a queen breeder or one reared in the beekeeper's apiary under the supersedure or swarming impulse. This can be done when there is brood of all stages and young adult bees present in the hive.

Swarm (reproduction)

Swarm queens are usually well developed with good egg-laying potential, but they may carry in their genes a tendency to swarm. Swarm queen cells are constructed on the surface and/or the edge of brood combs before the queen and the swarm leaves the hive. The queen may also lay eggs in queen cell cups which are the first stage of queen cell construction.

Supersedure (replacement)

When bees recognise that their queen is aging or failing, they begin steps to replace her by building queen cells, usually one to four but sometimes more than this. Because

the aging queen is still present in the colony, the queen larvae are well fed and raised in an unhurried manner. As a result, supersedure queens are usually well developed with good egg-laying potential. On occasions, the old queen may continue in the hive for some time and both she and the new queen may be observed laying eggs in the brood nest.



Two queens on a comb during the supersedure process.

Asls Sha'Non

Raising queens

Raising queens is a specialised activity which requires expert know-how, grafting of very young larvae into artificial queen cell cups and access to well-bred drones and breeder queens. The Jenter queen raising kit is suitable for beekeepers with a few hives, as well as sideline beekeepers.



Queen cells on a wooden cell bar raised by a commercial queen rearer.

Raising queens by Jenter kit

The kit may be used to raise small or large numbers of queen bees. It is sold by beekeeping equipment suppliers, with all the required components and good instructions. Unlike other methods of raising queens, this system removes one of the hardest steps in queen rearing, that is, grafting larvae by hand.

Beekeepers intending to use the Jenter kit should note that the following are required for the successful raising of good queens:

- a light nectar flow and good supply of a mixture of quality pollens

- an abundance of sexually mature, high-quality drones for mating with the new virgin queens
- suitable weather for mating of drones and queens
- a suitable cell raising colony (as described later)
- a queen whose progeny display excellent honey production (compared to other colonies in the apiary), docile temperament, low swarming tendency, quietness on the comb and general vigour.

Poor spring weather can hold back the queen from taking mating flights. As a result, she may mate with a low number of drones and not receive an adequate supply of semen and within a short time she may become a drone layer or be superseded. More successful mating takes place when the weather becomes warm and settled.

The Jenter queen-rearing kit consists of plastic plugs that form the base of worker cells in a small sheet of plastic foundation. The foundation is contained within a plastic laying box which is inserted into a hole cut in an empty drawn comb. The lid of the laying box is designed as a queen excluder. It confines the queen in the box and allows worker bees to enter and leave the box.



Components of the Jenter queen rearing kit

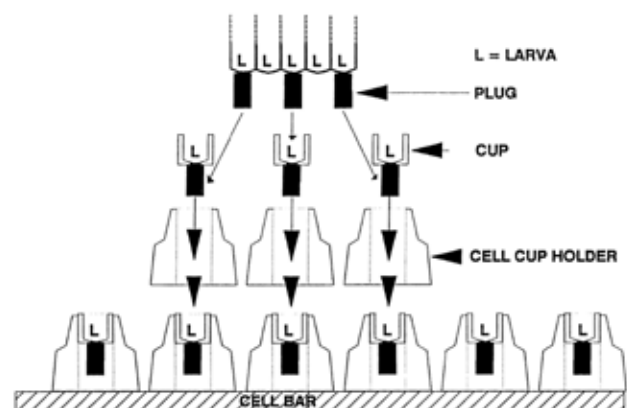


Figure 6. The Jenter queen-rearing kit

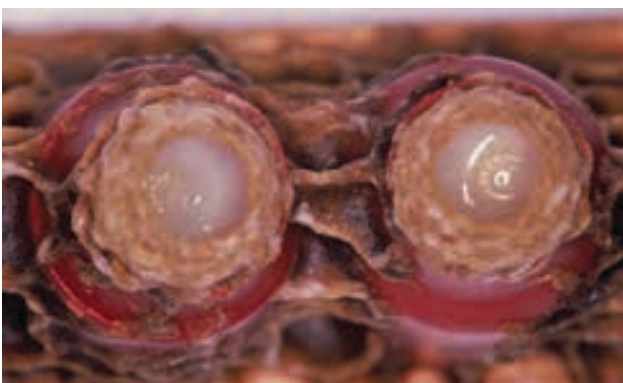
The breeder queen is first confined in the box. In about 12 hours, the queen has laid eggs in all the cells of the moulded comb. After three or four days the cells are checked for

newly hatched larvae. The cell bases containing these very young larvae are removed and placed into the cell cups and their holders. No more than 15 of these are fixed to a normal cell bar using molten beeswax. The cell in its specially built frame is then placed in a cell builder colony.

The cell builder colony must be very strong with worker bees and occupy a double storey hive. The queen is confined to the bottom box by an excluder. The bottom box should contain brood of all stages and empty comb for the queen to lay eggs. Two combs of very young bees are placed in the centre of the super with a comb containing unsealed honey and pollen on either side. The bar of cells, contained in the specially built frame, is placed between the two combs of unsealed brood.

The queens will emerge from their cells 16 days after the eggs were laid. It is important that each cell is distributed to a queenless nucleus colony before the queens are due to emerge because the first one out of its cell will destroy all the others. Any cells already started in the nucleus should be destroyed before the cell is introduced. Taking 'D' as the day the egg was laid, cells may safely be given to nuclei on D + 12 days. D + 13 is also adequate, but D + 14 is cutting it fine as the queens will emerge on D + 15. If one queen has developed a little faster than the others, then it will destroy its rivals. Keep a good record of when the eggs were laid in the Jenter kit plastic plugs.

Gently prise each cell cup with its fully developed queen cell from the cell bar, keeping each cell vertical. When preparing to introduce the new cell, a slight depression is pressed into the face of a brood comb of the nucleus hive which is to receive the cell. The plastic cell cup holder is gently placed, or pressed, into the surface of the depression. Take care not to squash or damage the beeswax component of the cell. In hot weather, wait until the cool of the evening before distributing cells.



Queen cells with larvae after 24 hours in a cell building colony.

If transporting the queen cells from one locality to another, prior to introduction, they must be treated with the utmost care. Avoid jarring, chilling and exposure of cells to hot, direct sunlight. They may be transported in the cell building hive or in a nucleus box moderately filled with queenless bees from the cell-building hive. Be careful to avoid overheating the cells by crowding this hive with too many escort bees.

Don't move or open the nucleus hive for ten days after emergence of the queen from its cell. Under normal field and mating conditions, virgin queens will mate and begin egg-laying about 10–15 days after emergence.

This method of raising queens is well worth a try for hobbyists as well as commercial beekeepers.

13. Brood diseases of bees

Sooner or later, most beekeepers will have to deal with an outbreak of brood disease in their hives.

It is not always possible to prevent disease from occurring in the apiary. However, early detection and a good understanding of disease management will help lessen the effect and further spread in the apiary, as well as spread to other beekeepers' hives.

Be sure to get a correct diagnosis (as discussed later). Be aware that more than one brood disease can occur in a hive and even in the one comb. If you ask another beekeeper to diagnose a disease in your hives make sure the person has the skill to do this. Some well-meaning beekeepers have incorrectly diagnosed a particular disease in another beekeeper's hives. This has resulted in unnecessary loss of colonies and honey production, and even further spread of disease.

Inspection for brood disease, especially American foulbrood, must be conducted in spring when colonies begin to expand. In each hive, inspect all combs that contain brood. Shake the bees off each comb in turn so that all cells containing brood can be easily seen. Shake the bees into the brood nest. Do another inspection of brood in autumn before colonies are packed down for winter. At least two other inspections should be done between the spring and autumn inspections.

American foulbrood (AFB)

AFB is a highly infectious brood disease that kills honey bee larvae and pupae. It occurs throughout Australia, but at the time of writing had not been confirmed in the Northern Territory. AFB does not affect humans and honey that contains AFB spores is safe to eat.

Cause and life-cycle

AFB is caused by the bacterium, *Paenibacillus larvae*, visible under an oil immersion lens of a microscope at a magnification of 1,000.

The disease begins in a bee larva after it swallows AFB spores with its food. Within 24–48 hours, the spores germinate in the larval gut and develop into vegetative 'rods'. The larva dies usually immediately after the brood cell is capped. On occasions, death occurs later at the pupal stage. The vegetative rods invade the haemolymph and body tissues. The final stage of the bacterium's lifecycle is reached when the rods form into spores. About 2,500 million spores occur in the remains of a single infected larva.

The spores are very resistant to heat, direct sunlight, dehydration, desiccation, fermentation, many chemical disinfectants and therapeutic drugs. They remain viable for about 50 years and probably longer. They occur on combs and hive components, and in honey, wax and propolis.

About ten spores are required to infect larvae aged less than 24 hours. More spores are needed to infect older larvae. Even millions of spores may not cause infection in larvae four or five days old. In the hive, spores are probably transmitted by nurse bees that have cleaned cells containing infected larvae.

Early detection is important

AFB does not always develop quickly. In the early stages of infection, there are no obvious signs of disease by simply looking at the number of bees and the amount of honey being stored in the hive. This is because, at this stage, there may only be one, or a few, infected larvae and pupae showing signs of disease. These are easy to overlook. But this is the time to detect and eradicate AFB, especially if you routinely move combs and other components from hive to hive.

As the number of AFB infected larvae greatly increases in the hive, the number of adult bees will begin to noticeably decline. It is obvious that there is something wrong and eventually the entire colony will die. This decline may occur over a period of two to three months or longer. In the case of a late autumn infection, the disease may not have much effect until large-scale brood rearing commences in the following spring.

Because AFB is difficult to detect in the early stages, take time to thoroughly inspect brood throughout the year, but particularly when colonies build up in spring and when hives are prepared in autumn for winter pack-down. It is standard procedure is to take excess supers of combs off hives during preparation for winter. An infected super stored during winter will spread infection in the apiary if it is placed on another hive in the spring. Hobby beekeepers can take steps to return supers to the same original hive by numbering both the hive and the super.

Carefully inspect weak and strong colonies alike for AFB signs. The symptoms are usually obvious in a colony weakened by the disease. They are less obvious in a strong colony that has recently become infected because the colony appears to be functioning normally.

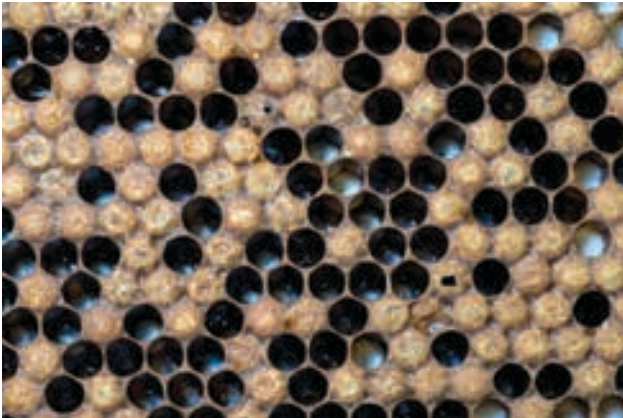
Symptoms in colonies and combs

In advanced cases, the brood pattern will be scattered. Cells containing healthy brood of all ages will be interspersed with cells containing diseased larvae, pupae or dried larval remains (scales). The appearance of the brood comb is an irregular pattern of cells not yet capped, cells that are capped and cells with perforated caps, and cells with caps entirely removed. Darker, sunken caps of diseased cells will be seen among the lighter convex caps of healthy cells. The appearance is sometimes described as a 'pepper-box' or 'shot-gun' pattern.

An irregular brood pattern is not exclusive to AFB, but it is certainly a sign that something may be wrong. Always determine the cause of irregular brood patterns. Never overlook AFB.

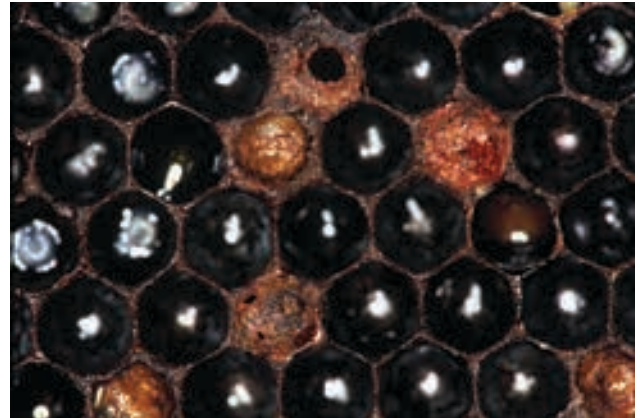
Caps over sick or dead brood are generally darker and tend to be sunken (concave), greasy-looking and sometimes perforated. Use a match, twig or hive tool to remove the cell cap to determine if the larva inside is diseased.

The caps of healthy brood are generally bright, convex, mostly uniform in appearance and not perforated. There may be a few caps which appear perforated but these are simply caps under construction and the cell is not yet fully sealed.

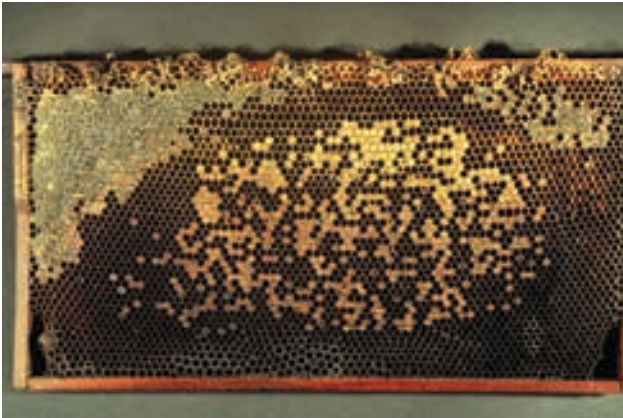


Early signs of AFB infection. A few cells with perforated caps and others with sunken caps.

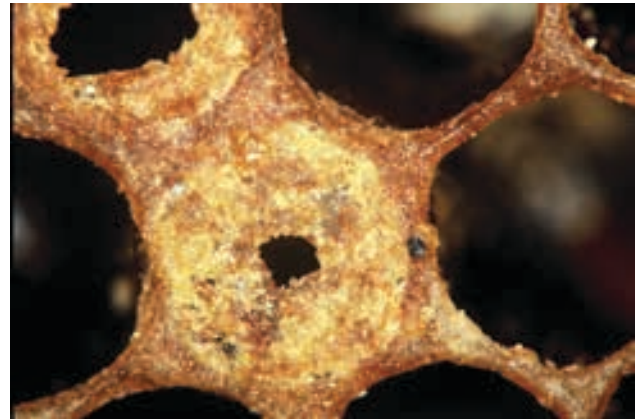
Doug Somerville, NSW DPI



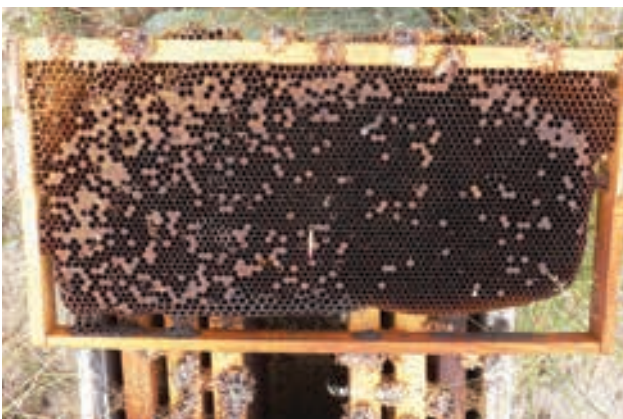
Typical AFB with dark, greasy, perforated and sunken caps.



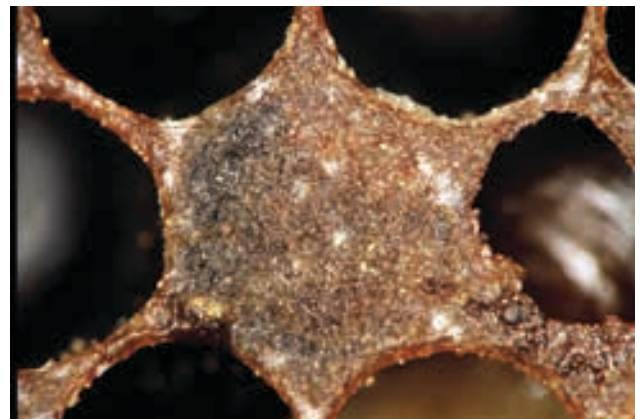
A comb showing irregular brood pattern of very advanced AFB infection. Many caps are dark and perforated. Ideally, the disease should be detected before it has developed to this advanced stage.



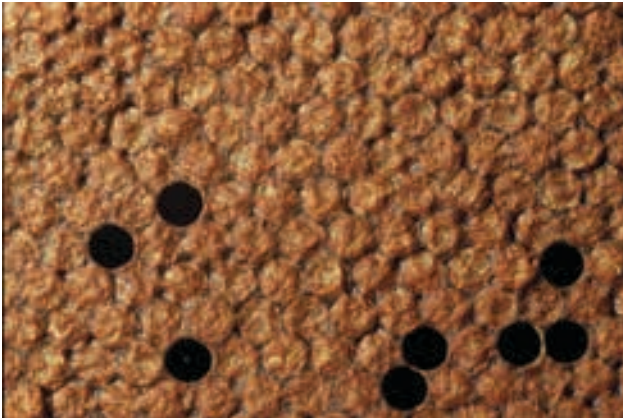
Perforated caps of brood cells.



Advanced AFB with irregular brood pattern. The colony has died and honey has been removed by robber bees.



Dark cap of a cell containing an AFB infected larva.



Healthy brood cells, regular brood pattern and slightly convex caps.

Never rely on an irregular brood pattern or the presence of the 'gluepot' odour as tell-tale signs of AFB. When these are obvious, the disease is already well established and there is every chance that the beekeeper has spread the disease to other hives when transferring combs and hive material. The disease should have been detected before these symptoms were obvious.

Symptoms in the brood

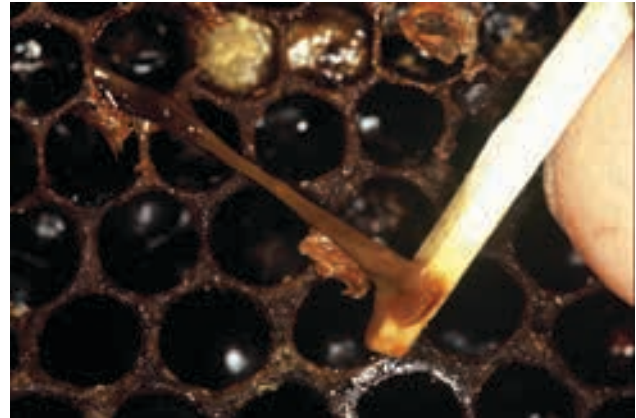
If you wear glasses to read, wear them while looking for AFB and other brood diseases.

AFB diseased larvae, pre-pupae and pupae always lie stretched out on their backs on the lower walls (floor) of their cells, from the back of the cell (the mid-rib of the comb) to the cell opening. If the cell opening is likened to a clock-face, the diseased individuals (and later scales) will be positioned at the bottom of the face between the figures 5 and 7.

Diseased larvae may become discoloured. They change from the glistening pearly white of the healthy larva, through a dull white, yellowish, light brown, coffee brown, to a dark brown, almost black mass.

The consistency of the diseased larva changes from the healthy, watery condition through syrupy, 'ropy' and pasty stages to a hard, dry, black brittle scale. The scale stage is reached in about one month from the time the larva became infected. The plump body of the larva reduces in size to a thin scale.

The ropy consistency during decomposition of the infected larva is the basis for a field diagnostic test for AFB, known as the 'matchstick' or ropiness test. A matchstick or twig is used to gently (or hardily) stir the contents of the cell. Using the match, the contents are gently withdrawn from the cell. If the larval remains stretch out like chewing gum in an even thread of 25 mm or longer, AFB is most likely present. Leave the match in the comb if there is any suspicion of disease, as it may be heavily contaminated with infective material.



The AFB ropiness test. The remains of a recently dead larva or pupa may be withdrawn from the cell in an even thread of 25 mm or more.

Sometimes, the remains of larvae that have died from European foulbrood disease may stretch out, but usually less than 18 mm. Where there is doubt as to which disease is present, the position of scales and presence of tongues, as described below, should be considered. If this does not assist the beekeeper to reach a confident diagnosis, a larval smear as described below should be sent to a diagnostic laboratory, or a commercially available field test may be used.

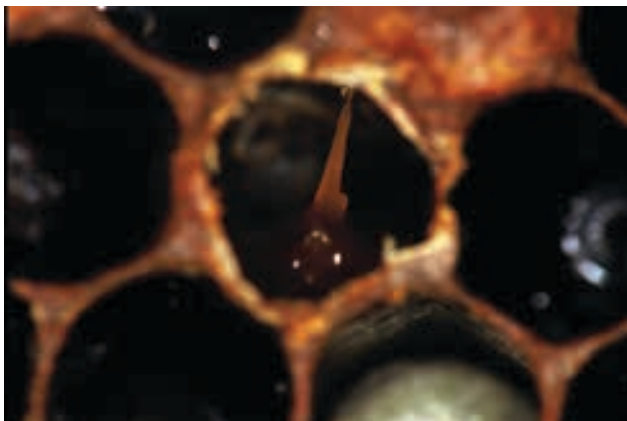
Almost certainly, if the matchstick test does not give a clear result, there will be other signs of the disease in the hive. The scale stage provides another good field test for diagnosing AFB. The scale, always lying on the lower cell walls between five and seven on the clock face, adheres tightly to the cell. It is impossible to remove it with a matchstick or similar implement without breaking the cell walls. Initially, the AFB scale may be difficult to see if the frame is held in the wrong position. Tilt the frame with the top bar towards the observer so that the sunlight falls directly on the lower walls of the cells. If scale is there, it will show up very clearly and once seen will make the observer wonder how they ever missed it.

Other brood diseases, at times, cause scales in brood cells. However, unlike AFB, European foulbrood and sacbrood scales readily separate from the cell walls.

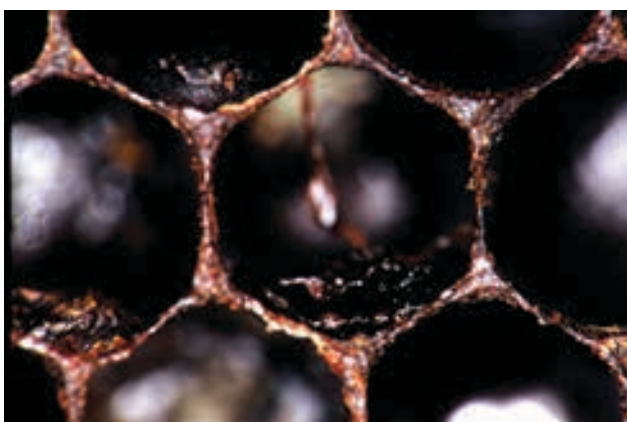


Inspecting a brood comb for signs of AFB. Tilt the frame so that sunlight falls directly on the lower walls of the cells.

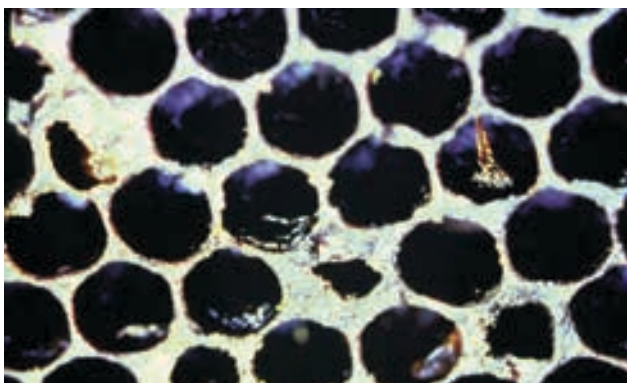
When bees die in the pupal stage, the mouthparts (tongue) are characteristically turned up towards and almost touching the top (roof) of the cell. The tongue dries and becomes almost a thread. The tongue is a very useful symptom when diagnosing AFB and its presence is almost a 100% confirmation of AFB. It is important to note that the absence of tongues does not indicate absence of the disease. AFB disease signs in individual hives of the same apiary will differ from hive to hive in that one infected hive may exhibit numerous tongues while the hive next door may show none.



The tongue of a recently dead pupa infected with American foulbrood.



Part of a comb infected with American foulbrood showing thin dried tongue (centre cell) and dark dried scales (left cells), on lower cell walls.



AFB scales (near centre) and tongue still drying (right).

Michael Hornitzky, NSW DPI

Spread

Unfortunately, once AFB appears in a hive, the beekeeper can be the prime cause of further spread within the apiary. If the disease is not recognised, it will be spread during normal apiary management and extracting operations by transferring combs and other components from diseased hives to healthy ones.

When an infected colony dies, the honey which contains AFB spores can be robbed by other bees from nearby hives or feral nests, thus spreading the disease.

If transferring comb from box hives, hollow trees and walls, carefully examine the brood for disease. Place bee swarms in a separate apiary and examine the brood for some months to ensure they are disease free.

Inspect the brood of hives before purchasing them. Don't purchase hives in late autumn, winter or early spring that are broodless. Several apiarists have disregarded this and have purchased diseased hives. Similarly, buying used hive components is risky because any AFB spores present can remain infective for 50 years or more. If these are purchased, it is good practice to sterilise all used hive components by gamma-irradiation as there is no way of knowing if AFB spores are present on these items. Irradiation is a proven, 100% safe and economical means of sterilising hive components. The company that provides this service will not accept combs that contain honey and brood, and those sticky with honey after extracting.

Honey from diseased colonies can contain AFB spores. Never feed honey to your bees unless it has been obtained from your own healthy hives. Unwashed honey containers left in the open are a potential source of AFB spores.

AFB is not spread by bees visiting flowers previously visited by bees from a diseased colony, nor is it spread by European wasps.

The use of an antibiotic, approved by the Australian Pesticides and Veterinary Medicines Authority, and prescribed by veterinarians (or other authorised persons) for treatment of European foulbrood means that some beekeepers have inadvertently treated AFB. The antibiotic only treats the vegetative stage of the AFB bacterium and it has no effect on the spores that can remain dormant on combs and hive components ready to initiate disease after the drug treatment is discontinued. The beekeeper gains a false sense of security. Believing a hive to be free of disease, the combs contaminated with spores are transferred to other hives during normal apiary management. AFB develops when the antibiotic is no longer effective. The result is that AFB is spread more extensively than before.

If AFB is suspected in a hive there is a lot at stake so beekeepers need to get their disease diagnosis right. Careful examination of the brood nest is essential. Where there is doubt, an AFB field test kit or submission of an AFB larval smear for laboratory examination, will give the beekeeper an accurate diagnosis.

The 'American foulbrood (AFB) diagnostic test kit' works like a home pregnancy test and reacts specifically to antibodies produced by the bacterium that causes AFB. These disposable single-use kits are available from bee equipment suppliers. They should be stored at room temperature of 18–25 °C until needed.

The larval smear is prepared as follows. Clearly label a clean, glass microscope slide at one end with your registered brand number given to you when you registered as a beekeeper with your state/territory Department of Primary Industries. On the slide, write an identification number for the hive and the apiary (if you have more than one apiary). If you have recorded the same number on the hive, this will enable you to identify the hive when you receive the diagnosis. Use a spirit-based permanent waterproof felt tipped pen, or if the slide is frosted at one end, use a pencil.

Using a clean match, take a single diseased or suspect larva (or its remains) from its cell and place it on the glass slide. Use the same match to crush and pulp the larva on the slide. Then use the length of the match to make a *thin* smear by pushing the pulped remains to the unlabelled end of the slide, and off the slide. Leave the match in the hive or place it in the smoker to prevent it from spreading disease to other hives.



A larval smear on a glass slide.



The dried larval smear with beekeeper identification and plastic slide mailers.

Allow the smear to air-dry out of direct sunlight. Don't cover the smear with a glass slide or cover slip as these are almost impossible to separate in the laboratory without shattering the glass. Place the dried smear in a plastic slide carrier or wrap it in paper and then place it in a strong cardboard box to prevent breakage when mailed to the laboratory.

Dried larval remains (scales) are difficult to remove and smear, and don't adhere to the slide. A scale mixed with a drop of distilled or clean tap water, and smeared when soft, overcomes this problem. Alternatively, the dried remains should be forwarded to the laboratory in a small, clean, unused vial.

Inspecting hives when AFB is suspected

If AFB is found or suspected in a hive, the beekeeper can continue to inspect other hives in the apiary provided certain steps are taken. When the diseased, or suspect hive, has been reassembled, thoroughly clean the hive tool, smoker and gloves using steel wool, water and detergent to remove all traces of honey, beeswax and propolis before inspecting the next hive. It is not necessary to sterilise these items. Spilt honey on the ground should be removed to prevent access by robber bees. Honey on the beekeeper's clothing should be removed using a damp cloth. Inspect all hives in the apiary to determine how many have AFB. If robber bees are active, stop all inspections and return to the task on another day when robbing is no longer a problem.

AFB is a notifiable bee disease

If you detect AFB or suspect it to be present in a hive, contact your state or territory Department of Primary Industries apiary inspector or apiary officer. You will be given advice on how to control and eradicate the disease. Remember, it is mandatory by law to notify the presence or suspicion of AFB in an apiary. To not notify, is to break the law.

Eradication of AFB

When AFB is found or suspected, reassemble the hive immediately and restrict the entrance to prevent robbing. If the colony is very weak and is being robbed, or is likely to be robbed, close the entrance completely to prevent further robbing. Move the closed hive out of the sun to prevent melt down and leakage of remaining honey.

Control of AFB is achieved by killing and burning the bees, frames, combs, honey and other hive components of infected hives in a pit. The burnt remains are then covered with at least 30 centimetres of soil.

Hive components and empty dry combs that are worth keeping can be saved and sterilised by gamma-irradiation. Alternatively, these items, but not frames, combs and hive mats, can be sterilised by hot wax dipping. Because wax dipping is an extremely hazardous activity it must only be done by persons who provide a commercial hot wax dipping service. Such persons must have read the publication *Hot wax dipping of beehive components* available on the Rural Industries Research and Development Corporation's honeybee web page. It contains all the details and safety measures. Please remember, wax dipping of beekeeping material is a hazardous activity and should not be done by hobbyists.

Points worth considering

- If in doubt as to whether AFB is present, use an AFB test kit or submit a smear for laboratory examination.
- Never interchange combs, boxes and other hive components between diseased and healthy colonies.
- Don't interchange hive components between apiaries. If AFB occurs in a hive, keep it confined to that hive and that apiary.
- Do not neglect bees. Sell them, or give them to someone who will care for them.
- By law, treatment of AFB with any drug is not permitted.

Honey culture test to monitor apiary health

In addition to the important inspection of brood in individual hives, the laboratory honey culture test can be used to monitor the AFB status of an entire apiary. The sample to be tested should contain honey from all the hives in the apiary. If the test detects AFB spores, the beekeeper will then check each hive for signs of disease. The sample must not contain even a trace of honey from another apiary, because you won't know which apiary may have an AFB problem.

A sample of clean honey, free of wax, dirt, and parts of bee bodies, and at least 120 ml in volume, is collected during extracting.

Beekeepers with only one yard of hives can collect a sample of honey direct from the settling tank.

Beekeepers with more than one yard of hives can collect honey at the extractor outlet before it reaches the sump and other points where mixing of honey from other apiaries may occur. As honey flows from the extractor during each extractor spin (or batch of combs), a small amount of honey is collected and placed in a small unused pail. This is done for each spin until all combs from the one yard are extracted. After thorough stirring, the sample is taken from the honey in the pail. It is essential to use a clean, unused pail and stirrer each time combs from a yard are extracted. Doing this will prevent cross-contamination of samples. If it is not possible to clean the extractor between yards, honey from the first extractor spin is not sampled but is allowed to flush honey of the previous yard out of the extractor.

Seal the lid of the container with tape to prevent leakage of honey. Write your name, beekeeper registration brand and your yard (apiary) identification on the label of the container and on the submission form. If you have samples from other yards, choose a different identification for each yard. Make sure the correct identification is written on the sample container and its submission form. If AFB spores are detected in a sample, you will then know which yard has a problem. Getting this right can save you a lot of work and worry in the future.

If only a small number of spores are detected, a follow-up inspection of brood may fail to find any AFB disease signs. In such cases, the test result provides a warning that AFB could develop in the future, but conversely it may not. The best advice is that beekeepers should conduct brood inspections in spring, autumn and throughout the active beekeeping season.



These samples of honey are unsuitable for testing. Left, the honey must not contain dirt and wax; right, the container must be filled with honey.



This container holds the right amount of clean honey for the culture test.

European foulbrood disease (EFB)

This disease occurs in all mainland states except Western Australia. It is particularly severe in Victoria and southern New South Wales. In severe spring outbreaks, many larvae die over a short period of time and this can cause a rapid decline in the number of adult bees and honey production. Apiarists may experience serious financial losses and an outbreak of EFB can have a far greater impact than an outbreak of AFB.

Fortunately, few colonies die due to EFB and many spontaneously recover over a long period that may be several months. Recovery is largely dependent on weather conditions suitable for honey bee foraging and availability of good supplies of nectar and pollen.

Cause and life-cycle

EFB is caused by the bacterium, *Melissococcus plutonius*. The bacteria multiply inside the mid-gut of the larva and compete for the available food supply. Infected larvae fed with a plentiful amount of food supplied by nurse bees may survive. When the bacteria consume most of the food in the gut, the larva can be under nourished and become an undersized adult bee. Those larvae that have insufficient food eventually starve and die, usually when they are four to five days old.

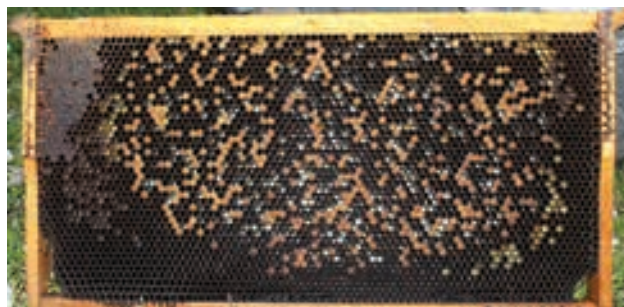
Faeces left behind in the cell after emergence of the newly developed bee are contaminated with bacteria ready to infect the next generation of larvae.

EFB is most severe in spring. When the brood nest is small and there is sufficient honey and pollen available, the larvae are usually well fed, even though the bees may be confined to the hive due to poor weather. There is enough food for both bacteria and bee larvae. The number of infected larvae and the number of bacteria in the hive can rapidly increase with little or no disease signs evident, because both are well fed.

When the weather improves and the nectar flow starts, there is a rapid expansion of brood rearing. More nurse bees are recruited to foraging duties. When this happens there are too many larvae to feed and many of the infected larvae starve. They die faster than the hive bees can remove them from their cells and the disease becomes obvious to the beekeeper.

Symptoms in the comb

In advanced cases, the brood pattern will have a mottled, pepper-box or irregular appearance. Sick or dead larvae will be intermingled with healthy ones. Most larvae die before the brood cell is capped. Where death occurs after sealing, the caps may be dark, sunken and perforated.



Spotty brood pattern of an EFB infected comb. There are some cells around the edge of the area of brood that contain yellow and dark pollen.

Rob Snyder at Bee Informed Partnership

Symptoms in the brood

Mostly, larvae die when they are coiled at the base of the cell or as they are in the process of turning into the longitudinal position to rest on the lower cell walls. The dead EFB larvae are twisted more or less spirally around the walls of the cell and can be in any position. There is much variation. This is unlike AFB larvae which are always the same position stretched out on the lower cell walls.

Healthy larvae have a gut line that is golden brown, yellow or orange in colour, but the gut line of EFB infected larvae is chalky-white, or interspersed with yellow, white or bleached bands. The white bands are pockets of the bacterium that causes EFB.



A larva killed by European foulbrood.



A larva killed by European foulbrood.

After death, the larva turns yellow, then brown or dark brown, and sometimes nearly black.



EFB infected larvae turning yellow.

Rob Snyder at Bee Informed Partnership



The perforated cap of a cell containing a larva killed by European foulbrood. Some infected larvae die after their cells have been capped.

The consistency of infected larvae varies from a healthy watery consistency through a sticky stage, to pasty and finally a hard, dry scale. A ropy stage may occur, particularly if *Paenibacillus alvei*, a secondary bacterium is present (see below). However, the larval remains will neither stretch out to the extent of AFB, nor form an even string and has a granular appearance.

Unlike larvae killed by American foulbrood, the larvae and scales resulting from EFB can be easily removed from their cells.

A 'foul', 'sour' or rotten oranges odour may be present in an advanced case, depending on the bacteria present.

Secondary Bacteria

The death of infected larvae may be accelerated by secondary bacteria. A common bacterium, *Paenibacillus alvei*, is often found in pre-pupae that have died as a result of EFB. The pre-pupae lie stretched out lying on their backs on the lower walls of their cells. Their colour may be reddish brown. On odd occasions, a tongue may be seen but these are not as fine as an AFB tongue and rarely touch the cell roof. They are also easily removed from the cell. The cell cap may be intact, perforated or totally removed by adult bees.

The ropy consistency of such pre-pupae is, at first, similar to that of larvae killed by AFB. Sometimes, the remains may stretch in a thread up to about 18 mm in length, though usually much less. The beekeeper must carefully inspect the brood when making a diagnosis, or obtain a laboratory diagnosis to accurately confirm which disease is present in the hive. Because AFB and EFB to even a trained eye can at times appear similar, it is important that a correct diagnosis is obtained. To get it wrong will be very costly.

Spread

There is very little a beekeeper can do to prevent EFB. It is highly contagious and combs remain infectious for two years and probably much longer. The bacterium occurs in latent form in most hives in Victoria and is easily transferred from hive to hive with the interchange of hive components. The organism can be spread by drifting bees, at watering places and probably by drones.

Diagnosis of EFB by smear

EFB may be diagnosed by submitting a smear of a diseased, or suspect larvae, for laboratory examination. Refer to *Diagnosis of AFB by smear* in the section on American foulbrood disease for detailed notes on how to prepare smears.

Control

Strong colonies of bees headed by young, vigorous queens and accompanied with good supplies of nectar and fresh high-protein pollen will usually eliminate the disease.

Colonies headed by poor or failing queens do not readily remove diseased larvae, thereby allowing the bacteria to build up in the hive. Conversely, colonies headed by a prolific queen and with a shortage of cells for brood rearing will readily remove sick larvae.

Where possible, avoid stress to the bee colony. Stress may be caused by moving hives to other apiary sites, particularly if they are moved with a closed entrance. Opening hives more than is necessary can also cause stress.

Annual replacement of 20–25% of old, dark brood combs is often recommended. This may assist in reducing the number of bacteria in the hive, but it will never totally eliminate the disease. In fact, the first generation of larvae raised in recently drawn comb can be diseased.

Colonies may be treated with a specific antibiotic, registered by the Australian Pesticides and Veterinary Medicines Authority and prescribed by registered veterinarians. The beekeeper may be asked to supply a laboratory diagnosis of EFB before the veterinarian will prescribe the treatment. Alternatively, written confirmation of the disease in brood may be supplied by an apiary inspector. Full details of this treatment and how it is prescribed and administered to colonies may be found on state Departments of Primary Industries honey bee websites.

Sacbrood

Cause and life-cycle

This brood disease is caused by the Sacbrood virus, and is generally not a major problem.

Larvae about two days old are most susceptible to infection. The virus multiplies in the body tissues and grey, granular fluid accumulates between the skin and the body of the larva, hence the name *sacbrood*. Larvae almost always die in the pre-pupal stage after the cell is sealed.



Accumulation of fluid between the skin and body of a larva infected with sacbrood.

Symptoms in the comb

In advanced cases, combs show a suggestion of irregular brood pattern as occurs in the foulbrood diseases. Dead brood will be found scattered among healthy brood and the cell caps may be discoloured, sunken, perforated or entirely removed by the bees.

Symptoms in the brood

Infected larvae change from glistening white to a yellowish colour, then brown, and finally from dark brown to black. Darkening begins at the head first and later spreads to the rest of the body.

Dead larvae lie fully stretch out on the lower walls of their cells. The head of the larva is prominently raised towards the upper cell walls at the opening of the cell. Larvae, and later, scales, have a characteristic 'gondola' or 'banana' shape.

As the larva dries, it wrinkles and forms a brittle scale on the lower walls of the cell. The scale is readily removed from the cell without damaging the cell walls.

Spread

Cell cleaning bees probably become infected when they remove remains of diseased larvae. The virus accumulates in their hypopharyngeal glands. When they become nurse bees they pass the virus to new larvae as they feed them.

Sick and recently dead larvae contain a large amount of virus and are highly infectious. Fortunately, the remains lose infectivity as they dry. The virus may be carried over from season to season by adult bees.

Control

The incidence of sacbrood in most colonies appears to be low and the disease clears up spontaneously in summer, although it may reappear in autumn.

Where infection is high, movement of hives to good conditions of nectar and pollen will help overcome the disease. If this is not possible, supplementary feeding with 1:1 sugar syrup will often assist the colony to recover. In addition, requeening with a young, prolific queen with good hygienic behaviour is recommended. Good strong colonies of bees are able to keep the disease under control reasonably well.



Larvae infected with sacbrood virus. The cell caps have been removed by nurse bees.

Rob Snyder at Bee Informed Partnership



The dead sacbrood infected larvae darkens and dries to form a scale.

Rob Snyder at Bee Informed Partnership



Stages of decay of larvae killed by sacbrood (from left to right):
 (a & b) The sac of clear liquid forms around the body
 (c) The head blackens first
 (d) The larva blackens further as it dries
 (e) The scale.

Chalkbrood

Colonies vary in their susceptibility to chalkbrood. The disease can cause loss of honey bee larvae and eventually a decrease in honey production as the number of foragers declines.

Cause and life-cycle

This disease is caused by the fungus, *Ascosphaera apis*. The spores, which are highly infectious, are swallowed by larvae with their food. They germinate and produce mycelia. This grows in the gut and eventually breaks out through the body wall at the rear end of the larva. When two different strains of mycelium come into contact, spores are formed within dark brown-green spore cysts known as fruiting bodies which appear on the outside of the larval remains.

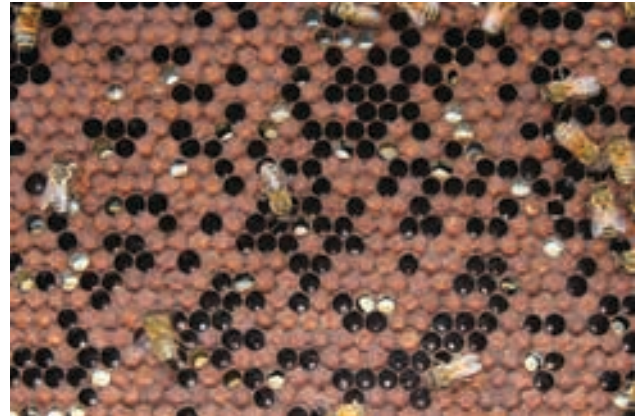
Larvae, three and four days old, are most susceptible to infection, especially when the brood is chilled. They die about two days after their cells have been capped.

Symptoms

The dead larva is covered with a fluffy white growth of mycelia and becomes swollen to the hexagonal shape of the cell. It eventually dries down to a hard, shrunken, chalk-like 'mummy' which may be white or dark blue-grey to black if fruiting bodies form.

Larvae die after the cell is capped, but the caps are often removed by adult bees. Larvae raised on the edge of the brood nest are more likely to be chilled and are often the first to be infected.

Dried-out mummies are easily removed from their cells. They may be heard rattling in their cells when the comb is shaken. Mummies are removed by adult bees and may be found on the bottom board of the hive and on the ground at the hive entrance.



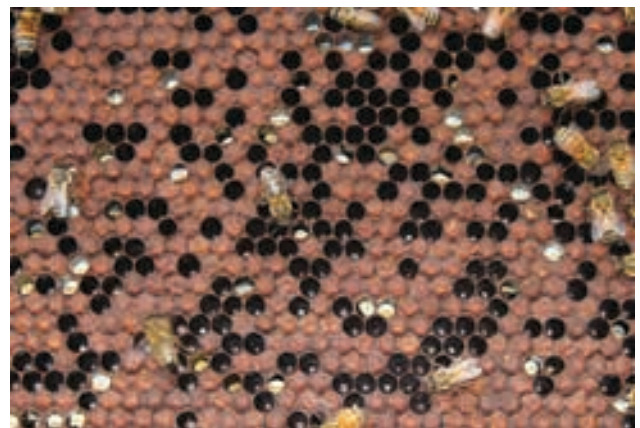
Chalkbrood infected larvae in brood comb.

Rob Snyder at Bee Informed Partnership



White chalkbrood fungal growth at rear end of a drone.

Rob Snyder at Bee Informed Partnership



Chalkbrood mummies on the floor of a hive. A heavy infection.

Courtesy: The Food and Environment Research Agency (FERA), Crown Copyright.

Treatment

There is no known chemical treatment for this disease. The spores are very resistant and remain infective for at least 15 years. Colonies, especially strong colonies, can generally recover from the disease by themselves.

Colonies should be kept warm and dry, but with good ventilation. Damp apiary sites should be avoided.

Opening hives unnecessarily in cool spring weather, division of colonies for swarm prevention and spreading the brood nest too early in the season can result in loss of heat from the hive. This can chill brood and cause an increase in the number of diseased larvae. Only add a super to hives when needed, because the colony may have difficulty keeping the brood warm. Very cool spring conditions may cause the bees to reform the winter cluster, thereby leaving some brood at the edges of the brood nest exposed to cold temperatures.

In addition to spring outbreaks, chalkbrood may occur in warm dry conditions in summer and autumn. Poor conditions such as limited supplies of nectar and pollen may be a factor. Moving hives to good conditions or feeding colonies sugar syrup and protein supplements may help recovery. While high protein pollen is preferred, any pollen is better than none at all. Ideally, the bees should have access to pollen from several plant species for a balanced, nutritional diet.

Colonies with queens bred for hygienic behaviour uncap cells and remove diseased larvae from the hive more readily than other lines of queens. Removal of diseased individuals by cell cleaning bees before they become mummies may help to reduce the severity of the disease.

Removal of mummies from the hive bottom board and outside at the hive entrance by the beekeeper may partly help the colony to recover. Removal of heavily infected combs from a hive and replacing them with foundation could also assist recovery. However, if conditions are poor, the bees may not readily draw the foundation.

Chalkbrood, because of its nature, can be a bit of a soul destroying bee disease for the beekeeper. It can just turn up in brood, and even be severe, even though there has been good management by the beekeeper. Please don't think you are a bad beekeeper or have done something wrong.

Stonebrood

Two species of fungus *Aspergillus flavus* and *Aspergillus fumigatus* may infect and kill both larvae and adult honey bees. The disease is relatively rare and short-lived. Very few bees in Victoria have been found infected with this disease. For practical purposes, the disease may generally be disregarded if good beekeeping methods are practised.

Larvae infected with stonebrood lose their normal glistening appearance and become dull white and fluffy. The remains harden, shrink and wrinkle within a day. The fungus generally seems to erupt through the skin of the larva in the form of a collar just to the rear of the head and then spreads over the surface of the larva.

The dead larvae become very hard 'mummies' after a few days. The colour changes from white to greenish when fruiting bodies are formed. Larvae may die at any age, but mostly when in sealed cells.

Differentiating characteristics for diagnosis of brood diseases

Characteristics to observe	American foulbrood	European foulbrood	Sacbrood	Chalkbrood
General appearance of brood pattern and comb	Advanced cases scattered. Diseased brood in darkened capped cells except when bees remove or partly remove caps	Scattered. Diseased brood mostly in cells that have not been capped	Slightly scattered. Diseased brood in capped cells, and cells with caps partly removed	Scattered in advanced cases. Diseased brood and mummies in capped cells, and cells with caps partly or entirely removed by bees
Appearance of caps over sick and dead brood	Sunken, dark, sometimes moist, perforated	Few caps sunken, dark, perforated	Usually perforated	May be perforated
Proportion of dead brood	A few larvae to 75% or more in advanced cases	A few coiled larvae to most of the larvae	A few larvae to 50% or more in severe cases	10% to 40% of larvae in severe cases
Age at time of death	Late larval and early pupal stage	Coiled stage, occasionally late larval stage	Late larval stage	Generally two days after cell is capped
Position of dead brood in cell	Stretched out on their backs on lower cell walls from cell opening to cell base. Head of larva/pupa at cell opening	Coiled on cell base or twisted on cell walls. Few larvae lie on lower cell walls. Very irregular	Stretched out on their backs on lower cell walls from cell opening to cell base. Head at cell opening.	Stretched out on lower cell walls from cell opening to cell base.
Colour of sick and dead brood	At first dull white, then light brown, later coffee brown, or almost black	Dull white, grey-white and then yellow-white, often becoming brown, dark brown or nearly black	Grey to straw coloured, then brown, grey-black or black. Head usually darkens first	Larval remains are chalk-white; others dark blue-grey or almost black
Consistency of dead larvae	Watery or slightly viscous at first, becoming ropy and will string out to 25 mm or more. Scales hard and brittle	Soft and watery at first. Afterwards pasty, rarely viscous and ropy and reluctant to string out	Skin fairly tough. Contents watery and granular	Covered with fluffy white fungal growth. Swollen to size of cell and later shrunken and hard
Scales and remains	Always fully stretched on lower cell walls from opening to cell base. If present, pupal tongue extends to upper wall near cell opening. Very difficult to remove from cell.	Coiled on cell base or irregularly twisted on any cell wall. Sometimes fully stretched out on lower cell walls. Tough, rubbery and easily removed from cells.	Uniformly stretched on lower cell walls. Outline wavy, grey-brown to nearly black with head darker. Head prominently raised. Gondola-shaped, flattened, easily removed from cell.	Mummies white or dark blue-grey to almost black, tending flattish. Loose in sealed cells. Deposited by bees on hive bottom board and outside hive entrance.

Additional information

Visit the **Plant Health Australia BeeAware website** (www.beeaware.org.au) for information for beekeepers and growers about honey bee biosecurity and pollination of agricultural and horticultural crops.

14. Diseases of adult bees

Nosema disease

Nosema is a microscopic, spore forming, fungal, parasite of adult honey bees. There are two species of nosema that affect European honey bees, *Nosema apis* and *Nosema ceranae*. The spores of each species are similar in size and shape and accurate diagnosis can only be achieved using molecular techniques.

The virulence of the two species appears to be the same. It is common for both species to co-exist in the one hive.

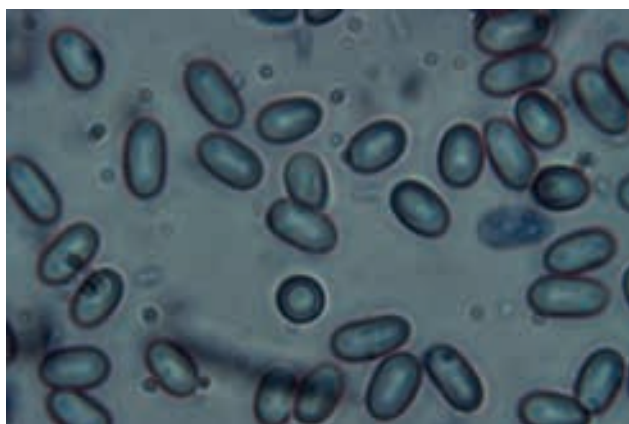
Nosema apis

Serious outbreaks or epidemics that cause heavy losses of adult bees occur only on odd occasions, usually in autumn or spring, but not every year. When epidemics occur, infected colonies decline very quickly and many can die. The disease probably has a more subtle effect in many apiaries through an insidious and obscure reduction of the production potential of many colonies due to minor infection.

Life cycle

The spores enter the bee's alimentary tract with food or water and quickly germinate inside the stomach. The organisms then penetrate the cells of the stomach lining where they grow and multiply, and complete the cycle by producing large numbers of spores in six to ten days.

During the normal digestion process of adult bees, healthy cells of the stomach lining are shed into the stomach. They burst open and release digestive enzymes. Infected cells are also shed in this way, but they release nosema spores and not digestive juices. Some of the infected cells of the stomach lining are excreted in the faeces while some infect other healthy cells of the stomach lining.



Nosema spores as seen using a light microscope.

Michael Hornitzky, NSW DPI

Spread and losses

Infection does not normally pass directly from infected bees to the next generation of adults. Instead, young bees become infected when they ingest spores as they clean contaminated combs.

During the summer months, most honey bee colonies carry a few infected bees with little or no apparent effect on the colony. Spores may also persist on the combs and other hive components. As the weather in autumn changes, these spores may initiate an outbreak of nosema.

Research has indicated that certain conditions appear to be associated with autumn losses. Firstly, heavy summer rainfall, secondly, an early autumn break in the fine weather about mid-March to early April and thirdly, bees working grey box (*Eucalyptus microcarpa*), red ironbark (*Eucalyptus tricarpa*) and white box (*Eucalyptus albens*).

The exact reasons for these apparent relationships are not known. There may be an association with fermenting nectar (see *Nectar fermentation* in chapter 5. *Apiary sites and flora*). Bees may be brought into the box-ironbark forests apparently in good condition, but colony strength suddenly drops alarmingly a short time after the grey box starts flowering, especially if the weather is cool and showery. Strong colonies may be seriously weakened before winter. These losses are not confined to areas having these conditions.

Nosema may cause losses of bees in winter in some years. In many cases, the losses are accompanied by dysentery and soiling of combs and interior walls of the hive with bee excreta and spores. This, together with spores produced in the preceding autumn can cause spring infection.

Spring outbreaks usually begin in late August or September, and may last until late spring or early summer, depending on the district. Nosema epidemics may reduce strong colonies to the size of a nucleus in a matter of days. When warmer spring weather arrives, the source of infection is largely removed because the bees are able to defecate outside the hive thereby reducing the contamination of combs.

Fortunately, serious nosema outbreaks and epidemics do not occur every year.

Spores of *Nosema apis* may occur in honey or pollen. Worker bees can transmit nosema to queens in queen mailing cages, queen banks and queen mating nuclei.

Symptoms

Bees infected with *Nosema apis* show no specific symptoms of disease. Sick or crawling bees outside the hive entrance, dead bees on the ground and excreta on hive components may be associated with nosema, but may equally be caused by other diseases and abnormal conditions. Nosema can aggravate dysentery, but the presence of dysentery inside a hive or on the external walls of the hive is not necessarily a symptom of the disease. Examination of adult bees using a light microscope is the only reliable method of diagnosing the presence of nosema spores.

Infected colonies can lose bees sometimes at an alarming rate. Infected bees often die away from the hive and only a few sick or dead bees may be found near the hive entrance. The term 'spring dwindle' is often used to describe this condition. However, this should not be confused with the normal weakening of colonies caused by the natural death of old, over-wintered bees in early spring.

Effect of *Nosema apis* on bees

The hypopharyngeal (brood food) glands of infected nurse bees lose their ability to produce royal jelly. These bees may stop rearing brood and begin guard or foraging duties that are usually undertaken by older bees.

The life expectancy of infected bees may be reduced to half that of healthy bees. As a result, honey production may fall by between 30% and 100%. In spring, colonies take a long time to recover and some may never expand into productive units without considerable assistance from the beekeeper.

A high proportion of eggs laid by the queen of an infected colony may fail to produce mature larvae. Infected queens cease egg-laying and die within a few weeks. Queens that begin to fail as a result of infection are often superseded by the colony.

When bad epidemics occur, heavily infected colonies may be beyond saving. Some commercial beekeepers have reported losses of hundreds of colonies.

Control

There are no chemical treatments registered in Australia for the control of nosema. Use of any chemical treatment is illegal and could result in unacceptable residues in extracted honey and prosecution of the beekeeper.

Prevention and management practices

Colonies with young prolific queens and large populations of young bees in autumn will usually have a better chance of surviving the disease. Small, weak infected colonies seem less able to survive.

Good supplies of quality pollens from a number of plant species, particularly during autumn, will help to ensure good populations of young healthy bees. Even though bees are infected with nosema, if they have supplies of quality pollen they will generally live longer than infected bees that have no pollen. Quality pollens are those that are relatively high in crude protein.

Ensure hives prepared for winter have good supplies of honey. Studies have shown that colonies in hives nearly full of honey had lower nosema spore counts compared to colonies wintered with far less honey.

Place the hives in a sunny position in the cooler months of the year. Avoid cool, shady and damp sites. The site should allow good drainage of cold air, but at the same time provide shelter from cold winds. Sites on sunny northerly slopes are ideal. Research has shown that the level of nosema infection in a colony can be reduced from about 85% to zero by placing the hive in a sun trap where it obtains maximum sun light and maximum shelter from cold winds.

Eucalypt species that yield nectar during winter should be avoided. This nectar can cause weak and sick bees, which in turn may aggravate the development of nosema.

Colonies should be packed down for winter in a minimum of space, so they remain compact and warm. Where possible, hives should be reduced to a single box, or two boxes if they are very populous. Remove supers of empty combs that are not required by the bees, especially those that could contain unsealed fermenting honey. Keep the hive dry. Tilt the hive slightly to enable any condensation to flow out of the hive entrance. The use of a hive mat may assist the colony to cope with condensation that often drips from the underside of the cover in winter.

When spring arrives, do not super the hive too early. Ensure good pollen supplies are coming into the hive so that brood rearing will be maintained. Avoid undue stress on the colony, by opening the hive only when necessary. Supplementary feeding of bees and manipulation of combs in hives may result in an increase of nosema spores.

Replacement of old contaminated combs, with newly drawn combs or foundation, will not eliminate the disease, but it may help to reduce the number of nosema spores in the hive.

Moving hives and opening them during winter can stress the bees and this may lead to an increase in the number of nosema spores. It may be necessary for the beginner beekeeper to check stores as the winter progresses, but these checks should be infrequent and very brief. Repositioning combs and disturbing the winter cluster should be avoided.

Nosema ceranae

This nosema was first found in Asian honey bees (*Apis cerana*) in China in 1994. It was found in European honey bees (*Apis mellifera*) in Taiwan in 2005 and later in Europe, South America, USA and other countries.

Much of the information known about this species of nosema in Australia is based on a study conducted during 2008–2010 by Dr Michael Hornitzky on behalf of New South Wales Department of Primary Industries with funds from the Rural Industries Research & Development Corporation (RIRDC). Dr Hornitzky's report is contained in the RIRDC publication *A study of Nosema ceranae in honeybees in Australia*. The key findings are presented below.

Nosema ceranae has been not been detected in Western Australia, but it occurs in all other Australian states and the Northern Territory. It is well established in eastern Australia. The study found that in New South Wales and Victoria, the peak infection occurred in winter and spring. This is similar to *Nosema apis* which has a peaks generally during spring. Unlike *Nosema apis*, *Nosema ceranae* is sensitive to the cold and appears to thrive in warmer climates. This indicates that Queensland may be more severely affected by *Nosema ceranae* than New South Wales or Victoria.

Bees that had continual access to pollen lived longer than bees that had no pollen, even if they were heavily infected with either nosema. In addition, bees fed pollen had lower levels of nosema when compared to bees that were not fed pollen.

Other adult bee diseases

The diseases described under this heading are unlikely to be obvious to most beekeepers. Some of them are rarely seen and seem to cause little or no apparent effect on bee colonies.

Viral diseases

A virus is a microorganism that consists of genetic material enclosed in a protein coat. It cannot multiply independently and can only reproduce inside living cells of its host.

Chronic paralysis virus

Some infected bees show abnormal trembling of the wings and bodies. The wings appear open and dislocated and they seem unable to fly. They crawl around the hive entrance and guard bees may prevent them entering hives. They eventually become unable to fly and die within a few days. Infected bees may also crowd together on top of the bee cluster and frame top bars inside the hive.

Infected bees may be hairless, shiny and appear greasy. The accumulation of liquid in the honey sac results in a bloated abdomen and dysentery. These symptoms can also occur with other bee diseases and conditions.

Paralysis seems to be related to genetic factors and queens may pass on a susceptibility to the virus to their worker progeny. In such cases, bees can carry the virus without ill effect until some factor, or factors, reduce the natural resistance of the bees to the infection.

Paralysis can usually be overcome by requeening the colony. Recovery of diseased colonies may be assisted by reducing stress and by placing hives on good nectar and pollen flows.

Kashmir bee virus

This virus was first detected in adults of the Asian honey bee (*Apis cerana*) sampled in Kashmir, India. Several strains of the virus have been found in adult European honey bees in Australia.

The disease may kill adult bees and brood. Infected brood resembles that of European foulbrood and sacbrood. Infected bees may have a reduced lifespan and this can cause a reduction of the number of bees in the colony, and in severe cases, cause the death of the colony. Infected colonies may improve if they are moved to better nectar and pollen conditions. Requeening colonies to change the strain of bee may also be beneficial.

Black queen cell virus

This virus causes the death of queen pre-pupae and pupae after the cell has been capped. Infected individuals turn pale yellow and then dark brown to black. In the early stages of infection, their appearance is similar to worker larvae that are infected with sacbrood. Infected queens fail to emerge from their cells. The walls of cells containing an infected queen may become brown or black.

The nature of the disease is not fully understood, but it appears that some colonies can recover spontaneously. It is thought that this virus may be associated with nosema disease. Queen rearing hives known to have the virus should not be used to raise additional batches of queens. Reuse of contaminated plastic queen cell cups is not recommended.

Cloudy wing virus

Cloudy wing virus has been detected in New South Wales, Queensland, Victoria and Western Australia. The wings of infected bees may become opaque (cloudy), though not in every case. Infected adult bees have a shorter life span than healthy bees. Heavily infected colonies become unproductive, inactive, weak, and eventually die. These effects were observed in an apiary in Victoria in 2005 where pupating and emerging bees were also wingless. There is no obvious seasonal occurrence of this disease. In the absence of firm recommendations, recovery of affected colonies may be assisted by placing hives on a good nectar and pollen flow.

Amoeba disease

Amoeba (*Malpighameoba mellificae*) is a microscopic protozoan parasite of adult bees. It has been found in adult bees in Victoria and southern New South Wales. It often occurs in bees infected with nosema.

The life-cycle of amoeba is not well known or understood. It forms cysts in the malpighian tubules in the abdomen of the bee. It is probably spread by cleaning bees which remove bee faeces from frames and combs.

Flagellates

This microscopic protozoan, *Crithidia mellificae*, has been commonly detected in adult bees in Victoria during the cooler months of the year. It is found in the rectum and posterior intestine of the adult bee.

The effect of this flagellate on adult bees is not known. However, a recent scientific study of bee pathogens in Belgium indicated that *Crithidia mellificae* and *Nosema ceranae*, interacting together, contributed to winter mortality of bee colonies in that country. It is not known if this interaction occurs in Australia.

Septicaemia

This disease is a bacterial infection of the blood of the adult bee. The bacterium multiplies in the blood and spreads to all parts of infected bees through the vascular system. Infection eventually leads to death. Although the disease was recorded in Victoria in the 1960s, it has not been confirmed since.

Infected bees show a progressive slowing of activity and general weakening, and soon lose their ability to fly. Their appearance becomes very similar to that of chilled bees as the weakening progresses. Leg movements seem abnormal and exaggerated at times. The movements become slow and uncertain leading to loss of balance, and in many cases bees fall over. In the last stages, the only signs of life are feeble movements of the abdomen, legs and mouth parts.

The best indication of septicaemia is the disintegration of bees that have been dead for about two days. This includes

a simple shedding of the legs, wings and antennae and separation of the head, thorax and abdomen. A strong putrid odour, like that from a sewer duct, is also associated with the disease in the post mortem condition.

Septicaemia seems to do better under slightly warm conditions. A high level of moisture is essential for transmission within the hive.

Diagnosis of adult bee disease

Beekeepers should contact their state/territory apiary officer for advice about bee disease diagnostic services, including the correct method of obtaining suitable samples. This information may also be available on the relevant state/territory honey bee web page.

It is important that directions for preparing and submitting samples for laboratory diagnosis are carefully followed. Usually, samples should have at least 30 sick or freshly dead bees gathered from around the hive entrance. If this is not possible, collect live bees from the top bars of frames inside the hive. Place the bees in an unused, clean, small plastic specimen container.

Post the sample to the laboratory on the day of collection. If this is not possible, place it in a fridge, or freezer if a virus is suspected. Samples held in the mail during the weekend may deteriorate to the extent that diagnosis of the suspected disease or disorder is impossible. Samples that are allowed to dry or become mouldy may also be unsuitable.

When forwarding a sample to a laboratory, include a note with your name, registered beekeeper brand number, full contact details and background about the occurrence of the suspected disease. This will enable a diagnostic report to be sent to you.

Additional information

Visit the Plant Health Australia BeeAware website (www.beeaware.org.au) for information for beekeepers and growers about honey bee biosecurity and pollination of agricultural and horticultural crops.

15. Pests and enemies of bees

Wax moth

Wax moth larvae can cause serious economic damage to stored combs, as well as combs in hives that contain very weak colonies or in which the bee colony has died. They can also infest and damage some apiary products.

A healthy populous honey bee colony will not tolerate the presence of wax moth in the hive. If wax moth larvae are damaging combs in a hive it indicates that all is not well with the bee colony. The colony may have been weakened by disease or some other cause.

The development of wax moth communities in hives is an indication of neglect by the beekeeper.

Greater wax moth (*Galleria mellonella*)

The moths have pale brown to grey wings that are often mottled and appear as roof-shaped or boat-shaped when folded over the body. Moths are about 20 mm long, but their size largely depends on the food supply and temperatures which affect the rate of development in the larval and pupal stages.



Adult greater wax moth with wings stretched out for display.

Simon Hinkley and Ken Walker, Museum Victoria, PaDIL

Wax moth eggs are almost spherical, pinkish to white and about 0.5 mm in diameter. Clusters of them are laid on comb or in small cracks in hive components. Eggs will hatch within three to five days when temperatures range from 29–35 °C. At lower temperatures, a much longer period occurs before hatching begins. At 18 °C, hatching commences about 30 days after the eggs were laid.

After hatching, the small but very active wax moth larvae tunnel in wax comb, lining their tunnels with silky web as they go. They also travel from comb to comb through a mass of webbing. At first, larvae are creamy white, but they turn grey when fully grown at about 25 mm in length.

Wax moth larvae are very active in warm weather, but become somewhat inactive in the extreme cold of winter. At the optimum temperature of about 32 °C, they reach full development about 19 days after hatching. At cooler temperatures and when food is scarce, the larval period may extend to five months.



Larvae of the Greater wax moth.

The fully-fed larvae spin silky cocoons that may be found in a mass of debris in the comb or on the wood of the frame or the hive body. Larvae may chew away small canoe-like cavities in which to spin their cocoons and pupate. In a heavy infestation, it is common to find the top and side bars of frames bored right through by the larvae. The pupation period is about 14 days when temperatures are high but may be as long as two months at cooler temperatures. After emergence, adult moths mate and the life-cycle begins again.



Wax moth larvae in their recently spun cocoons on a frame end bar immediately under the frame lug.

Lesser wax moth (*Achroia grisella*)

This smaller, slender bodied moth measures about 13 mm in length. It is silver-grey to buff in colour.

The larvae of this wax moth are smaller than greater wax moth larvae and are usually white with a brown head. Larvae feed on combs, pollen and even litter on the hive floor. Lesser wax moth larvae are usually solitary, whereas greater wax moth larvae often congregate in large numbers.

Damage caused by wax moths

Beehives

Bees cannot effectively guard their hive against wax moths if the colony becomes numerically weak due to queenlessness, excessive swarming, disease or pesticide poisoning. The moths enter the hive and lay eggs. In a short time, the combs not used or protected by the bees will be infested with the larvae. *The moth invasion is a result of weakness or dying out in the hive, not the cause.*



Webbing and wax moth excreta cover this comb removed from a neglected hive. The comb under the webbing is totally destroyed.

The odd wax moth larvae may be seen in healthy, numerically strong hives. They do very little, if any, damage and are mostly removed by the bees. Often a lone wax moth larva may be found between the hive mat and the top bar of a frame. The presence of the odd larva in a populous hive should not concern the beekeeper.



Early stage of wax moth infestation on a brood comb infected with American foulbrood disease. The diseased honey bee colony had died due to the disease.

Bald brood

Developing honey bee pupae are exposed when wax moth larvae partly remove the cell caps. Worker bees chew the remainder of the capping thereby exposing the heads of the pupae which continue to develop normally. The lines of bald brood follow the direction of the larva's travel. This is not the bald brood that sometimes occurs as a result of a poor queen.

When wax moth larvae can tunnel through brood comb and the excreta of the larvae can affect the final moult of bee pupae. The pupae may have deformed legs or wings. The bees may remove cell caps of affected pupae.

Galleriasis

Newly formed adult bees are sometimes unable to emerge from their cells after removal of the cappings. The bees are trapped by silken threads spun by greater wax moth larvae as they tunnel at the base of the cells. The trapped bees eventually die in their cells and are later removed by hive bees. This is a minor problem and is rarely seen.

Damage to stored combs

Damage caused by wax moths will vary with the extent of the infestation and the time that has elapsed since the infestation first began. Damage will not be great if only a few larvae are present. When infestation is heavy, stored combs may be completely destroyed and the frames filled with a mass of tough, silky web. Larvae may damage frames and hives by chewing away the wood to make cavities for cocoons.

Most of the damage occurs in the warmer months of the year as this is when wax moths are most active. In contrast, little, if any damage is seen in the extremely cold winter period, as the larvae are relatively inactive. However, greater wax moths can congregate together and create their own heat, so significant damage may occur even during the cool months of late autumn and early spring.

The beekeeper should frequently monitor stored combs for moth infestation. Although combs and other hive material may appear free of wax moth at the time of storage, they may contain moth eggs that will later hatch. In addition, moths may lay eggs in the external cracks and joints of stacked supers, and after hatching, the tiny larvae quickly move inside the stack to the combs.

Wax moths prefer dark brood combs that contain some pollen, but sticky combs, white combs and combs containing honey are all prone to infestation, particularly if a few cells of pollen are present.

Damage to apiary products

Wax moth larvae grow extremely well on a diet of pollen and can deposit their eggs whenever bee collected pollen is exposed during trapping, drying and packaging. The eggs can hatch at any time, even after packaging, making the pollen unsuitable for human consumption.

Comb honey may contain wax moth eggs when it is packaged. After hatching, the small larvae begin tunnelling. This together with webbing and larval excreta, makes the comb unfit for sale.

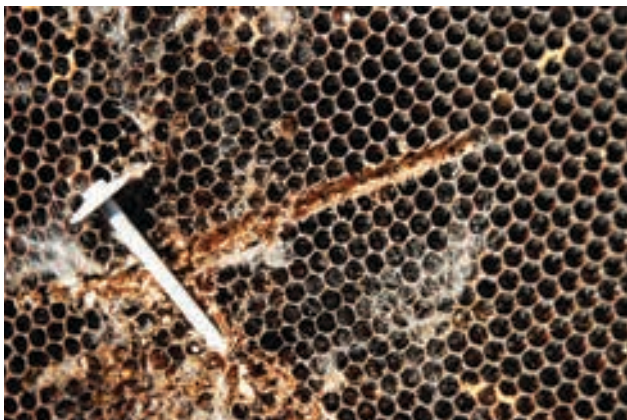
Beeswax that is clean and refined, including foundation, is not readily subject to attack. The damage is usually minor and the larvae fail to grow to full size. Dirty, unrefined beeswax and slum gum are more readily infested.

Control of wax moth

As both species of moth are very similar, control measures detailed below will be effective for either species. Maintain strong, populous colonies and wax moth will not be a problem. Weak colonies can be united with other colonies of bees.

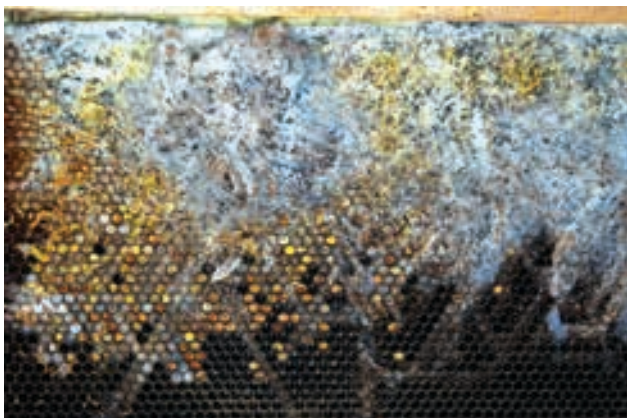
Combs

Some beekeepers who store combs in late autumn and reuse them in early spring find that control methods are not needed, especially when the ambient winter temperatures is very cold. However, greater wax moth larvae that collect together can produce a large amount of metabolic heat and can raise the immediate temperature around them by up to 25 °C above the normal environment. As a result, careful, regular monitoring of stored combs is essential, even during winter. Hobby beekeepers who find a moth larva tunnel in a stored comb can use a wire or nail to find and squash the burrowing larva.



A nail can be used to remove a wax moth larva from a comb.

Where there is a very small infestation of wax moth in a few stored combs, the beekeeper could place the combs on a hive with a strong colony. The bees will remove the wax moth larvae, their cocoons and webbing, and repair the damaged comb. This method of control should not be done in winter when bees in most districts are relatively inactive and colonies have relatively few bees. Where there is a heavy infestation, the combs should be treated by freezing.



Wax moth webbing and excreta (black particles) in an advanced wax moth infestation in a comb containing pollen.

Freezing

The following minimum temperatures are required to kill all life-cycle stages of wax moth: minus 6.7 °C for four-and-a-half hours; minus 12.2 °C for three hours; and minus 15.0 °C for two hours. Care must be taken to commence timing of this treatment only after all the hive equipment or apiary products have reached the minimum temperature. Domestic chest freezers are ideal for hobby beekeepers to treat these items.

Immediately after freezing, store the treated items in a moth-proof environment to prevent re-infestation. Very strong plastic garbage bags are suitable. Bagged combs should be stored away from sunlight in a rodent proof environment.

Combs that have been frozen and then placed in untreated supers for storage are immediately at risk to re-infestation because the supers may contain wax moth eggs. It is best to treat the super and the combs, and then place them in a sealed plastic bag. When combs are placed in untreated supers after freezing, wax moth eggs laid in the external cracks and the joints between supers will hatch and the tiny larvae will move through the joints and infest the combs. This is why some combs that have been treated by freezing are later found to be infested.

Some commercial beekeepers use cool rooms to store combs and protect them from wax moth. A temperature of 4 °C will restrict wax moth activity.

Pollen and comb honey

Freezing these products will kill all life-cycle stages of the moth. Frequent collections of pollen from traps, for example, two or three times a week, will help to minimise moth infestation, as will drying and packaging of pollen in a moth proof environment. Some types of honey (for example, clover and lucerne) may candy after freezing.

Small hive beetle

The larvae of small hive beetle (SHB) (*Aethina tumida*) can cause serious damage to honey bee colonies and combs in the hive, including those that contain brood, honey and pollen. The larvae can ruin stored combs, comb honey, as well as combs of honey taken from hives for extracting.

The beetle is a relatively new beekeeping pest in Australia. It is widely spread in New South Wales, Queensland, Australian Capital Territory and Victoria. An isolated occurrence was also found at Kununurra in the north of Western Australia. It prefers a warm to hot, humid climate, where it is most damaging, but is obviously adaptable to relatively cool conditions of Victoria.

Life-cycle

Eggs are laid in clusters on comb, in open and sealed brood cells, in cells containing pollen and in crevices and cavities in the hive. Eggs can hatch 21 hours after they were laid, but most hatch after two to four days, and sometimes six days when temperatures are cool. SHB may have up to five generations during the warm months of the year. Breeding usually ceases during the cold winter months.

SHB larvae are about 11 mm long and 1.6 mm wide. Fully grown larvae are cream to white with pairs of spines on the upper surface of the body. The rear pair is more prominent than the others. The larva has six legs, all at the front of the body.



Small hive beetle larva showing spines on upper body.

Simon Hinkley and Ken Walker, Museum Victoria, PaDIL



Small hive beetle larvae on end bar of frame. SHB activity produces slime.

Lowan Turton, NSW DPI

Larvae are usually fully grown within 10–16 days, but sometimes up to 24 days. Mature larvae enter the ‘wandering’ phase and move from the hive to pupate in the soil, generally within 900 mm of the hive. Some may pupate under the hive. Larvae leaving infested combs in honey extracting plants have crawled over 200 metres on concrete to reach suitable soil in which to pupate. They prefer loose sandy or sandy-loam soil with some moisture. As a result, the beetles may be more prevalent in districts with these soils, compared to areas with hard clay soils.

Pupae are white at first and turn brown as they mature in the soil. Adults emerge from the soil, generally within 15 to 24 days and sometimes 60 days depending on soil temperature. At 10°C, emergence from soil may extend to 15 weeks.



Adult small hive beetle.

Lyle Buss, University of Florida

Adult beetles are 5 mm to 7 mm long, and 3 mm to 4.5 mm wide, broad and flattened with clubbed antennae. They are yellowish brown at first, sometimes turning reddish brown, then light brown to black.



Adult small hive beetle and honey bees.

Adrian Murray, DEDJTR

Adults prefer to enter weak hives in spring and summer. They choose strong hives in autumn where they can keep warm. They are found in the bee's winter cluster and entice bees to feed them. In cool districts, the presence of beetles in hives throughout the beekeeping season does not always result in egg laying and damage by SHB larvae.

When the hive is opened, adult beetles very quickly run to hide in dark places, often into empty cells in the comb, and some may play dead.

Damage caused by SHB

SHB larvae eat honey, pollen and all stages of honey bee brood. They tunnel through comb, piercing and damaging the wax comb and cell caps. They defecate in the honey.



Small hive beetle burrow and tunnel through comb, causing honey to weep from cells and ferment.

Nick Annand, NSW DPI

A yeast (*Kodamaea ohmeri*), carried by the SHB larvae, contaminates the honey causing it to ferment. The fermenting honey froths and weeps from the cells. There is an odour of decaying oranges. The combs, cell caps and hive components become slimy as the larvae move throughout hive. The slime may be seen at the hive entrance when larvae move from the hive to pupate in soil (See below for health warning when cleaning slimed hive components).

Contaminated honey is unsuitable for sale and unacceptable to bees as bee food.

Queen bees in infested hives may stop egg-laying and the number of adult bees in the hive may quickly fall. The colony may abscond when infestation is heavy and slime is present.

Combs of honey taken from hives and put aside for extracting at a later time can be quickly ruined. This also applies to wax cappings, stored combs, section comb honey and bee collected pollen. Combs containing pollen, dead brood and honey are very attractive to beetles, but white combs are less attractive.

Management of bee colonies

Maintain strong colonies. Beetles will mostly choose weak colonies in which to breed, including queen rearing nucleus hives and mini-nuclei. It is best to unite weak colonies to form stronger ones. Alternatively, strengthen weak colonies by adding one or two combs of sealed brood taken from your own strong healthy colonies. Never place infested combs and hive components onto hives free of SHB because the infestation will soon spread throughout the entire apiary. Bees are unlikely to accept combs with slime and contaminated honey. Don't allow robbing in the apiary. Beetles are attracted to bees that are stressed.

Combs in the hive not covered by bees are especially prone to damage by SHB larval. Remove any boxes of combs not required by the colony and protect and store them as described below. Supers of combs should only be added to hives when the bees need more room. As a guide, only add a super when at least 70% of combs in the hive are filled with honey and/or brood.

The combined odours of honey, pollen and adult bees attract adult beetles to apiaries. They are more attracted to hives that have been opened, especially when bees have been squashed. Opening a hive and manipulating combs appears to trigger female beetles already in the hive to lay eggs. While it is best not to open hives too often, it is still necessary to inspect brood during the season to conduct normal hive management and to look for signs of American foulbrood and other diseases.

Avoid leaving honey combs above clearer boards

Combs of honey left above a clearer board are not protected by bees. Remove the combs as soon as the bees clear the supers, and extract the honey without delay.

Maintain good apiary hygiene

Keep the hive bottom board clean. Discarded comb, burr comb and beeswax scraps left around the apiary can attract beetles and encourage them to breed. Collect these items and process or cold treat them before damage occurs. Hives in which colonies have died should be checked for signs of American foulbrood and then cold treated if they are free of the disease.

Management at the honey extracting plant

Extract combs of honey immediately after their removal from the hive. While combs may appear free of infestation, SHB eggs or very small larvae may be present and because the eggs hatch within two to four days the combs will soon be damaged. The risk of infestation is greater if pollen is present in the combs. Additionally, if beetles gain access to the combs before, during or after extracting honey they will lay eggs.

Keep the extracting premises and cold/hot room free of dead bees, wax and other debris that may attract SHB.

Cappings collected during extracting should be melted and processed without delay within one to two days. Harvested bee-collected pollen can be protected by packing it into sealed containers and then freezing as described below. Slum gum, a residue after rendering wax scraps and cappings, is prone to damage. The gum can contain significant amounts of wax which may be made into foundation or sold. It should be protected by cold treatment and/or sent to a commercial beeswax rendering service.

Cold treatment of combs, hive components and apiary products

All SHB life-cycle stages are susceptible to cold temperature. The minimum exposure times needed to disinfest boxes of empty comb and other items are: six hours at minus 13°C to minus 22°C, or, 12 days at 1°C to 9°C. Allow additional time for the items to reach the required cold temperature before commencing the actual treatment period.

After cold treatment, the items should be immediately protected from SHB infestation by placing them in sealable containers.

Trapping to reduce SHB numbers

Traps to capture adult beetles are available at beekeeping supply outlets. Vegetable oil is placed in the trap which is then placed in the hive. Beetles enter the trap to hide and drown in vegetable oil. Check the trap and empty it of beetles as needed.

Squat plastic containers having a hinged lid and several compartments, as used by anglers, make useful traps. Holes, measuring 4.5 mm in diameter, are drilled in the lid to allow entry by beetles but not bees. The compartments are partly filled with vegetable oil. The partitions are helpful in retaining the oil where hives are situated on a slight incline. The trap is best placed in the hive on the bottom board underneath the frames, but some adjustment to the height of the bottom board riser may be necessary.

Apithor, an in-hive insecticidal hive beetle harbourage (trap) developed by research funded by the Rural Industries Research and Development Corporation and NSW DPI, is registered for use by the Australian Pesticides and Veterinary Medicines Authority. Users must read the product label before using the harbourage. After cleaning the bottom board, the device is inserted into the hive, so that it sits flat on the floor with the open slot ends facing away from the hive entrance. The harbourage is available at beekeeping equipment suppliers.

If SHB larvae are a problem in extracting plants, it means that they have successfully developed on unprotected combs or apiary products. Fluorescent lights placed on or near the floor at night will attract larvae looking for soil in which to pupate. The larvae accumulate at the light and can be swept up and destroyed in soapy water.

SHB and wax moth larvae

Both SHB and greater wax moth larvae may be found in the one hive. Both species have six legs near the head, but wax moth larvae also have small, less developed, prolegs in pairs along the body. Unlike wax moth, SHB larvae have two rows of short spines on their backs, two of which protrude at the rear of the larva. SHB doesn't produce silk webbing as wax moth larvae do. SHB larvae are about half the length of mature greater wax moth larvae. Wax moth larvae spin cocoons and pupate in the hive. Beetle larvae move out of the hive to pupate in soil.

Health warning for beekeepers

The slime on combs and hive material of beetle infested hives contains the yeast, *Kodamaea ohmeri*. There have been some reports of this organism being an opportunistic pathogen in humans. The Queensland Department of Agriculture, Fisheries and Forestry advises beekeepers who clean slimy material to wear gloves and a P2 or N95 face mask and to apply water-proof dressing to exposed broken skin. When the cleaning is completed beekeepers should immediately shower and put on clean clothes. Anyone with a weakened immune system should not clean SHB affected hives.

Ants

Ants can be troublesome in an apiary, and some species can kill bees and take honey from the hive. Their presence may irritate and excite the bees and in some cases cause the bees to abscond.

In small apiaries, the bees may be easily protected from ants by placing the hives on a small stand, the legs of which are immersed in oil. Clear away any fallen leaves or twigs that will bridge the gap and enable the ants to reach the hives. This method of ant control is quite impractical for a large apiary.



An ant-proof hive stand.

The common meat ant is probably the most troublesome of the species which annoy bees. Sugar ants may also be a problem. Small black ants occasionally nest in the hive lid between the metal cover and inner insulation sheet, and also in pollen traps fitted to hives. They do not seem to be a serious problem and it is doubtful whether they would make any significant inroads into the honey stores of the colony.

Argentine ants can invade hives, especially nuclei and hives with weak colonies. In time, the colony will die out unless the ant nest is found and destroyed. On occasions, the bees will abscond to escape the invasion. These ants may establish their nests immediately under the hive and may go unnoticed by the beekeeper for some time.

If an ant nest is to be treated with a chemical, only use a product registered for that use. **Always read the label before using any chemical product.** These products can kill bees. Don't apply chemicals to hives or near hives, or in a manner that will cause the treatment to contact any bees, including flying bees and bees at the hive entrance. Remember, all ant killing products are hazardous to bees and can kill them. Obtain the permission of the landholder to apply a chemical if the apiary is situated on land not owned by the beekeeper. In some states and territories, it is a legal requirement to keep written records of all chemical use. Beekeepers should make enquiries with their Department of Primary Industries.

Other insects and hive visitors

The dragonfly is the most formidable of insects, other than wax moth and SHB, which prey on bees. It cruises about over the hives, pounces on a bee drawing juice from its body and then drops it. One dragonfly can destroy many bees in a day. It is swift and alert and is impossible to combat.

Robber flies are big insects which catch their prey on the wing and suck the juices from their bodies. Fortunately, for the beekeeper, they do not generally occur in large numbers.

The praying mantis is not considered a serious enemy of bees, but will nevertheless add bees to its diet should an unwary field bee venture close enough for the mantis to attack.



A red-back spider. Spiders are often found under bee hives.

Cockroaches are often found among bees, even in the strongest colonies, but particularly on the hive mat and on combs not used by bees. The fact that the bees tolerate them while ejecting other intruders seems to show that cockroaches are not detrimental to the bee community. It has been observed that combs among which cockroaches are plentiful remain free from wax moth larvae. It is possible that cockroaches, which are omnivorous, eat the eggs of the moth.

Wood lice are found in and about hives in shady and sometimes damp situations. They do no harm.

Some spiders will eat bees, but they are probably not a significant cause of bee losses. Red-back spiders, and other spider species, may occur under the bottom boards of hives and sometimes in the ventilator holes in hive lids. It is advisable to wear gloves when moving hives.

Birds

The rainbow bird or Australian bee-eater (*Merops ornatus*) is a very effective destroyer of bees. The general plumage of the bird is a beautiful golden green and azure blue, the feathers of the throat being a rich yellow. The bird is 254 mm long, the tail 152 mm long, and the bill 38 mm long. The tail feathers have a peculiar shape and colour. The bird is partly migratory and occurs in much of mainland Australia. In Queensland, it can be found all-year round and appears in Victoria in September and leaves again in March.

The bird is a master at taking fast flying worker bees on the wing and very importantly will prey on slower-flying queen bees taking orientation and mating flights from queen rearing yards.

The wood swallow (*Artamus personatus*), of which there are several similar species, is much more numerous than the bee-eater. Each wood swallow will eat fewer bees and more of other insects than a bee-eater, but the aggregate damage done by wood swallows is much greater than that caused by bee-eaters.

On cool days, when few insects other than bees are about, hundreds of wood swallows sometimes stay near an apiary for days catching bees as they leave the hive. This depletes the numbers of adult bees. These birds land after catching a bee and break the bee in two discarding the abdomen with the sting.

The face, ear coverts, and throat of the male masked wood swallow are jet black, bounded with a narrow line of white. The crown of the head is sooty black, gradually passing into the deep grey which covers the whole of the upper surface, wings and tail, the latter being tipped with white. All the under surface is a very delicate grey, and thighs are dark-grey. The pale blue-grey bill has a black tip, the legs and feet are grey to black. The female differs mainly in having a paler bill and a black mark on the face.

Ducks and bees are generally mutually destructive. In the case of young ducklings, the vice supplies its own remedy, for sooner or later a sting will lodge somewhere in the bird's anatomy and with fatal consequences. Adult ducks

cannot be cured of the habit once they start to eat bees. They do not seem to be affected in any way, no matter how many bees they swallow. They prey on bees collecting water at the ducks' water-hole and catch bees foraging on low-flowering plants such as dandelions and clover.

Chickens do not interfere with bees. When insect food is scarce, fowls will eat dead bees, and sometimes drones, but they have not been seen eating live workers.

Mice

These rodents are primarily a nuisance when they seek shelter in hives from the weather during the cool months of the year. They can feed on pollen, honey, and comb not covered by bees. They also chew combs and frames to provide space for their nest. They are not regarded as a pest in hives that are well populated with bees, but they can be a problem where the colony is weak or has died.

Maintaining hive material in sound condition will help to minimize invasion by mice. Where necessary, reduction of the hive entrance to the height of a bee space (9.5–10 mm) will also assist to keep them out. If this fails, wire mesh of 4-mesh per linear 25.4 mm fixed over the entire entrance will prevent mice entry while allowing bees to exit and enter the hive. The mesh should be removed when the bees become more active and the number of foragers increases with the beginning of the active beekeeping season.

Combs stored for winter, and at other times of the year, should be protected from mice damage and contamination.



A mouse nest on the bottom board. Part of the comb has been gnawed by mice.

European Wasp

European wasps (*Vespula germanica*) have pale lemon-yellow and black stripes on their abdomen compared with the darker orange-yellow, brown or grey of the honey bee. They also have black dots between the stripes on each side of the abdomen. Bees do not have these dots. European wasps can establish quite large football sized nests underground and also in protected cavities above ground. Many householders who find wasp nests mistake them for bees.

Wasps require protein to feed their larvae. They obtain this by preying on a variety of insects, including bees. Their need for sugar reaches a peak in autumn, the time that they are most troublesome around hives. Adverse weather conditions have little effect on their foraging. Even in winter when bees have clustered and are not flying, wasps from overwintering nests can be quite active. They are less of a problem in summer, because there is usually an abundance of other food and their numbers are reasonably low.

European wasps remove dead or dying bees found in front of the hive entrance and prey on live bees. In addition, they try to enter hives to remove honey and brood. While strong colonies are usually able to repel such attacks and kill the intruders, significant losses of bees in nucleus and other weak colonies can occur. Some colonies under sustained attack become demoralised and may be unable to repel an attack.

If wasp attack is a serious problem, reduce the width of the hive entrance. This is particularly helpful in autumn and winter. Don't reduce the entrance too much so that the colony smothers during hot weather. As the weather becomes cooler, entrances may be reduced to around 50–100 mm. The entrance of nucleus hives may be reduced even more.

For a hobby beekeeper with a small number of hives, a small sheet of clear plastic 35 cm by 10 cm resting at an angle in front of the hive will help to deter wasp attacks. The sheet stands on six millimetre blocks of wood placed on the ground in front of the hive and rests on a six millimetre block attached to the face of the hive. Bees travel under and around the glass but wasps tend to collide with it. Bees usually kill any wasp that penetrates this defence.



European honey bee (left) and European Wasp (right).

The best method of control is to locate the wasp nest, or nests, in the surrounding area and eradicate them using an insecticide registered for the purpose. Usually, the wasp nest will be up to 500 m from where they are foraging. Obtain the landholder's permission to apply a chemical if the apiary is situated on land not owned by the beekeeper. Always read the label of an insecticide product before using it. Don't apply insecticide near the apiary as it may also kill bees.

When dealing with European wasps it is important to wear protective clothing and a bee veil as wasps have the ability to sting repeatedly. The sting usually causes far more discomfort than a bee sting. Depending on breeding, the temperament of bees will vary from colony to colony, but European wasps when disturbed are always nasty.

Wasps are also a nuisance in honey extracting plants and gain entry when bees would not normally do so. Unlike bees, they do not immediately fly to windows, but continue to fly throughout the building.

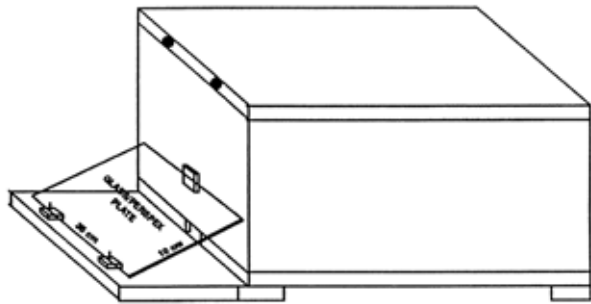


Figure 7. A means of deterring European wasp attack.

Additional information

Visit the Plant Health Australia BeeAware website (www.beeaware.org.au) for information for beekeepers and growers about honey bee biosecurity and pollination of agricultural and horticultural crops.

16. Parasites of honey bees

Australia is fortunate not to have the serious honey bee parasites that are found in other parts of the world. If they establish in Australia they will seriously affect honey bee colonies causing them to decline and die. Beekeepers will need to change the way they manage bees to avoid such losses.

Strict quarantine is in force to prevent the introduction of exotic bee species and their parasites into Australia. Detector dogs at Australian airports and international mail centres are trained to detect introduction of bees, apiary products and used beekeeping equipment that could carry parasites. It is illegal to import European honey bees from other countries unless approval has been obtained from the Australian Government Department of Agriculture.

Surveillance for early detection of incursions of exotic parasitic mites and bees occurs at and near major Australian air and shipping ports. This includes laboratory examination of bees sampled from sentinel hives and from swarms that lodge in swarm catch boxes located at or near these ports. Early detection is essential if an incursion is to be successfully eradicated.

If a beekeeper sees or suspects varroa mite, other exotic parasites, or anything unusual, he or she should immediately call the Exotic Plant Pest Hotline on 1800 084 881 to report it. To not report is to break the law.

Of the parasites described in this chapter, only braula fly occurs in Australia and it only occurs in Tasmania.

Varroa mite

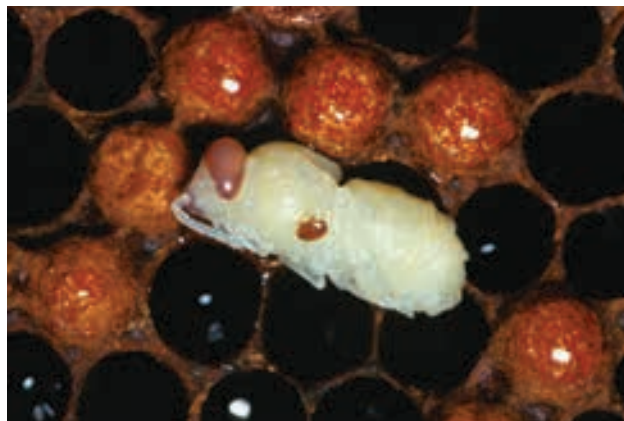
This mite (*Varroa destructor*) is a natural parasite of the Asian honey bee (*Apis cerana*). However, two variations (genotypes) of the mite can also reproduce on European honey bees. Varroa has spread throughout the world, including both islands of New Zealand, infesting European honey bees. Fortunately, at the time of writing Australia remains free of this devastating pest.

Another varroa species, *Varroa jacobsoni*, was known to be unable to reproduce on European honey bees. However in 2008, a genotype of this species was found reproducing on European honey bees in Papua New Guinea.

Varroa destructor infests adult European honey bees and brood, weakening and eventually killing their colonies. It also transmits honey bee viruses which probably have a far greater effect on the colony than the mite itself. Should varroa establish in Australia, it will be a major problem to commercial and hobby beekeepers. The mite will also cause the death of wild (feral) honey bee colonies and drastically reduce the amount of free bee pollination in cities, towns and rural areas.

Biology

The reddish brown, adult female *Varroa destructor* is shaped like a scallop shell. It is about 1.1 mm long and 1.7 mm wide, and can be seen with the naked eye. If you use glasses when reading, you should use glasses when looking for varroa.



A female varroa on a developing honey bee pupa.

Scott Bauer, USDA ARS image gallery

Adult mites mostly attach themselves between the first abdominal plates (sclerites) of the exoskeleton of the bee's abdomen. They puncture the thin membranes between the plates with their mouthparts and suck the haemolymph (blood) of the bee. Mites in this position are often difficult to see as they are largely hidden by the abdominal plates.



Two varroa mites on the thorax of a worker bee.

Stephen Ausmus, USDA ARS image gallery

The mature female varroa enters a brood cell shortly before it is sealed, and lays two to five eggs. The first egg develops into a male and the remainder into females. The female and her offspring feed on the haemolymph of the bee pupa. Full mite development from egg to adult takes about seven to ten days. The new females mate with their brother inside the cell. They and their mother emerge from the cell with the adult bee. They spread to other bees in the colony to feed before entering other brood cells about 14 days later. When brood is not present in a hive, mites will overwinter on adult bees. Female varroa can live for about two months in summer and five to eight months during winter. Varroa prefer to reproduce on drone brood, but readily reproduce on worker brood.



A family of varroa mites at the bottom of a honey bee brood cell.

Scott Bauer, USDA ARS image gallery

Effects of varroa

Varroa can cause reduced longevity and deformity of adult bees, and even death of parasitised brood. It may take up to three or four years before the colony is significantly weakened and the infestation detected. The mite can spread in this time to other hives and apiaries. Once infested, a colony will not recover by itself and will eventually die. The viruses spread by varroa also affect the colony.

Bee pupae parasitised by varroa usually survive to emerge from their cells as adults, but their body weight and lifespan may be reduced. When mite numbers build up in the colony and more than one female mite enters a brood cell to reproduce, the parasitised bee may be deformed. Such bees may be seen at the hive entrance unable to fly due to deformed wings.

Spread

Varroa is spread by the activities of beekeepers. This includes movement of hives and used hive components, bees including package bees, queens and escorts within the apiary and from apiary to apiary. Bee swarms, drifting bees especially drones and robbing bees, also spread the mite.

Steps if you find or suspect varroa in your apiary

It is important to follow these steps to reduce the risk of spread:

- Collect a specimen of the suspect mite and place it in a small jar of methylated spirits. Keep the jar in a cool, safe place away from sunlight. Don't mail or forward any samples until advised to do so by a state/territory apiary officer. Never take live specimens away from the apiary as this may help to spread varroa.
- Reassemble the opened hive to its normal position.
- Mark the hive with a waterproof felt pen (or similar) so it can be easily identified later. Mark the lid and all boxes of the hive with the same identification number.
- Thoroughly wash hands, gloves (and gauntlets), hive tool, smoker and any other equipment to ensure varroa is not carried from the apiary.

- Place overalls, gloves, veil and hat in a strong plastic double bag and leave them at the apiary site until advised by a state/territory apiary officer.
- Don't move bees or any hive components from this apiary as this could help spread varroa.
- Before leaving the apiary, inspect your vehicle to make sure there are no bees trapped inside or on the radiator. Check the tray of the vehicle or trailer as well. Boxes of combs and other hive material on your vehicle which bees may have entered must be left at the apiary.
- Varroa may be carried by and on people. Where possible, wash skin and hair that has been in contact with hives to prevent moving varroa from the apiary. Hair and beard may be checked by combing with a very fine toothed comb. Clothes should be decontaminated by washing with laundry detergent.

Varroa – a notifiable bee pest

Don't forget! If you see or suspect varroa in your apiary, notify a state/territory apiary officer without delay by the quickest means possible. The easiest way to do this is to ring the Exotic Plant Pest Hotline on 1800 084 881 (24 hours a day, every day of the year). Notification is required by state/territory laws. To not notify is to break the law. Importantly, your early notification could save the Australia honey bee industry.

Early recognition of varroa is one of the most important factors influencing the chance of controlling the disease and reducing its economic and social impact on the whole community.

Sugar shake test for detection of varroa

In addition to surveillance for varroa at Australian shipping ports and airports, beekeepers add to these efforts by testing one or more of their own hives for varroa. They use the simple sugar shake test which doesn't take much time and doesn't damage bees. The test is usually conducted in spring, summer and autumn. More beekeepers are welcome to join the present team in all states. Enquire with your state/territory apiary officer about obtaining a test kit.

When varroa mites are dusted with pure icing sugar, the fine granules stick to their pads (feet) and they are no longer able to grip the surface on which they cling. The dusted mites fall off infested bees into the white sugar where they are more easily seen. Bees coated with the icing sugar are stimulated to groom themselves and remove the mites from their bodies.

First, obtain a 500 gram or 750 gram jar with a plastic or metal lid. Drill 50–70, 3–4 mm holes in the lid. Place a heaped tablespoon of pure icing sugar in the jar after removing the lid. Kits supplied by state apiary officers will have woven wire mesh in the lid.

Open the hive to be tested and select three combs of brood. Inspect each comb for the queen. If you find her, place her back into the hive before doing anything else. Shake some bees from the three brood combs onto a

double thickness of newspaper or an upturned hive lid placed on the ground. If brood is not present, shake bees from one comb taken from the centre of the cluster of bees. Scoop or pour about 300 bees (half a cup) into the jar. Place the lid on the jar to stop bees from escaping.

Rotate (roll) the jar for two minutes ensuring all bees are dusted with sugar. Be careful not to lose any sugar. Wait two to three minutes, and rotate the jar for another two minutes. The hive can be reassembled during the waiting period.

Shake the jar so that the icing sugar (and any mites) pass through the holes in the lid into a small bucket half filled with water. The icing sugar will dissolve and any mites will float on the surface of the water. Do the shaking in a sheltered position protected from strong wind that could blow mites away. Release the bees from the jar onto the ground close to the hive entrance in case you have missed the queen and she is present.



Pour about 300 bees (half a cup) into the jar.

D Martin, DEDJTR



Items required for sugar shake test.

D Martin, DEDJTR



Roll the jar so that all bees are dusted with sugar.

D Martin, DEDJTR



Shake some bees from three brood combs onto newspaper.

D Martin, DEDJTR



Shake the icing sugar into a container of water.

D Martin, DEDJTR

Examine the empty jar and its lid for reddish-brown varroa. Inspect the water surface and if you find varroa, other mites or insects, carefully place them into a small jar with methylated spirits and place it in a cool position away from sunlight. Alternatively, pour the water through a piece of light coloured, fine, close-weaved, household cleaning cloth, or coffee filter paper. If you suspect varroa, place the cloth or filter paper in a small sealable zip-lock plastic bag or jar. Refer to the heading *Varroa – a notifiable bee pest* for how to label the container and where to notify presence of suspect varroa.

Examination of pupae for varroa

Varroa spend most of their life cycle inside sealed brood cells and prefer drone pupae. A minimum of 100 capped pupae, at the pink-eye stage of development, are lifted from their cells and examined externally for reddish mites. Sample pupae from three combs. The process may be speeded-up by lifting a number of drones from their cells at the one time using a cappings scratcher. This tool is used by some beekeepers to rupture the caps of honey comb cells prior to honey extracting. If drone brood is not present, worker brood may be checked for varroa.

Examination of brood is important because up to 85% of mites are in sealed brood cells away from sight and detection by the sugar shake procedure. Beekeepers are encouraged to conduct sugar shaking and drone brood examination at the same time.

Braula fly

The braula fly (*Braula coeca*), previously known as the bee louse, is a reddish-brown wingless fly about 0.75 mm wide and 1.5 mm long that can be seen with the naked eye. The fly is a scavenger. It clings to the hairs of the honey bee and can easily move from one bee to another.

Female braula lay eggs under the caps of honey cells. The eggs hatch and the larvae consume honey pollen and beeswax. They form raised tunnels up to 10 cm long made from wax gnawed from the cell caps. The larva pupates in its tunnel and emerges after three weeks as an adult.



Braula fly

Simon Hinkley and Ken Walker, Museum Victoria, PaDIL

Many braula, up to 30, may collect on a queen probably because she is the most permanent member of the colony. They also occur on adult workers and drones. Braula feed on honey and pollen fed to bees and scavenge food from the mandibles of adult bees. Braula do little apparent harm to honey bee colonies, although heavy infestations may affect the egg-laying performance of queens.

In Australia, braula only exists in Tasmania. The introduction of bees, hives, combs, comb honey, bee-collected pollen, used hive components and used beekeeping tools and appliances from Tasmania to the mainland is strictly regulated or prohibited by mainland states and territories. Anyone wishing to introduce these items to the mainland must first contact the relevant state or territory authority to determine the current rules.

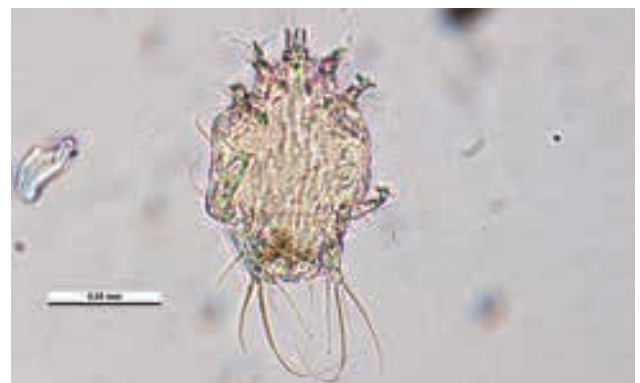


Braula flies on the thorax of a queen.

Rod Bourke

Honey bee tracheal mite

The Honey bee tracheal mite (*Acarapis woodi*), also known as Acarine mite, invades the tracheal system of adult bees where it feeds on the haemolymph (blood) and interferes with the respiration of the bee. The entire life cycle of the mite occurs in the tracheal system except when the female migrates to another bee. Mites have been found in the trachea of the thorax and in air sacs in the head of the honey bee.



Female honey bee tracheal mite.

Simon Hinkley and Ken Walker, Museum Victoria, PaDIL

The mite can be detected by microscopic examination of the tracheal system of adult honey bees. It should not be confused with *Acarapis externus*, *Acarapis dorsalis* and *Acarapis vagans*, which are similar mites, found in Australia, that live on the external surface of bees and do not appear to affect them.

The mites invade the tracheal system of young bees usually, within 24 hours of the bees emerging from their cells. Female mites lay up to seven eggs and the resultant larvae move about the tracheal system feeding. Mated females move out of the trachea and crawl to the ends of the bee's body hairs where they wait to attach themselves to other passing bees.



Tracheal mites inside air way (trachea) of honey bee.

Simon Hinkley and Ken Walker, Museum Victoria, PaDIL

Bees infested with the mite die sooner than healthy bees, especially in over-wintering colonies. Severely infested colonies have been found to produce less brood than healthy colonies. As a result, the population declines more rapidly than usual, retarding the development of the colony during the spring build-up period. Reduced longevity of bees and decline of population is likely to result in reduced honey production.

There are no reliable field symptoms of mite infestation. Diagnosis must be by microscopic examination of the trachea by trained personnel.

The main means of natural spread is by robber bees, drifting bees and bee swarms. The movement of infested colonies can also result in mite spread.

Tropilaelaps mite

Tropilaelaps clareae and *Tropilaelaps mercedesae* parasitise the giant honey bees of Asia. *Tropilaelaps mercedesae* is present in Papua New Guinea, but at the time of writing had not been detected in Australia. They are smaller than varroa being approximately 1 mm long and 0.5–1 mm wide.

They are also capable of parasitising European honey bee larvae and pupae, reproducing inside sealed brood cells. The mites later emerge from the brood cells when the new adult bee emerges from its cell. The parasitised adult

honey bees may be stunted and have deformed wings and shrunken abdomens. These are discarded from the colony. Infested colonies may abscond.



Female tropilaelaps mite.

Ken Walker, Museum Victoria, PaDIL

Tropilaelaps mites cannot survive for more than three days in a broodless colony. This is because they cannot pierce the membrane of adult honey bees to feed on their haemolymph.



Tropilaelaps clareae on European honey bee larvae and pupae.

Denis Anderson, CSIRO

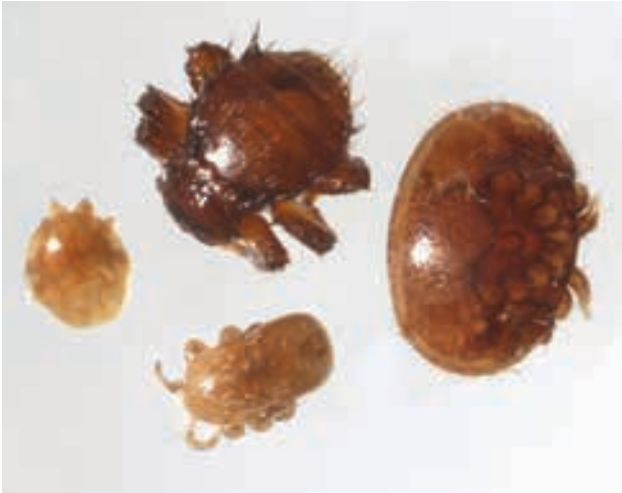
The destructive nature of this mite has been reported to be much greater than varroa infestations in those countries where the European honey bee has come in contact with it. The fact that the Asian mite has not spread rapidly around the world may be related to its inability to spread without the presence of brood upon which it relies for its survival.

Mellitiphis mite

The pollen mite (*Mellitiphis alvearius*), occurs in Australian honey bee colonies, but is not a parasite of honey bees. It is brown, smaller than varroa, measuring 0.75 x 0.75 mm.

Comparative diagnosis

At first glance, Varroa mite, Tropilaelaps mite, Braula fly and Mellitiphis mite may look similar to the untrained eye. Although their colour appears similar, their appearance and size is quite different as shown in the illustration below.



Braula fly (top), varroa mite (right), tropilaelaps mite (bottom) and mellitiphis mite (left).

Courtesy: The Food and Environment Research Agency (FERA), Crown Copyright.

Additional information

Visit the Plant Health Australia BeeAware website (www.beeaware.org.au) for information for beekeepers and growers about honey bee biosecurity and pollination of agricultural and horticultural crops.

17. Quick problem solving table

Problem	Possible causes	Suggested reason and/or action
Brood not present in hive	• Bee colony is queenless	Requeen colony
	• A virgin queen or newly mated queen is present but is yet to begin egg-laying	Inspect for brood again in ten days and then requeen if brood not present or unite hive
	• It is a natural occurrence for brood rearing to stop in some districts that have a lengthy period of cold late autumn and winter temperatures	This depends on apiary location; check for queen in early spring
	• Queen may be above the queen excluder (if fitted)	Check for brood above the excluder
Drone brood present in worker cells, worker brood not present	• Queen is unable to lay fertilised eggs; she is known as a drone layer	Remove queen and replace her if the colony is not too weak and some young bees are present
	• Colony is queenless and one or more workers lay unfertilised eggs	Unite this colony with one that has a queen. Refer uniting hives
Honey bee eggs laid on side of cell walls	• The colony is most likely queenless and one or more laying workers are present	Unite colony with one that has a queen. Attempts to requeen a colony with laying workers are usually unsuccessful.
Dead adult bees head first in comb cells, usually a large number clumped in the same area	• A classic sign that the colony has starved	Better management is required. Always leave sufficient honey for the bees; if there is a shortage of honey, feed sugar to prevent starvation
Dead drones outside hive entrance	• It is natural for drones to be ejected from the hive in times of poor food supply and also before winter	Monitor hive to ensure sufficient stores are present for the colony
Dead or sick adult bees on ground near hive entrance; also sometimes on hive bottom board. Note: it is normal for small numbers of dead adult bees to be found outside the hive entrance	• Adult bee disease	Refer to chapter 14. <i>Diseases of adult bees</i>
	• Starvation	Check hive for stores
	• Pesticide application within the bees' foraging range	Remove dead bees from inside hive. Consider moving hives to a pesticide free location
	• Extreme heat wave	Provide shade in summer
	• Fighting caused by robber bees	Refer to chapter 6. <i>Spring management</i>
	• Honey in unsealed combs that has fermented over winter	Refer to chapter 9. <i>Winter management</i>
	• Fermented nectar gathered by bees from some species of flora, particularly late autumn and winter flowering species	Move hive to another location to avoid suspect plant species

Problem	Possible causes	Suggested reason and/or action
Large numbers of dead bees in hive	<ul style="list-style-type: none"> • Hive entrance has fallen shut or was not opened by beekeeper after hive was moved to new site • (refer also to possible causes contained in preceding section) 	Check entrance closure after moving hive. Conduct regular inspection of bee flight to and from the hive entrance
Loss of adult bees; the colony appears to have less adult bees	• Spring dwindle when over-wintering bees die in late winter or early spring depending on locality	Governed by the locality
	• Colony has swarmed	Minimise swarming
	• No queen present	Requeen colony if the colony is not too weak and some unsealed brood and young bees are present
	• Poor or aging queen, or drone laying queen present	Requeen or unite hive
	• Adult bee disease	Careful inspection of bees for signs of adult bee disease
	• Extreme heat wave	Locate hives in broken shade and ensure bees have an adequate water supply
	• Pesticide application within the bees' foraging range	Remove dead bees from inside hive. Consider moving hives to a pesticide free location
Bees hanging out of hives in very warm to hot weather	• A natural occurrence; some bees move outside the hive to assist the natural process of hive cooling	If this condition continues in cooler weather refer to the points immediately below
	• Hive is full, or nearly full of honey	Extract some honey and/or add another super
	• This may be an early sign of swarming	If swarming is a possibility inspect for swarm cells
Combs in hive have been gnawed	• One or more mice have moved into the hive to seek shelter in the cold time of the year	Reduce the size of the entrance to prevent mice entry
	• On occasions, the bees will gnaw the bottom of combs in the brood nest at the hive entrance end of the frame	Reversing the gnawed frame, end for end, may be an advantage. Deep bottom boards or grates in the bottom boards may prevent the problem
Silky web and cocoons in weak hives and stored combs	• An infestation of wax moth larvae	Refer to chapter 15. <i>Pests and enemies of bees</i>
	• Spider webs	Remove the spiders

Problem	Possible causes	Suggested reason and/or action
Slime in hive and on combs removed from the hive for honey extracting or storage	<ul style="list-style-type: none"> • Small hive beetle larvae have attacked the combs 	Refer to chapter 15. <i>Pests and enemies of bees</i>
Larvae (other than honey bee larvae) in combs in hive or in storage	<ul style="list-style-type: none"> • Small hive beetle larvae 	Refer to chapter 15. <i>Pests and enemies of bees</i>
	<ul style="list-style-type: none"> • Wax moth larvae 	Refer to chapter 15. <i>Pests and enemies of bees</i>
Spotting on hive and sometimes on frames inside hive (may also occur on cars and washing etc.)	<ul style="list-style-type: none"> • This is bee excreta and may be associated with dysentery and nosema infection in adult bees, but spotting is not always indicative of this adult bee disease 	Refer to section <i>Nosema disease</i> in chapter 14. <i>Diseases of adult bees</i>
	<ul style="list-style-type: none"> • Cleansing flights taken by bees after being confined to the hive for extended periods, such as inclement weather 	This is normal bee behaviour
Bees fail to emerge from their cells after pupation	<ul style="list-style-type: none"> • Brood has been chilled and has died 	Keep hives well populated so as to provide warmth, remove any super(s) not required by the bees
	<ul style="list-style-type: none"> • Silken threads produced by wax moth larvae tunnelling through brood comb prevent bees from leaving their cells 	Refer to chapter 15. <i>Pests and enemies of bees</i>
Bald brood	<ul style="list-style-type: none"> • Greater and lesser wax moth larva tunnelling through comb beneath pupating bees or in a line just under the cell caps and perforating the cell caps 	Refer to chapter 15. <i>Pests and enemies of bees</i>
	<ul style="list-style-type: none"> • Genetic causes 	Requeen the colony if bald brood is a continuing major problem
Beetles and other insects (etc.) in hive	<ul style="list-style-type: none"> • Adult small hive beetle 	Refer to chapter 15. <i>Pests and enemies of bees</i>
	<ul style="list-style-type: none"> • Other beetles may sometimes occur in hives and do no apparent damage (e.g. scavenger beetles); cockroaches and slaters may also be present 	Bees usually tolerate cockroaches and slaters in the hive
Powdery, moist, substance of various colours in cells predominantly around the area of brood	<ul style="list-style-type: none"> • Stored pollen, collected by bees usually from a variety of flowers (and various colours, for example, white, cream, orange, brown, purple) and packed into pollen storage cells 	Stored pollen in the hive is vital for colony nutrition

Problem	Possible causes	Suggested reason and/or action
Scattered or irregular brood pattern	• Brood disease	Carefully inspect brood nest for brood disease
	• Poor or failing queen; queenlessness	Requeen colony
	• Little or no nectar and/or pollen yielding flowers in the bees' foraging range	Relocate hives to better flora conditions or feed colonies
	• Pesticide application within the bees' foraging range	Remove any dead bees from hive and feed bees if required
	• Extreme heat stress	Locate hives in broken shade and ensure bees have an adequate water supply
Perforated caps over honey and brood cells	• Caps over honey and brood cells are under construction and the cells are yet not fully capped	Check contents of cell to ensure that brood, if present, is healthy
	• Brood disease	Carefully inspect brood for brood disease and submit samples for diagnosis if necessary
	• Brood dead by natural causes	Monitor brood nest and submit samples for diagnosis if disease is suspected
Sunken caps over brood cells. White, off-white, coffee-brown to black, or grey to black remains of larvae or pupae in open or sealed brood cells	• Brood disease	Carefully inspect brood for signs of disease and submit samples for diagnosis
	• Brood dead by natural causes	Monitor brood nest to ensure disease is not present
Cell walls of brood comb have changed from white to dark brown or black	• Natural causes – although newly built comb is mostly white, the cocoons spun by each generation of brood adhere to the cell wall, which over time causes the comb to darken	It is normal for combs to darken but they should be replaced if the cell walls are thickened, distorted and very black
White to grey-black chalk-like mummies on the hive bottom board and on ground outside hive entrance	• Chalkbrood, a fungal disease of bee larvae	Refer to chapter 13. <i>Brood diseases of bees</i>

Problem	Possible causes	Suggested reason and/or action
No bee flight to and from the hive	<ul style="list-style-type: none"> • Weather is unfavourable for bee flight (e.g. low temperature, wind and rain) 	Under these conditions, it is normal for no bee flight
	<ul style="list-style-type: none"> • Temperature of the surrounding environment is too cold or too hot for bee flight 	Under these conditions, it is normal for no bee flight
	<ul style="list-style-type: none"> • The colony has died 	Inspect combs to determine if brood disease was the cause
	<ul style="list-style-type: none"> • Sometimes a newly hived swarm will have very few or no bees foraging as they settle in a new hive and begin comb building 	This is normal activity. Wait seven to ten days for the bees to settle and after 21 days new bees will be hatching if a queen is present
Bees are savage and difficult to handle	<ul style="list-style-type: none"> • Genetic 	Remove queen, replace with a new queen of a docile strain
	<ul style="list-style-type: none"> • Weather 	Don't attempt to handle bees on a poor weather day. The bees will tell you this with their behaviour
	<ul style="list-style-type: none"> • Handling skills 	Improve your bee handling skills. Apply gentle smoke, handle hive components gently, wear correct personal protective equipment, avoid odours that bees dislike and don't leave hive open too long

18. Honey bee pollination

Pollination is the transfer of pollen grains from the male part of the flower, the anthers, to the receptive female part, the stigma. It is the first step of a process that results in fruit and seed set.

Honey bees are very good pollinators of many flowering plant species. The hairy nature of bees enables them to carry large numbers of pollen grains during foraging. As they brush against the reproductive parts of flowers, pollen grains are picked up and deposited.

When compatible pollen is deposited on a stigma, the pollen grain germinates and sends a pollen tube down the style to an ovule in the ovary of the flower. The fusion of pollen with an ovule is known as fertilisation and this causes development of seed or fruit. Although bees may do an excellent job in transferring pollen, factors affecting fertilisation can cause poor fruit and seed set.

Many horticultural and seed crops require bee pollination to ensure good, economic yields. Some fruits such as almonds, apples, cherries, pears and plums, require compatible pollen of another variety or cultivar of the same species. This is known as cross-variety pollination. Where cross-variety pollination is required in an orchard, a main crop variety and a polliniser variety are planted. Interchange of pollen between the two varieties occurs when a bee visits both varieties on the one foraging trip. Some interchange of viable pollen grains can also occur when forager bees brush against each other in the hive.

Pumpkins, zucchinis, cucumbers, melons and kiwi-fruit, have separate male and female flowers and pollen must be transferred to female flowers. The flowers of some plants such as berries, pumpkins and kiwifruit, have more than one stigma and more than one ovule. They need multiple visits by bees to ensure sufficient pollen grains are placed on the receptive stigmas to produce well-formed fruit.

In addition to yield, pollination can improve quality in some crops. For example, high seed numbers improve the size of apples and pears, as well as their storage qualities. Low seed numbers and uneven seed distribution in the ovary can cause small and/or misshapen fruit.

Beekeepers who provide a pollination service to growers, can generate income by charging a fee for the hire of their colonies. Bee colonies must be prepared well in advance of flowering so that they conform to certain standards to give growers the best pollination result. The beekeeper and grower should agree on a pesticide spray program to avoid damage to the bees. The use of a written contract will provide both parties with an understanding of their responsibilities.



Pears cut open to show seed content. Top photo: an example of good pollination with a high number of seeds and good fruit shape. Lower photo: an example of poor pollinated fruit with fewer seeds and misshapen fruit.



Kiwifruit: good pollination ensures marketable fruit (left), as opposed to poor pollination and small misshapen fruit (right).

Factors affecting bee activity and distribution of colonies

Bees do not usually fly when the temperature is below 10°C. Some flight will occur at 12–14°C if the day is still and sunny. Good flight begins at 16°C, and at 19°C, it reaches a relatively high level.

In poor weather, bees may only fly about 150 metres from the hive between showers. Flight is reduced a little on very overcast days, especially if it is cool. Strong winds make it difficult for bees to fly and the number of foraging trips per day may be reduced.

In districts that have cold, showery, spring weather, for example Southern Victoria, hives are best distributed evenly throughout the orchard individually, or in small groups, so that all trees are within 100–150 metres of a hive. Where the distance between the hives and target crop is greater than 150 metres, bees will be unlikely to visit the blossom in inclement weather, because foraging in these conditions is limited to short trips. In contrast, hives in almond plantations where temperatures are warmer are placed in large groups around the edge, and in the centre of blocks of trees.



Hives placed to pollinate cherries in southern Victoria. It is preferable that all trees are no further than 150 metres from a hive.

Where possible, locate hives in a sunny north to north-east facing site, sheltered from cold southerly and westerly winds. Bees are less inclined to forage when hives are located in cool, shaded areas. Keep hive entrances clear of weeds. In summer, provide partial shade. Ensure the bees have access to clean, fresh water. Place hives in positions where they are not affected by flood or spray irrigation.

Bees are generally not inclined to fly into crops covered by hail netting, especially if the netting causes significant shading. It is best to place hives in the crop under the netting.

Bees will usually prefer flowers with the highest concentration of sugar, for example, apples (approximately 23% nectar sugar) in preference to pear (approximately 7% nectar sugar). Similarly, bees have deserted pumpkins to visit flowers of nearby Messmate (*Eucalyptus obliqua*) trees. Many weeds are very attractive to bees and may draw bees away from a crop.



Bee hive placed under hail mesh to pollinate apples.

Colony stocking rates

The number of colonies (hives) required per hectare of crop for pollination is known as the stocking rate and will vary according to a number of factors. High stocking rates are used for densely planted crops where there are more flowers. Older fruit trees will require more bees than younger trees because they also have more flowers. Large numbers of colonies are sometimes recommended for crops that are relatively unattractive to bees as this allows for the loss of those foragers that desert the crop to seek more attractive flora elsewhere.

Number of colonies per hectare required

Fruit Crops

Almond	5–8	Kiwi fruit	8
Apple	3–5	Loganberry	2–3
Apricot	2–3	Passion fruit	1
Nashi pear	2–4	Pears	2–3
Blackberry	2–3	Plum	2–4
Blueberry	5–8	Quince	1–2
Boysenberry	2–3	Raspberry	2–5
Cherry	3	Strawberry	1–10

Vegetable Crops

Cucumber monoecious	2–4	Squash	2–7
Cucumber gynoecious	3–6	Water melon	2–7
Pumpkins	2–4	Zucchini	2–7

Seed (field) Crops

Canola (rapeseed)	1–2	Lupin	1–2
Clover-white	2–5	Sunflower	2.5
Lucerne	5–8		

In addition to bees managed by beekeepers, wild (feral) bee colonies can also help to pollinate crops. Their contribution to pollination will depend on the number of colonies in the surrounding area, as well as the number of foragers in the colony. Because wild bees are subject to bee disease and pests, as well as nectar and pollen shortages, the number of bees in these colonies may be quite low compared to that of a managed colony. In adverse field conditions, wild colonies may die or become seriously weakened with few foragers left to deliver a good pollination result for growers.

Preparation of colonies for pollination

Pollination contracts stipulate the minimum standards for colonies for the time of the year that the pollination is to occur. For pollination of almonds flowering in August in north-west Victoria, colonies should have eight to ten frames of adult bees and two to four frames of brood including unsealed brood. However, colonies kept in cold winter conditions may have less brood than this. Provided there are sufficient adult bees and egg-laying room for the queen, the colony will soon have unsealed brood which stimulates foragers to collect pollen.

As the season progresses and colonies expand after winter, the amount of brood and numbers of bees required will usually be greater. For early spring pollination of crops such as plums and other stone fruit, an amount of six combs of brood, well covered with bees, should be considered a minimum standard.

Small colonies have fewer foraging bees than large colonies and are less inclined to forage during cool weather and the cooler times of the day. Delivery of two weak colonies when a strong colony is unavailable is unacceptable. The number of foragers in two weak colonies will be less in total than the foragers of one strong colony.

There should be ample comb space for the queen to lay eggs so that there is always a large amount of unsealed larvae, preferably about 25% of the total amount of brood. The presence of larvae creates a demand for pollen, and pollen foragers are usually the most efficient pollinators.

When other nectar and pollen yielding flora, such as weeds, are available, colonies can quickly expand and become too populous. If this occurs they should be weakened or divided to prevent swarming.

Preparation of colonies for early spring pollination should begin in autumn, taking advantage of autumn nectar and pollen flows. The colonies will then overwinter with large numbers of bees. They may be wintered in double or single box hives, with sufficient stores to carry them through winter and the early pollination period. Some supplementary feeding may be necessary in late winter to stimulate brood rearing and increase the number of adult bees. Feeding may also be necessary when honey stores are low during the pollination period, or immediately after it.

In general, for crops that flower after mid-spring, preparation of colonies should begin four to six weeks in advance so that there is a good population of bees ready to forage as soon as hives are introduced to the crop. Failure to achieve this can result in poor pollination. Brood rearing can be encouraged by placing the hives on good build-up flora prior to the period of pollination. An alternative is to feed light sugar syrup, one part sugar and one part water by volume, and a pollen supplement. (See under heading *Online* publications for publication *Fat Bees Skinny Bees – a manual on honey bee nutrition for beekeepers* in chapter 20. *Additional information*).



Bee pollinating carrot flowers for the production of carrot seed.

Pollination fees

If a profit is to be made, fees charged by the beekeeper must cover all the costs of providing a pollination service. These include special management of colonies prior to pollination, movement of hives to and from the crop, travel incurred to manage colonies while on-site, feeding colonies (if required), rehabilitation of colonies after pollination and any loss of honey production that might have been harvested if the hives were not on pollination (net after extraction costs).

Pollination contracts

Misunderstandings between grower and beekeeper can occur. Written, signed agreements can specify the conditions which protect the interests of both parties. These are better than verbal agreements and handshakes. A solicitor may be consulted, especially if a legal document is to include penalties for non-compliance of the contract.

The use of an agreement requires quite a degree of trust between the parties. The grower has to pay the agreed amount to the beekeeper for delivery of a professional pollination service. The beekeeper has to supply colonies that conform with, or exceed, the agreed minimum standard

for the number of frames of brood and bees. It is not good enough to supply boxes with a few bees flying in and out of the hive. The grower may request that hives be opened to determine if they conform to the agreement.

The following agreement has been used in southern Victoria for spring flowering fruit tree crops and is included as a guide only. The amount of brood present in an overwintering hive will depend on the prevailing seasonal conditions. For very early flowering crops it may not be possible for hives to have the amount of brood detailed in the agreement and this should be discussed with the grower.

POLLINATION AGREEMENT FOR SEASON 20__	
Beekeeper	Grower
Name:	Name:
Address:	Address:
Telephone:	Telephone:
Number of hives ordered	Date of Delivery
Minimum colony strength	
As a minimum, bee colonies shall have six combs of brood well covered with bees. If colony strength is in dispute, within five days of delivery the grower may request an inspection of the colonies. If a colony is found to be under minimum strength, the beekeeper shall pay any inspection cost. Where a colony meets or exceeds the minimum standard, the inspection cost shall be paid by the grower. If a hive has less than the minimum strength then either:	
(a) a replacement hive shall be provided, or	
(b) the hive may be removed and no fee shall be payable.	
Crop name and fee per colony.	
1	\$
2	\$
3	\$
Location of crop	
Distribution pattern of hives shall be	
The Grower agrees	The Beekeeper agrees
1. To give ____ days notice to bring colonies into the crop.	1. To ensure that colonies are healthy at the time of delivery and that they conform to the minimum standard agreed by the grower and beekeeper.
2. To give ____ days notice to take colonies out of the crop.	2. To ensure that colonies are properly maintained in good condition while pollinating the crop.
3. To pay in full within ____ days after the completion of pollination period, or pay deposit of \$ ____ within ____ days of placement of hives in the orchard and the remainder within ____ days of the completion of the pollination period.	3. To open and demonstrate the strength of colonies randomly selected by the grower.
4. To use no chemical without notifying the beekeeper at least 48 hours in advance.	4. To leave the bees in the crop for a period for effective pollination estimated to be approximately days but not later than date _____ after which day the bees will be removed or the contract be extended at \$ ____ per day.
5. To not damage hive material during operation of orchard equipment.	
6. To not move or handle hives, or allow this to be done, without permission of the beekeeper.	
7. To allow the beekeeper unrestricted access to property for ongoing hive management.	
8. To assist the beekeeper with distribution and later removal of hives in the crop when requested.	
Signed	Signed
Date	Date
Grower	Beekeeper

Biosecurity

Be wary of any hives left on a property that have died or are neglected as they may be diseased. Seek permission to inspect them before locating your own bees on the property.

Pesticides and bees

Severe losses of foragers and hive bees can occur when pesticides hazardous to bees are used in areas where bees are foraging, or flying over to reach suitable flora. Losses of bees can seriously reduce the pollination potential of a colony, and later honey and beeswax production. In severe cases, the colony may weaken and die.

While insecticides are hazardous to bees, some losses of bees have been reported when large scale spraying of herbicides has occurred. Some fungicides have been shown to be toxic to bee larvae. The hazard may be increased when two or more chemicals are mixed together, even though one or both are considered safe when applied individually.

Bees may be poisoned when they forage for nectar and pollen on contaminated flowers, contact sprayed foliage, fly through spray drift and drink contaminated water, including contaminated dew on sprayed foliage. They die mostly in the field, or shortly after they arrive back at the hive. In the latter case, when many bees are affected, large numbers of them may be seen dying outside the hive entrance. Some may be seen crawling away from the hive.

When contaminated pollen is stored in the hive, some deaths may occur over a long period of time as the pollen is consumed by bees and fed to brood.

The regular application of sprays in orchards means that bees foraging on weeds growing beneath the trees are at considerable risk even though the trees are not in bloom.

A written agreement can provide some protection for bees while they are pollinating the crop. The grower can confirm in writing that hazardous pesticides will not be applied while the bees are on-site. However, the agreement does not apply to adjacent growers. The beekeeper should advise neighbouring growers of the location of the bees and request that they give notice of their intention to apply sprays which are hazardous to bees. Insist that they give you at least 48 hours notice so that there is time for you to move the hives to a safe area to avoid losses of bees.

Leave your name and telephone number (mobile and landline) with each grower, because if hazardous pesticide application is imminent a quick contact is vital. Also, place these details on one or more hives that may be easily seen by the grower, just in case he/she has mislaid your details. A stand-alone sign near the hives is strongly recommended.

A well-placed, eye-catching sign can attract the attention of people who pass by. It can alert nearby growers that bees are on the property and also encourage them to advise the beekeeper of any intent to apply chemical sprays. A template for a biosecurity sign is available at the honey bee section of the Plant Health Australia website www.phau.com.au.



This biosecurity sign displays the contact details of the owner of the hives.

Photo courtesy Sam Malfroy, Plant Health Australia

Beekeepers can use an on-line *Pesticide risk management plan* and a form *Notification of beehives in your area* detailed in the first reference below (Connelly 2012).

If hives cannot be moved, encourage growers to use chemicals which have a low, or moderate, hazard to bees. Additionally, and where possible, they should also have a short period of residual effect.

If chemicals with a long residual effect must be used, the beekeeper should move the bees to a safe area at least five, and preferably ten kilometres, away and return them only after the residual activity of the chemical has dissipated. Information on the toxicity and residual effect of chemicals can be obtained from the chemical manufacturer and in some cases, the chemical product label.

Confining bees in their hives until the residual effect of the chemical has dissipated is an extremely dangerous practice. Colonies can quickly smother and die when shut in the hive, even when the temperature outside the hive is relatively cool. This is because bees panic and race inside the hive, creating heat.



Many pesticides are hazardous to bees.

If colonies suffer insecticide damage, remove any dead bees from inside the hive so that the entrance does not become blocked, thereby restricting ventilation and flight. Move the hives to good nectar and pollen build-up flows to enable the colonies to restore bee numbers. If necessary, requeen the hive with a young vigorous queen. If build-up conditions are not available, supplementary sugar and pollen feeding may be necessary to prevent starvation and to encourage brood rearing.

When colonies are damaged by pesticides, some beekeepers generally don't return to provide pollination services in subsequent years.

Additional information

Connelly D 2012. *Honeybee pesticide poisoning: a risk management tool for Australian farmers and beekeepers*. <https://rirdc.infoservices.com.au/items/12-043>

Goodwin M 2012. *Pollination of crops in Australia and New Zealand*. <https://rirdc.infoservices.com.au/items/12-059>

Keogh R, Robinson A & Mullins I 2010. *Pollination Aware*. <https://rirdc.infoservices.com.au/collections/poll>

McGregor, SE. 1976. *Insect Pollination of Cultivated Crop Plants*. United States Department of Agriculture. Washington, DC, USA. This book is available online at <http://www.ars.usda.gov/SP2UserFiles/Place/53420300/OnlinePollinationHandbook.pdf>

Plant Health Australia *BeeAware* website (www.beeaware.org.au) contains information about pollination of crops and how beekeepers and growers can work together to provide and receive best practice pollination services. <http://www.planthealthaustralia.com.au/industries/honey-bees>

Somerville D 2005. *Fat Bees Skinny Bees – a manual on honey bee nutrition for beekeepers*. <https://rirdc.infoservices.com.au/items/05-054>

19. Legal

Registration as a beekeeper

If you keep bees in mainland Australian states and the Northern Territory you are required by law to register as a beekeeper. Enquiries should be directed to the department of primary industries (or equivalent) in the state or territory where the bees are to be kept (See chapter 20. *Additional information* for web site addresses). At the time of writing, registration was not compulsory in Tasmania, but it was encouraged.

Registration must be renewed annually, or every two years, depending on the regulations applicable in the state or territory. In most cases, a fee is charged for registration and renewal of registration.

A brand (or registration number) is given to the beekeeper when he or she registers for the first time. The brand remains with the beekeeper for as long as the beekeeper continues to renew registration.

The allocated brand and beekeeper's contact details are kept on the relevant state or territory department of primary industries beekeeper database. This allows apiary officers to identify hive ownership which is important in the event of an outbreak of an exotic bee disease or pest. The Department may use the details to send beekeepers helpful information from time to time.

Beekeepers are also encouraged to place a sign with their name and telephone contact numbers at the apiary, so that they may be contacted in the event of an emergency such as fire, flood, application of an agricultural chemical and vandalism. Some beekeepers place their contact details on one or more hives in the apiary. In this case, the letters and numerals should be of sufficient size so they can be read from a distance. This is important because there will be people who may wish to help but are unwilling to walk close to hives to read small lettering.

An alternative is to place contact details on signs that are positioned so that local farmers are aware that hives are located on the site. This is especially helpful if agricultural pesticides are to be applied close-by. Hobbyists who keep hives on their suburban or town residential property do not need to have these signs.

Branding hives

The branding of hives is compulsory, but the size of letters/numerals and their position on the hive varies from state to state. In the Northern Territory, branding is requested as part of the registration system, but it is not compulsory.

Beekeepers who obtain second hand hives are required to place their own registered brand on the hives. Again, the rules vary from state to state. Some states require that the brand of the previous owner be cancelled by placing a mark through the brand on the hive.

Disposal of hives

Some states require beekeepers to notify their department of primary industries that they have sold or otherwise disposed of one, some, or all of their hives. It will be necessary to advise who acquired the hives.

Moveable frame hives

Bees must be kept in hives that have frames and combs that can be individually and readily removed from the hive without cutting or tearing. This is required so that honey bee brood can be inspected for presence of brood disease.

On occasions, a beekeeper will not have enough hive material in which to place swarms. The swarm may be temporarily put in a box without frames. The good intent is to assemble frames with foundation and place them in the box the next day. When frames are not inserted, the bees will readily build comb in the space and fill the box. It is then very difficult, and in many cases, virtually impossible to transfer the combs to frames to comply with the law.



A hive without frames in the super. By law, hives must have all combs fitted in moveable frames.



Another illegal box hive.

Notification of bee diseases and pests

Exotic honey bee pests and diseases must be notified immediately. This means that a beekeeper who detects or suspects the presence of an exotic pest or disease in a hive or apiary must, by law, report it without delay. To not notify, is to break the law. The lack of notification could potentially put the Australian honey bee industry at risk.

The easiest way of notifying is to call the Exotic Plant Pest Hotline on 1800 084 881. Alternatively, contact your state or territory department of primary industries apiary officer. More information and contact details may be found on each state or territory Department of Primary Industries website.

Certain established (endemic) bee diseases and pests are also notifiable. Notification must be made within certain times of the disease or pest being found or suspected of being present. Full details may be found on your state or territory department of primary industries website. American foulbrood disease is a notifiable disease.

Exposure of bees to infected hives and equipment

Bee diseases and pests can be easily spread when bees gain access to hives, beeswax, hive components and other beekeeping equipment that are diseased or infested with pests.

Honey, beeswax, bee-collected pollen, hives, used hive components and other used beekeeping equipment infected with disease, or taken from a diseased hive, must not be exposed in a way that enables bees to have access to those items. This does not apply to hive components if they have been sterilised by gamma-irradiation or hot wax dipping.



A neglected apiary. Exposure of bees to honey and infected hive components is illegal.

Access of bees to honey

It is quite alright for bees to use honey that they have stored in their own hives. However, it is illegal to allow bees access to honey that is outside the hive. This includes honey that is in or on comb, wax cappings, wax scraps, hive components, beekeeping equipment, and when extracting honey and rendering beeswax.

Interstate movement of bees and used equipment

Some states and territories are free of certain bee diseases and pests, and they want to keep it that way. As a result, there are regulations that totally prohibit, or restrict (subject to certain conditions), the entry of bees, queen bees, queen cells, package bees, used hives, used hive components, used apiary equipment and apiary (bee) products, including honey, from other states and territories. Beekeepers should contact the department of primary industries of the state or territory that the items are to be introduced for current information.

Where introduction of an item into another state or territory is allowed, it may be compulsory by law for the beekeeper to ensure that a completed interstate health certificate accompanies the consignment. Blank certificates can be obtained from the department of primary industries in the state or territory where the items are located before the intended movement. The beekeeper must write certain required information on the certificate, sign the form and have it countersigned by a government apiary officer or other authorised person in the state of origin.

Chemical use and records

Some states and territories require beekeepers to keep certain written records of all chemical use (for example, ant control around apiaries). Audits have been conducted to ensure that beekeepers have complied with this requirement. Beekeepers should make enquiries with their department of primary industries for more information and forms to be used.

Codes of practice

These codes have been established to assist beekeepers to follow good beekeeping practice. They set out a minimum standard for beekeeping activities to ensure that the bees do not become a nuisance to other people. Visit your department of primary industries website to find out if a voluntary or enforceable code applies in your state or territory. The following codes were available at the time of writing.

New South Wales

Beekeeping code of practice for NSW

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/270679/Beekeeping-code-of-practice-for-NSW.pdf

Queensland

Guidelines for keeping bees in Queensland 2011

http://www.daff.qld.gov.au/__data/assets/pdf_file/0016/62512/Guidelines-for-keeping-bees-in-Queensland.pdf

Beekeeping in suburbia

<http://www.daff.qld.gov.au/animal-industries/bees/beekeeping-essentials/beekeeping-in-suburbia>

Tasmania

Code of practice for urban beekeeping in southern Tasmania.

<http://www.southerntasbeekeepers.org.au/urban-beekeeping-code-of-practice/>

Victoria

Apiary code of practice May 2011

http://www.dpdc.vic.gov.au/__data/assets/pdf_file/0018/41832/Apiary-Code-of-Practice.pdf

Packing and selling honey

Honey and comb honey are food items. Beekeepers who want to sell these items should first contact their local government public health unit about the legal requirements for extracting and packaging premises, labels for honey containers, record keeping and compliance with food safety laws. It is always a good idea for beekeepers to do this before designing and building extracting and packaging facilities, as costly alterations may be requested by council.

Honey levy

At the time of writing, beekeepers who sell more than 600 kg of honey in a calendar year were liable to pay a levy to the Australian Department of Agriculture. Further information may be found at: www.daff.gov.au/levies or levies.management@daff.gov.au

Water for bees

South Australian beekeepers must provide and maintain a supply of clean water of suitable mineral content for the bees in each place where bees are kept. The water should not be more than 200 metres from any hive. Beekeepers in other states and territories should check the relevant legislation and beekeeping or apiary code of practice.

Smokers and fire

Never use a smoker on a Total Fire Ban day unless the beekeeper has obtained an official written permit that authorises its use. Even if a permit is granted, the smoker should not be used unless special circumstances apply, such as a road accident involving transport of hives.

Beekeepers should also enquire with the relevant state/territory fire agency about regulations controlling use of smokers during declared the Fire Danger Period. The date of declaration and length of the period will vary according to seasonal conditions. Detailed information on use of smokers and necessary items to be carried, including minimum firefighting equipment required by law, are found in chapter 3. *Handling bees and beekeeping safety.*

Horticultural areas and local laws

Some local government councils have local laws that prohibit the location of bee hives within a certain distance of horticultural areas during the months when fruit is dried on racks in the open. As the fruit dries, the skin splits open and bees are able to collect the sweet juice. The weight of the fruit is reduced and eventually all that remains is the skin. Beekeepers who have bees in these areas should obtain information from the relevant local government council.

20. Additional information

Beekeeper associations and clubs

There are many beekeeper associations and groups for both hobby and commercial beekeepers throughout Australia. The contact name and address will often vary from year to year, so beekeepers and other interested persons are advised to contact their state or territory peak beekeeping association for referral to beekeeper clubs and associations.

Beekeeper clubs cater for beginner beekeepers and some provide 'hands-on' bee handling opportunities at field days and similar events. Some have a library where books and DVDs may be borrowed.

Victorian Apiarists' Association Inc.

www.vicbeekeepers.com.au

New South Wales Apiarists' Association

www.nswaa.com.au

Queensland Beekeepers' Association

qbabees.org.au

Tasmanian Beekeepers Association Inc.

tasmanianbeekeepers.org.au

Northern Territory Beekeepers Association

For a contact, visit the NT Department of Primary Industry & Fisheries honey bee web site (see below for listing under State and Territory Departments of Primary Industries).

South Australian Apiarists' Association

www.saaa.org.au

Beekeepers Association of the ACT

www.actbeekeepers.asn.au

Western Australian Apiarists Society

www.waas.org.au/

Australian Honey Bee Industry Council (AHBIC)

Honeybee.org.au

AHBIC has developed a document *Best management practice for the transportation of open entrance beehives* which can be downloaded from: <http://honeybee.org.au/wp-content/uploads/2014/07/Best-Management-Practice-for-the-Transportation-of-Open-Entrance-Beehives-April-2014.pdf>

State and Territory Departments of Primary Industries (or agriculture)

New South Wales

Department of Primary Industries

<http://www.dpi.nsw.gov.au/agriculture/livestock/honey-bees>

Northern Territory

Department of Primary industries and Fisheries, Phone (08) 8999 5511

http://www.nt.gov.au/d/Primary_Industry/?newscat1=Other+Animals&newscat2=&header=Honey+Bees

Queensland

Department of Agriculture, Fisheries and Forestry

<http://www.daff.qld.gov.au/animal-industries/bees>

Tasmania

Department of Primary Industries, Parks, Water and Environment

<http://dpiuwe.tas.gov.au/biosecurity/animal-biosecurity/animal-health/bees>

South Australia

Department of Primary Industries and Regions South Australia

http://www.pir.sa.gov.au/biosecuritysa/animalhealth/other_animals/bees

Victoria

Department of Economic Development, Jobs, Transport and Resources.

Go to vic.gov.au, then type "honey bee page" in the search box.

Western Australia

Department of Agriculture and Food Western Australia

<https://www.agric.wa.gov.au/livestock-animals/livestock-species/bees>

Beekeeping journals

Australian Bee Journal published by the Victorian Apiarists' Association Inc.

www.vicbeekeepers.com.au

The Australasian Beekeeper

<http://www.theabk.com.au/>

Australia's Honeybee News published by the New South Wales Apiarists' Association Inc.

<http://www.nswaa.com.au/>

Books

Note: Publications produced for northern hemisphere beekeepers will have different months for the seasons of the year.

Anatomy of the honey bee. Snodgrass RE 1984. Cornell University Press, Ithaca, New York.

Beekeeping for Dummies (second edition). Blackiston H 2009. John Wiley & Sons Australia Ltd, Camberwell.

Beeswax production, harvesting, processing and products. Cogshall WL & Morse RA 1984. Wicwas Press, Ithaca, New York.

Honey bee pathology (second edition). Bailey L & Ball BV 1991. Academic Press. London.

Honey bee pests, predators and diseases (third edition). Morse RA & Flottum K 1997. AI Root Company. Medina, Ohio.

Insect pollination of cultivated crop plants. McGregor SE 1976. United States Department of Agriculture. Online updated version at: www.ars.usda.gov/SP2UserFiles/Place/53420300/OnlinePollinationHandbook.pdf

The ABC & XYZ of bee culture (41st edition). Edited by Shimanuki H, Flottum K & Harman A 2007. AI Root Company. Medina, Ohio.

The bee book. Cliff A 2010. Manna Press, Melbourne.

The bee book – beekeeping in Australia (third edition). Warhurst P & Goebel R 2013.

The beekeeper's handbook (third edition). Sammataro D & Avitabile A 1998. Cornell University Press. Ithaca, New York.

The hive and the honey bee. Edited by Graham JM 1992. Dadant and Sons. Hamilton, Illinois.

Online publications

BeeAware

This site contains information about honey bee biosecurity and pollination and is provided by Plant Health Australia. The site provides information about established and exotic pests and diseases of honey bees, and how to identify and respond to them. The site also provides information about pollination and how beekeepers and growers can work together to provide and receive best practice pollination services. Visit beeaware.org.au to subscribe to the BeeAware newsletter.

State and territory Departments of Primary Industries (or equivalent)

These Departments have fact sheets on a range of beekeeping subjects including bee diseases and pests, honey bee colony well-being, honey production and pollination of crops. For web addresses, see above under heading State and Territory Departments of Primary Industries (or agriculture).

Rural Industries Research and Development Corporation (RIRDC)

RIRDC's honeybee web page contains research reports on various honey bee and associated subjects that may be down loaded or purchased in printed form. Visit: <http://www.rirdc.gov.au/research-programs/animal-industries/honeybee>

The following are a selection of RIRDC reports:

Fat bees skinny bees – a manual on honey bee nutrition for beekeepers.

<https://rirdc.infoservices.com.au/items/05-054>

Bee friendly: a planting guide for European honeybees and Australian native pollinators.

<https://rirdc.infoservices.com.au/items/12-014>

Pollination of crops in Australia and New Zealand.

<https://rirdc.infoservices.com.au/items/12-059>

An investigation into the therapeutic properties of honey.

<https://rirdc.infoservices.com.au/items/09-180>

Flowering ecology of honey producing flora in south-east Australia.

<https://rirdc.infoservices.com.au/items/08-098>

Screened bottom boards.

<https://rirdc.infoservices.com.au/items/14-061>

Nosema disease literature review and survey of beekeepers – part 2.

<https://rirdc.infoservices.com.au/items/08-006>

Glossary

Adult bee – fully-developed, bee after emergence from the brood cell.

Apiary – a place where bees and beehives are kept. Also, one or more beehives.

Apiarist – a person who engages in beekeeping (apiculture).

Beekeeper – see apiarist.

Beeswax – wax secreted by the wax glands of the worker bee.

Box hive – an illegal hive consisting of a box, drum or other similar cavity without movable frames and combs in which bees are allowed to establish and build their combs.

Brace comb – spurs of beeswax built by bees linking frames and combs, and the outer comb and the internal side wall of the hive.

Brood – honey bee eggs, larvae and pupae.

Brood nest, brood chamber – part of the hive in which the brood is reared. Usually refers to the lower section of multi-storey hives, but may not be confined to just the bottom box.

Burr-comb – comb usually built between the top bars of frames in the top box of the hive and the hive lid.

Candy – the natural granulation of honey. Also a food for queen bees made from sterilised honey and sugar, or sugar and water.

Cappings – wax caps on brood and honey cells.

Castes – specialised individuals comprising the honey bee colony (that is: worker, queen and drone).

Cell – an hexagonal compartment contained in brood and honey combs. Queen cells are peanut shaped.

Colony – the honeybee community including queen, workers, drones and brood – distinct from the term hive which refers to the domicile of the bees.

Comb – comprises beeswax hexagonal cells constructed by bees on both sides of a midrib (or wax, or plastic, foundation). Used to store pollen, honey and raise brood (hence honey comb, brood comb).

Comb honey – usually newly built comb containing honey in capped cells, not intended for extraction, but sold without alteration in containers to consumers.

DEDJTR – Department of Economic Development, Jobs, Transport and Resources

Drawn comb – comb in which the cells have been completely built or drawn out from the foundation (or midrib).

Drifting – foraging bees returning to the apiary and entering a hive other than its own. This may be caused by prevailing winds and/or lack of landmarks that usually assist bees to find their own hive.

Drone – an adult male bee. Drones are not always present in a colony.

Drone layer – a queen that has lost the ability to lay fertile eggs. All her progeny are drones.

Excluder (or queen excluder) – a device for confining a queen to a particular section of a hive.

Extractor – a machine for removing honey from the comb.

Foundation – a sheet of beeswax impressed with the pattern of bases of worker cells on which the bees build cells and comb.

Frame – a man-made moveable frame in which bees build comb.

Hive – domicile or home of a colony of bees. Strictly, it does not include the bees, brood and comb, but is often used by beekeepers to include the colony (Hence “the hive has swarmed” etc.)

Honey flow – More correctly nectar flow (see nectar flow). A commonly used term.

Larva (plural – **larvae**) – grub, the immature stage of the honey bee life-cycle immediately after hatching of the egg.

Laying worker – worker bee which, in the absence of the queen and her pheromones, is able to lay unfertilised eggs. These develop into drones only.

Migratory beekeeping – system of beekeeping whereby hives are moved from place to place to obtain nectar and pollen flows.

Movable frame hive – a hive that has combs securely fixed in or on frames that can be removed for inspection of brood and honey.

Nectar – a sugary liquid produced by the nectaries of flowers and also extra-floral nectaries that occur outside of flowers in some plants. It is collected by bees, processed and stored in the comb as honey. It is the carbohydrate food of bees.

Nectar flow – a source of nectar available to bees for honey production. A light flow is one where bees gather enough nectar to feed brood but not enough for honey production.

Nucleus – a small colony of bees, usually consisting of three or four frames of bees, queen, brood and honey. Commonly known by beekeepers as a nuc.

Pheromone – a chemical secreted by glands that convey a message to influence behaviour or development of members of the same species.

Pollen – fine, usually powdery, substance produced by anthers of flowers and collected by bees and stored in the comb as bee bread. It is the protein food of bees.

Pollen supplement – a mixture of ingredients used to supplement the protein supply of a colony during a scarcity of pollen.

Pollination – the transfer of pollen from the anthers to the female parts of a flower. Cross-pollination is the transfer of pollen from a cultivar to another cultivar of the same plant species.

Prime swarm – the first swarm that leaves the parent colony. Swarms that issue later are referred to as ‘after-swarms’ or ‘secondary swarms’.

Propolis – a resinous substance collected by bees from plants and used as a cement and caulking compound, primarily to seal cracks in the hive.

Queen – The reproductive female in a colony of honey bees.

Queenless colony – a colony which does not have a queen. The queen may have died or been lost by the beekeeper.

Queen introduction – the process of putting a new queen in a colony of bees.

Rob – removal of combs of honey by a beekeeper from a hive prior to extracting the honey.

Robber bees – bees from a colony that attempt or succeed in entering another hive or stored equipment, including combs of honey waiting to be extracted, to steal honey.

Robbing – activities of robber bees.

Slum-gum – the remains of melted comb and cappings left after the wax has been rendered and mostly removed.

Spring dwindle – the normal drop in population at the end of winter when old over-wintered bees die off and are not yet replaced by newly raised bees.

Supersede – replacement by the bees of an old queen or failing queen with a new young queen raised by the bees of the same colony.

Super(s) – a box, or boxes, above the bottom box of the hive.

Swarm – a settled cluster or flying mass of bees, including the queen, workers and drones that left the parent colony to form a new colony elsewhere. On some occasions, a swarm may be queenless.

Uncapping knife – a sharp, heated knife for removing cappings from honey combs prior to extracting honey.

Uniting – the process of joining two colonies into one. Often one or both colonies are weak.

Worker bee – a sterile female member of the colony that works in the hive, including caring for the young, cleaning the hive, guard duty and also forages for food and water outside the hive or nest.

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