The Basics of Beekeeping

by

Members of Dunblane and Stirling Beekeepers' Association

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Contents

Chapter 1

Introduction — beekeeping, the beekeeper and our bees

1.1 Development of methods of beekeeping

Honey bees in more or less their present form have existed on earth for far longer than human beings. From the very earliest human records there is evidence that men have sought their honey. There are several primitive stone-age cave paintings apparently showing men robbing bees' nests. Some people say they can even see in some of the pictures that the man is carrying a smoking torch — evidence that even at this early date smoke was being used to pacify the bees.

In prehistoric times the discovery must also have been made that if the hollow log containing a bees' nest was moved to a convenient place near home, the bees would continue to live in it, and also that if a swarm of bees was introduced to a hollow log, earthenware pot or straw skep in the evening, there was a good chance that they would set up home there.

All early civilisations in Europe and Asia show familiarity with beeswax and honey. There are many references in the Old Testament. Ancient Egyptian tombs that have been investigated by archaeologists have contained offerings to the dead of both beeswax and honey, remarkably well-preserved, especially the wax.

The ancient Greeks and Romans wrote many treatises on the art of beekeeping, some of which have come down to us. The system they describe is similar to one still practised in parts of Africa and the less well-developed parts of Europe even today, and was almost universal until about 150 years ago.

The bee-keeper using this primitive system starts by capturing a swarm, whose cluster he shakes from its branch into a box or basket, using smoke if necessary to subdue them. In the evening he throws the bees on to an upward sloping board leading up to the entrance to his bee-hive which is merely a hollow vessel of ten to twenty litres capacity, reasonably waterproof, made of wood, straw, pottery or whatever is available. The bees take up residence and the bee-keeper watches over them but does not otherwise interfere.

In their second season it is likely that further swarms will issue from the first stock, which the beekeeper tries to capture, so increasing his number of stocks.

At the end of every summer, the beekeeper assesses his stocks. Those hives which are very heavy with honey and those which are very light and not prospering he decides to sacrifice. Those of middle weight he leaves to over-winter, hoping they will survive till next season.

By the use of much smoke and drumming on the sides of the hive the bees are driven from the hives to be sacrificed and all the combs inside are then removed for harvest. The honey is pressed out, and the residue is melted down for beeswax.

This is a very wasteful system. The best-yielding colonies and their brood-nests are destroyed. The worker bees driven off may gain entry to some of the other hives and supplement their numbers, but often the smoke used in this operation was that of burning sulphur which killed the workers.

In the eighteenth and nineteenth centuries many improvements in agricultural practice were being introduced in Western Europe and America, and those beekeepers who had enquiring minds began to consider how beekeeping might also be improved. Such improvement depends upon accurate knowledge of the needs and behaviour of the species being cultivated. This knowledge about bees was growing fast at that time.

The first systematic account of honey bees we have is that of the Greek philosopher Aristotle of about 350 BC contained in his works on the "Natural History of Animals" and "Reproduction of Animals". He distinguishes the drones, the workers and the queen and speculated that the queen might be female and the drones male. But as the mating of the queen and drones had never been observed, he remained doubtful about how bees reproduce, and in the end went along with the common male chauvinist line of his day that the bees were ruled by a king. This wrong belief about the sex of the queen persisted till the seventeenth century. Aristotle also noted the division of labour among the workers, and described swarming, although he could not explain it. He also noted how the workers carry "bee bread" — pollen — in the pollen baskets on their hind legs, and how honey is ripened by the worker bees. He also knew that a queenless stock becomes full of drones but could not account for it.

The sex of the "king" was questioned in 1586 by Luis Mendes de Torres of Spain who said she was the mother (a most accurate name) and in 1609 Charles Butler in England described in his work "The Feminine Monarchie" how the queen laid eggs. The date is just after the death of Queen Elizabeth I of England. In 1686 Swammerdam in Holland settled the matter by dissecting queens and drones using the newly invented microscope. He also showed that workers and queens are produced from the same eggs by the feeding of the larvae, as he got worker bees to raise queens from worker eggs placed in queen cells by him — a result confirmed in 1855 by Leuckart in Germany.

In 1730 de Réaumur in France and independently in 1792 John Hunter in Scotland discovered the spermatheca of the queen bee. In 1845 Dzierzon discovered parthenogenesis — the origin of drones from unfertilised eggs. Thus by the mid-nineteenth century a fairly complete picture of the biology of honey bees was available.

The practical question of how to manage bees without having to kill off stocks was now addressed. The main difficulty was how to remove some of the honeycomb from the bees without disrupting the hive to such an extent that it could not survive the winter.

François Huber, a blind beekeeper in Switzerland, had constructed in the eighteenth century an elaborate "leaf" hive which could be opened for investigation, and Hunter in Scotland made a hive in sections separated by a division board. These were experimental rather than practical however.

Wildman in England in 1773 designed a hive with combs built on wooden frames, and Kerr in Ayrshire in 1819 invented the "Stewarton" hive on a similar principle but with a separate top box like John Hunter's hive, that could be removed with its honey while leaving the brood-nest below intact.

The problem with all these initial designs lay in how the bees treated them. All cracks and crevices less than 6 mm ($\frac{1}{4}$ in) in width in a bees' nest are quickly filled by the bees with *propolis* — first described and named by Aristotle — a sticky mixture of resin collected by the bees with beeswax. It forms a very effective glue. Larger spaces are filled by the bees with comb in times of prosperity. Thus all the neatly fitting parts which went together so easily have to be separated with hammer and chisel and much loss of temper by bees and beekeeper.

In 1851 the Reverend Lorenzo Lorraine Langstroth in America, building on Dzierzon's observations that the spaces left by the bees between their combs were about 6 mm ($\frac{1}{4}$ in) wide, proposed that if a "bee space" of this size was left between all separable parts, the bees would leave them free. He then designed on this principle a hive with movable wooden frames in which the bees would build their combs, basically the modern Langstroth hive, which is still in use with some simplifications. As Wedmore says in his book, this invention was treated like so many others as "*not good, then not new, then not invention, a thing anyone might have done, and [was] then brought into general use*". It is no exaggeration to say that modern beekeeping practice is totally dependent on Langstroth's observation which turned out to be more or less completely correct, although sometimes bees seem to forget it, and a fair bit of ungluing is needed!

Four other inventions play a major role in modern beekeeping:– the modern smoker invented by

Quinby in the USA in 1866, the queen excluder invented by the Abbé Colin in France in 1849, embossed beeswax foundation by Kretschmer and Mehring in Germany in the 1850s, and the centrifugal honey extractor invented by Hruschka of Austria in Italy in 1865.

How all these inventions are used will be described later.

The most complete and up-to-date account of the development of methods of beekeeping is "The World History of Beekeeping and Honey Hunting" by Eva Crane *(Duckworth, 1999).*

1.2 What is needed in a beekeeper?

The qualities which are needed in someone who is to be a successful beekeeper can be arranged under several headings.

- **Physique**

  Beekeeping involves the lifting, carrying and gentle handling of awkward heavy boxes weighing up to 30 kg (60 lb) in round figures.

- **Access to a suitable site**

  Traditional requirements for an apiary site are: open sunny location but with some shade; ready access to clean fresh water for the bees (within 200 metres or 200 yards); the presence of ample amounts (many hectares/acres) of suitable foraging plants within 2 km (1 mile) — see later in this chapter. Of equal importance these days are protection from vandalism and screening (by hedges or distance) from neighbours who may be frightened of bees and complain if they are stung when bees are out of temper.

- **Available time**

  The keeping of even a few (3 or 4) stocks of bees demands roughly one afternoon a week during the active season from April to August. Bees given less attention than this will yield less well and may become a liability. In addition a fair amount of time will be required in August-September to process the honey crop. If heather honey is sought, more late season (August-October) work is involved. Bees satisfactorily bedded down for winter need very little attention from September to March — mainly an occasional glance to ensure that hives have not been disturbed by the weather or by vandals. Additional winter tasks are regular checks to ensure bees are not running short of food. Some types of control measures for the *Varroa* mite are best carried out in winter at one dedicated visit, if the beekeeper decides to use one of these: see later on pests and diseases.

  Obviously keeping bees on a larger scale requires proportionately more effort.

- **Inclination and enthusiasm**

  There is no point in beginning to keep bees unless you are interested. Many beekeepers (including myself) enjoy working with bees in a small way and getting enough honey for family and friends. Others like the harder challenge of trying to make a small supplementary income by keeping 20 or more stocks, and selling honey either direct retail or selling to shops (which must be allowed a generous mark-up and so will not pay so well).

  Those who keep 40 or more stocks are aiming to make a significant part of their income from their bees. It is a hard and demanding occupation on this scale and the return is very uncertain, being dependent on weather and fluctuating honey prices which naturally fall during glut years. Competition from imported honey from countries with easier climates than ours — Mexico, Australia, etc. — limit the income that can be made. The *average* annual yield per stock in Scotland is around 15 kg (30 lb), and the wholesale price of Scottish honey in 2017 was about £5.00 per lb, so the basis of calculation is fairly clear. The provision of a pollination service to fruit growers and other farmers can help the commercial beekeeper to make a more reliable income. However if you are thinking of beekeeping on this scale, don't forget the overheads and inevitable costs!

In Scotland there are a very few people who can genuinely be classed as bee farmers. These are people who choose to make their principal livelihood, or at least a large part of it, from beekeeping. This involves keeping many hundreds of stocks of bees, and being knowledgeable and careful about making efficient use of the limited time that can be devoted to each individual colony. On this scale also it is worth the large outlay of investing in industrial-scale equipment for the extraction and bottling of honey, and for moving hives. Great care needs to be given to the siting of apiaries and stocking them to an appropriate level, so that no area is over-populated with your honey bees. After all they cannot get more honey from a district than is available from the flowers that grow there. It is no use having your own bees competing to the death with one another and starving in consequence. That kind of beekeeping in my view should only be undertaken by someone who has been trained for it by working on a bee farm, so that the methods and hazards are explored before the big investment decisions are made.

- **Some modern problems beekeepers must face**

  Bees have been much in the news in recent years because keeping bees is now more difficult than it was when I began. Some of the reasons are outlined below.

  - **Exotic pests and diseases and using local bees**

    In the globalised world of today, bees are frequently traded over large distances. The result is that not infrequently exotic pests and diseases have been introduced to places where the local bees have never met them before. This is frequently devastating for the local bees which have no genetic resistance to these unfamiliar enemies. In addition the cross-bred bees which arise in later generations are all too often cross in another sense as well, and unpleasant to handle, and are sometimes ill-adapted to the climate they have been introduced to.

    For these reasons, it is the policy of our local association to encourage all in our area to work with locally sourced bees. Our Association does its best to breed new stocks in sufficient numbers to meet the demands from new beekeepers, and from others who have had the misfortune to lose their bees over-winter. We hope that those of you who become beekeepers will wish to follow this route.

  - **Dealing with pests and diseases**

    Unfortunately we have to deal with those new pests and diseases which are with us now. The worst new one, which has been with us here since 2001, is the *Varroa* mite. You will learn about this later in this course. But there are other diseases as well.

    All these problems mean that we sometimes have to apply chemical treatments to our bees, and it is important that when we do so, we do not endanger either our bees, or ourselves, or those who eat the produce of our bees. All medicaments that are used must be safely and legally handled. We shall later be telling you how to do this.

    In addition in order to avoid spreading disease around, since 2009 when major outbreaks of two older diseases occurred, we have had to become much more disciplined in taking precautions to avoid the risk of spreading any outbreak which is found from one apiary to another. This will be dealt with when we speak later about apiary hygiene.

1.2.1 Stings

All worker and queen honey bees have at their tail end both an ovipositor for laying eggs and a sting. Beekeepers are inevitably stung from time to time, and need to know how to deal with the problem.

The queen has an unbarbed sting which she never uses except in fighting a rival queen. She mainly uses her ovipositor. Workers normally do not lay eggs, but the worker's sting is a sophisticated barbed weapon which is highly effective against large animals like human beings, for which the stealing of the nutritious honey store is an attractive idea. Bees away from home only sting if they are crushed or hit. Near home, if the alarm is raised, they can become extremely aggressive. Any vibration or waved arms will arouse them at the end of summer when they have much to defend. Hair-spray smells, sweat or whisky breath are also attacked.

The scent of one sting attracts more bees to the attack and the result can be unpleasant and dangerous if you are unprotected. The sting is usually left behind by the bee when she tears herself free, and continues to inject venom by reflex action for up to half an hour. The bee herself dies.
If you are attacked when without protective clothing then:–

- Move away from the colony site/beehive quickly and quietly.
- If bees continue to follow you, go under trees or go indoors.
- As soon as practicable remove the sting by *scraping* it out with a finger-nail or other tool: do not pinch it out or you will inject more venom.
- Do not return to the site without protective clothing or you *will* be stung again.

Most people when stung experience a sharp pain immediately, but if the sting is promptly removed they suffer no further ill effects apart from inflammation and itching of the place for a day or two afterwards. Many people are unreasonably frightened of being stung by bees. There can very occasionally be serious consequences, but it is important to keep a sensible view of these risks.

Modern advice on stings from the book by Harry Riches

There are many old wives tales about how to deal with stings, but an excellent and up-to-date explanation for the layman of the medical risks involved is *"Medical Aspects of Beekeeping"* by Harry Riches, MD, FRCP published by Northern Bee Books in 2000. Dr Riches is himself both a doctor and a beekeeper and ex-President of the British Beekeepers' Association who dealt with his own allergy to bee-stings with complete success. I would recommend anyone worried about stings to read this book, but below is a summary of his main recommendations.

- A severe stinging, involving the reception of many hundreds of stings is a potential hazard to life for anyone, but no beekeeper should ever be in danger of that provided sensible precautions are taken when handling bees.
- Being stung inside the mouth (involving the danger of suffocation due to swelling of the throat) or being stung in the ball of the eye (involving possible loss of the sight of the eye) are hazards that should be avoided by always wearing a veil when handling bees. Incidentally a bee which gets *inside* a veil hardly ever stings. She is always in a panic to get out!
- Normally a sting, if promptly removed, gives a sharp pain initially, which subsides within a minute or so, followed by slight itching for a day or so afterwards. The use of antihistamine cream for this itching is not recommended as it can sometimes set up a dermatitis. If the itching is troublesome, Dr Riches recommends the use of a cold compress or calamine lotion. Most beekeepers do not use anything, as to most people it is less bother than a nettle-sting.
- When a beginner starts to keep bees, the first sting or two provoke little reaction, but a minority go on to experience occasional quite severe swelling locally. Usually this simply subsides after a time as they develop an immunity mediated by the IgG immune response, and thereafter experience little trouble from the occasional sting. If the local swelling is troublesome, Dr Riches recommends taking an antihistamine *tablet* (Piriton (chlorpheniramine)), available over the counter from pharmacists, an hour or so before working with the bees. This can cause drowsiness which can be dangerous if you are going to drive or work with dangerous machinery of any kind. A slightly more expensive alternative in

that case is Zirtek (cetirazine), which is less likely to cause drowsiness. Of course before taking any medication you should ensure that you do not suffer from any medical condition that might make it dangerous. Read the instructions!

- A small minority of people develop a severe allergy to bee-stings mediated by the IgE immune response. This can lead to an extremely dangerous anaphylactic reaction in this minority, with breathlessness, nausea, sickness and fainting. Such a reaction must be regarded as a medical emergency, and hospital help sought urgently, since people can die of anaphylactic shock.

- If people who develop a severe allergy to bee-stings wish to continue to work with bees, then immunotherapy with pure bee venom is recommended. This involves a course of hospital administered injections with slowly increasing doses of bee venom following a careful program. Successful completion of such a treatment renders people more or less normal in their reaction to stings, though it is recommended that they should try to get stung once a week or so to keep their IgG immunity levels up. Unfortunately this treatment is not usually available on the NHS! Again the use of an antihistamine tablet before visiting the bees is recommended.

- For a fuller exposition, consult *"Medical Aspects of Beekeeping"* by Harry Riches MD FRCP published in 2000 by Northern Bee Books (ISBN 0–907908–94–2).

1.3 The place of the honey bee in nature

The scientific classification of living creatures initiated in the eighteenth century by Linnaeus places honey bees in the scheme (which is now tied to Darwin's theory of evolution) like this:—

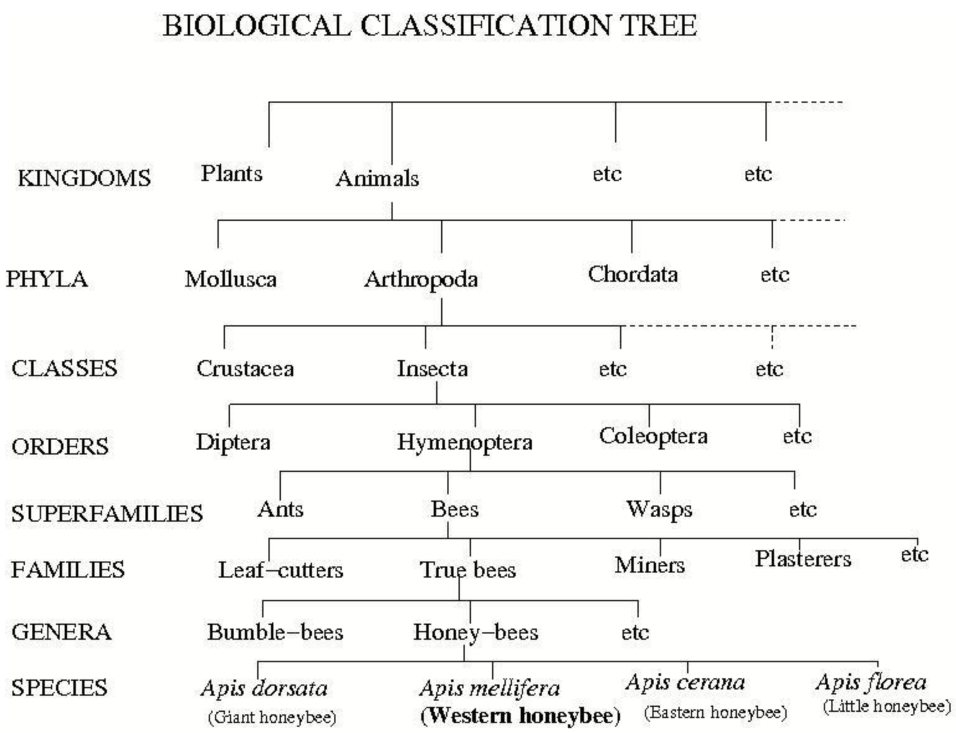

Figure 1.1: Biological Classification Tree

In the fossil record the *hymenoptera* first appear about 150 million years ago in the Jurassic period, or, as some others claim, 225 million years ago in the Mesozoic period. Bees first appeared about 26 million years ago, at the same time as the majority of flowering plants. This is no coincidence. Flowering plants need a mechanism whereby the pollen (male reproductive cells) can be transported to another plant of the same species to fertilise the female reproductive cell and form a fertile seed. Many plants use the wind, notably most of the grasses, which is why their pollen is such a common cause of hay fever. But many insects feed on plants, and their ability to move from plant to plant has allowed the plants to evolve flowers with *nectaries* which secrete the sugary fluid nectar as a deliberate attractant for the insects. The pollen which is dusted on to the feeding insects is then spread by them from plant to plant, as the plants require.

Nectar is an excellent source of carbohydrate (energy food) and pollen itself is a source of protein (body-building food). The bees and the flowering plants have thus evolved in co-operation with one another. The bees have specialised in exploiting this food source, and live solely on these plant products. Some of the plants have in turn come to rely ever more heavily on such systematic visitors as the bees, and will completely fail to set fertile seed unless they are visited by bees. There is a double cost involved for the plants. First of all the production of nectar involves using up energy which could have been spent in other ways, and secondly there is a risk of failure to set seed if bees do not visit. But these plants find these costs worth paying for the generally reliable pollination service provided.

An example of this plant specialisation is provided by plants of the pea family, the most obvious one locally for our bees being the broom, whose flower relies entirely on being "tripped" by a bee in order to be fertilised.

Among the ants, wasps and bees it is remarkable that from the original solitary forms, socially organised species have evolved in all three superfamilies, with remarkably similar forms of social organisation. The ways of life of these super-families are however fundamentally different. The ants in general are eaters of a wide variety of foodstuffs, although individual species of ants have specialised in many remarkable ways. Wasps (and hornets) usually feed on other insects (or other forms of animal food). Bees, as stated above, specialise in one particular form of plant food. There are exceptions to these general rules in all the superfamilies.

Solitary wasps and bees of numerous species exist. Their general life pattern is that the female after mating prepares a nest, often in an underground burrow, which she stocks with sufficient food of the appropriate kind, and on it she lays her eggs which she then abandons. The females of many species of solitary wasps use stings associated with their ovipositors in this process to paralyse but not kill insect food left for their young. This is perhaps the most likely evolutionary origin of the sting present in most wasps and bees. There may be one nest with several eggs, or several nests with one egg each. The eggs hatch into larvae or maggots which live on the food provided, and after growing to adult size pupate — form a chrysalis like a butterfly's. From these the adults of the next generation emerge in due course.

An intermediate stage of social organisation is exhibited by the bumblebees and by the familiar wasps we all know and (generally) hate. A queen (female) which, after mating at the end of the previous summer, has hibernated alone in a sheltered spot throughout the winter, finds a suitable site in the spring. There she builds a small nest in which she lays a few eggs. She herself brings food to the developing larvae, and feeds and tends them. These emerge as sexually imperfect females called workers, who then take over the nursery and feeding duties, the queen confining her activity after that to the laying of ever larger numbers of eggs in a nest which is steadily expanded by the increasing number of workers. At the end of the summer a special generation of eggs is laid by the queen which emerge as sexually mature males (drones) and females (queens). These fly from the nest and mate away from home, thus avoiding close in-breeding as far as possible as mates from other nests will also be available. The rest of the colony then goes into decline and dies out. It is at this stage that the worker wasps cease to hunt for insect food and become a nuisance to us as in their dying days they seek to assuage their discontent with our plums, pears and jam.

The honey bees, like the ants, have taken social organisation a stage further. They almost certainly evolved in the tropics and subtropical regions, the only regions where the giant honey bee and the little honey bee are found. They store large amounts of honey, which is derived from nectar by a process of concentration and partial digestion. This stored food enables their colonies like ant nests to be perennial.

Instead of individual queens founding new colonies, these are produced from the old one by the process known as *swarming*. The giant and little honey bees have nests consisting of a single comb containing both honey stores and developing bees. Both the western and the eastern honey bees have larger nests — much larger in the case of the western honey bee — of many parallel vertical combs. The amount of stored honey frequently reaches 50 kg (100 lb) or more. This feature has enabled the western honey bee (with the assistance of humans) to extend its range from the tropics to the sub-arctic regions. It has also made it worthwhile for people to exploit it both for its yield of honey and for its unequalled usefulness as an agricultural crop pollinator, since honey bees can be available in reasonably large numbers to pollinate even the earliest spring flowers.

The details of the life-cycle of the western honey bee colony as it has been elucidated by many people over the centuries are explained in the later chapter on bee biology.

1.4 Significant bee forage plants in our Association area

Gardens in small towns in Scotland contain a wide variety of flowers, many of which are valuable bee plants. However it is only when large acreages are available that they make a significant contribution to the honey crop from a colony of bees. For this reason I mention very few of such plants in the table below, and instead concentrate on those plants which are of such wide occurrence that they can be more or less guaranteed year after year to make a useful contribution.

One crop in particular, namely Oil Seed Rape, was in the 1980s and early 1990s very widely cultivated throughout Scotland, and transformed honey yields. To a large extent it compensated for the loss of what used to be a major source, namely large amounts of wild white clover in grazing land, much of which has disappeared due to the widespread use of artificial nitrogenous fertilisers on grassland. Because of reductions in subsidies, the cultivation of oil-seed rape declined locally from the mid 1990s, and tree sources such as sycamore and lime became of greater importance. Within the last few years however growing of oil-seed rape locally has again started to increase, so if you are fortunate enough to be near fields of oil-seed rape, a crop is more or less guaranteed. In late summer a recently arrived plant, Himalayan balsam (which is classified as a harmful invader!), is proving to be a valuable new late season source for bees where it is present. If you have it, you will know, as foragers returning from it have a very distinctive streak of white pollen all down their backs, so that they don't even look like honey bees any more.

Season	Primary sources	Secondary sources
Very early (March/April)	Willow, wild cherry	Dandelion, gorse
Early (May)	Sycamore, autumn-sown Oil Seed Rape	Broom, hawthorn, gorse
Mid-season (June)	Raspberry, spring-sown Oil Seed Rape	Cotoneaster
High season (July)	Clover, lime tree, rose bay willow herb (fireweed)	Bramble etc.
Late season (August)	Heather (if you take bees to moor)	
Very late (Aug/Sep/Oct)	Himalayan balsam (a useful new arrival)	Ivy

Note that this table has been compiled from experience in the Dunblane area. If you live elsewhere, then some of what is shown here may be lacking, and you may have other sources which are not shown here. It is up to you to explore the flowers of your own area. Your bees will open your eyes to aspects of the flowering scene which you never saw before.

The COLOSS international bee monitoring organisation ran a Citizen Science Investigation into pollen availability from 2013 to 2016. It ran in Scotland from 2014 to 2016 and detailed results from that are expected to become available soon. They may well reveal unexpected aspects of what Scottish honey bees are foraging on.

Chapter 2

Beekeeping Equipment

In this chapter I shall not try to explain all the possible uses of all the types of equipment available, but will try to deal with just those which are the essential everyday tools of the beekeeper and to explain how they work.

Apart from one diagram, all that these notes contain are verbal descriptions. Try to ensure that you have the opportunity to see and handle as much equipment as possible before you are dealing with bees as well.

The equipment dealt with here in detail is grouped under three separate headings:– (1) beehives and their accessories, (2) protective clothing to prevent stings, (3) tools used in opening, inspecting, manipulating and transporting hives. These are all that a beginner needs to start with.

Two further groups, namely (4) equipment used in handling the crops of honey and beeswax, and (5) miscellaneous and specialist items will only be briefly dealt with. Very little of this is needed by a beginner, and so it is well to wait a while before deciding how much of this more specialised equipment you need if you do decide to become a beekeeper.

2.1 Beehives and their accessories

2.1.1 Introduction

Most modern beehives follow more or less closely the pattern of the original Langstroth hive as it has been simplified by commercial beekeepers. This simplified Langstroth pattern itself is in very widespread use throughout the USA, Canada, Australia and New Zealand.

In the UK however a different size of wooden frame in which the bees build their combs has become the British Standard, and the great majority of hives in use in Britain are designed round this frame size. In addition the design of honey extractors most commonly sold in Britain are for the British Standard frame. For this reason my advice for beginners here is to use a type of hive designed for this size of frame.

Too many different patterns of beehives are readily available on the market in Britain. All are equally well liked by the bees, but different beekeepers all swear by their own favourites. The problem they cause is that parts from one type of hive will not fit another type.

The one crucial piece of advice about them to intending beekeepers is to CHOOSE ONE READILY AVAILABLE TYPE, THEN STICK TO IT AND REFUSE ALL OFFERS OF INCOMPATIBLE EQUIPMENT. The essence of modern beekeeping practice as initiated by Langstroth is complete flexibility, allowing boxes or even individual combs to be transferred between hives. Any mixed equipment will tie your hands and be a source of frustration.

The most commonly used patterns in our area are the British (Modified) National hive made of wood and the Smith hive made of wood. The Smith hive, designed by Willy Smith of Innerleithen, has been very popular in Scotland, but as the National hive is being deliberately promoted by Thornes, one of the main local beekeeping equipment suppliers, the popularity of the Smith hive is waning.

The National hive is also available in polystyrene. The main advantages of polystyrene over wood are said to be:–

- its superior insulation leads to more prosperous colonies with fewer winter losses;
- it is lighter;
- the boxes are easier to assemble.

Its main disadvantages are said to be:–

- it is more expensive to buy;
- it is less long-lasting and is quite easily damaged;
- polystyrene roofs are so light that they must be weighted down or they will blow away in the wind;
- boxes cannot be disinfected by scorching the interior with a blowlamp;
- the exteriors of all polystyrene boxes must be painted, whereas wooden hives, if made of western red cedar, will last for many decades unpainted.

However National polystyrene hives are compatible in all dimensions with National wooden hives, so a decision to use one material does not preclude later experimentation with the other.

I shall therefore present this section in terms of the National hive made of wood. Descriptions of other types available, their history, and their characteristics are dealt with in the Appendix at the end of this chapter.

2.1.2 The National hive and its accessories

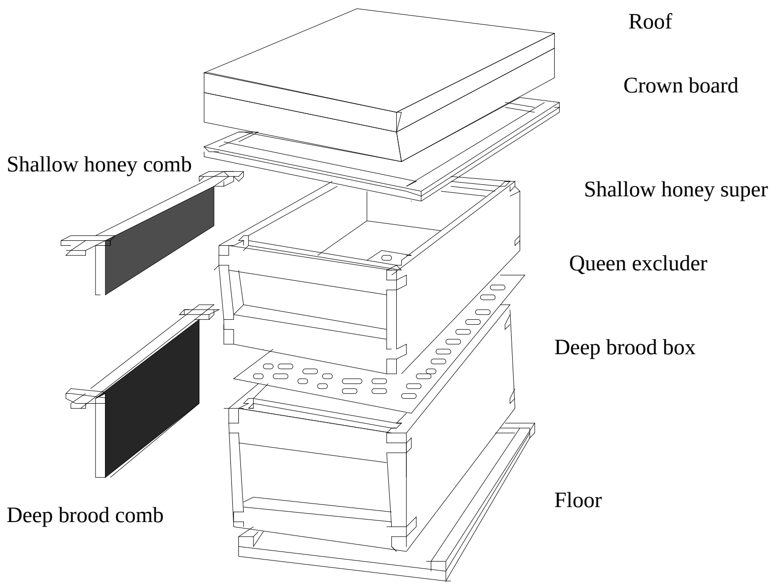

Figure 2.1: Picture of the main features of a National hive

A National hive is illustrated in Figure 2.1 and consists of a *floor*, which is a rectangular board (or nowadays often a bee-proof rectangular metal mesh screen as an anti-*Varroa* measure — see Chapter 6), with raised $\frac{1}{2}$ inch (about 13 mm) wooden cleats on three of its four sides, the fourth open side providing an entrance slot, the outer dimensions being 460 mm ($18\frac{1}{8}$inches) square; one or more *brood boxes* which are simple square wooden boxes of the same outer dimensions without top or bottom, having rebates in the top edges of a pair of opposite sides to hold the ends of the top bars of the carefully dimensioned wooden *frames* in which the bees are guided to build their combs. These boxes simply stack one above the other. There may also be one or more shallower *honey supers* of the same basic design as the brood boxes; the boxes will be topped with a *crown board*, which is a flat board to cover the topmost box which has 6 mm ($\frac{1}{4}$ inch) cleats round the edge to give a bee space above the frame tops, and usually has one or two feed/bee-escape holes cut in it; and finally a *roof* with sides which fit down over the topmost box for security against wind, and which is covered with roofing felt or metal to make it weather-tight.

Most beekeepers will also use a *queen excluder* — either a sheet of slotted metal or plastic, or a frame of accurately spaced wires — which can be laid to fit exactly between two boxes. The slots are just wide enough for worker bees to pass through, but prevent the passage of queen or drones which are larger. Those honey supers above the queen excluder remain entirely free of brood — developing young bees — which simplifies harvesting at the end of the summer.

There may also be a wooden *entrance block* with a cut-out at one edge to allow the size of the entrance to be reduced when this is advisable or to be closed completely for transporting the bees if necessary.

It is also essential to have a *mouse-guard* for each hive, to prevent mice gaining access during the winter.

Feeders are also available to give supplementary feeding of sugar syrup in autumn to those stocks which have been left after harvest with too little honey to see them through the winter, or to those stocks found in spring to be dangerously near starvation, or as a boost to a newly established swarm. There are two basic designs, *contact feeders* which slowly drip feed syrup through the perforated lid of the inverted feeder, and *rapid feeders* which allow access to the surface of a large volume of syrup through a *narrow* slot, so the bees do not drown themselves in the syrup. All contact feeders have to be enclosed by an empty super, as do some rapid feeders, though the *Ashforth* and *Miller* designs are of the size of a hive box, and simply sit above the top box of the hive under the crown board. At least one feeder per two hives is needed.

Painting hives

Hive boxes of single-walled wooden hives should not be painted with standard outdoor paint because the damp from within sweats through the wood and causes the paint to blister. Polystyrene hives however (unless supplied pre-painted) must be painted after assembly on the outside with exterior masonry paint.

An alternative for wooden hive boxes is to treat them with a wood preservative such as Cuprinol but **MAKE ABSOLUTELY SURE THAT IT IS NOT A BRAND CONTAINING INSECTICIDE AS A PROTECTION AGAINST WOODWORM**. Remember that bees are insects! Thornes and the other beekeeping equipment dealers sell a kind which is suitable.

Hive boxes made of Western Red Cedar do not need treatment since they are resistant to the weather for many years without treatment, provided they are not allowed to remain damp.

Frames and foundation on which the bees will build combs

The frames for the bees to build their combs in, of whatever design, are best bought in pieces for assembly at home.

The cost of each frame is currently about £1.30 (2017 prices) for deep frames (DN1) and shallow frames (SN1). However before it is used, each frame must be fitted with a sheet of wax foundation which costs between £0.60 for shallow frames and £1.00 for deep frames. The foundation is what induces the bees to build their combs inside the wooden frames as we choose, rather than where they choose which might well be spanning several frames, making it impossible to withdraw combs, and defeating the whole Langostroth idea. Foundation is cheaper bought in bulk.

In the brood box *wired* BS Deep foundation is advisable for strong brood combs. In the honey supers BS shallow wired foundation for strength in extracting honey may be used, or, if producing cut comb honey where comb and all is eaten, *thin unwired super* foundation should be used. The thin unwired is cheaper, but has to be replaced each year, whereas the combs should last quite a few years if extracted carefully on wired foundation.

Frames must also be spaced properly within the boxes. In the brood box spacing of DN1 frames is by *plastic ends* or achieved by using self-spacing Hoffman (DN4) frames which are a little dearer.

In the shallow supers the choices are SN1 frames spaced by plastic ends, Manley or Hoffman self-spacing frames, or the fitting of *castellated runners* to the supers.

Tools for removing honey from the hive

When the bees have filled the combs in a honey super with fully ripened honey, the bees have to be separated from the combs before the box is harvested. The usual way to do this is to use a *clearer board* fitted with *Porter bee escapes*, and placed below the honey super. The Porter escapes are one-way valves allowing the bees to go down out of the super to join the queen, but not to return. The top of the box must also be made bee-proof however, with a spare crown-board or a *travelling screen* — a mesh cover to replace the crown-board giving full top ventilation necessary when a hive is closed for moving — or the bees will rob the honey for their own use if they can, and do it surprisingly quickly too! Clearer boards must not be left on hives for more than a couple of days at most, or bees will invariably find a way to rob the honey.

What makes up a complete hive?

What constitutes a single hive? The whole point of the modern system of beekeeping is that all parts are interchangeable. A basic hive however, as shown in Figure 2.1 will consist of a floor, a deep brood box, complete with frames fitted with foundation (or perhaps with drawn comb), a shallow honey super, also complete with frames and foundation, a queen excluder, a crown board with holes to double as a clearer board and feeder board, a travelling screen, and a roof. In addition there should be in reserve for each hive (or at least for each two hives) a second deep brood box and a second super each complete with frames and foundation. As extra equipment I would want to have one spare roof, floor and crown board. If you do not have this, what will you do when you take that swarm in the summer?

All this could be expensive if bought new, although quite generous discounts are available to DSBKA members who make use of our bulk purchase arrangements. Boxes, crown boards and roofs *may* occasionally be available second-hand. If you are worried about perhaps buying in disease, these items can be disinfected by carefully scorching with a blowlamp. Because of the risk of disease, I would *not* use old second hand combs or even frames in a hive freshly stocked with bees, but use these instead as excellent kindling for a fire. If you have some joinery skills it is perfectly possible to make satisfactory Smith boxes at home, and crown boards and floors are simple. Even roofs are not too hard to make. The new type of open mesh floors can also be made fairly simply, though the metal mesh for them needs to be bought. That is now not too expensive however. Cutting plans for most of the standard hive types are now available in the downloads section of the Scottish Beekeepers' Association's Internet web site at

`http://www.scottishbeekeepers.org.uk/`

You will also need at least one feeder per two hives and Porter bee escapes or rhomboid escapes for the clearer boards. To space the frames you need an adequate number of plastic ends, or Hoffman converter clips, unless you use Hoffman or Manley self-spacing frames. One mouse-guard per hive is also essential, and is a fairly cheap item, though entrance blocks with a *narrow* entrance slot can be used instead *provided they are in good condition.* If in doubt use a mouse guard.

In brood frames full sheets of preferably wired foundation are needed for straight and strong combs which permit satisfactory inspections.

In supers where honey for extraction and bottling is the method of harvesting, wired foundation is also best. But if cut comb is to be produced then *thin unwired* foundation should be used, which is cheaper but which has to be replaced each year. See later in Chapter 8 for details.

2.2 Protective clothing

Although the choice is varied, it is not so crucial to make the right choice and stick to it. To work bees with confidence it is essential to feel adequately protected, and it is not hard to obtain clothing that will under normal conditions keep all stings at bay. Note that this is NOT a licence to ill-treat your bees, nor is it a guarantee that you will not be stung. In fact I can guarantee that if you keep bees for long, you certainly WILL be stung. But it will be your own fault when it happens, and you certainly need never get a severe stinging unless you are careless.

A well-fitting hat-and-veil or helmet-and-veil combination to protect the head and neck is the basis of the armoury, backed up by some form of overall or bee suit, which also keeps your other garments clean from honey, wax and propolis. An alternative is a full bee suit with a veil incorporated into it.

Cost can range from that of a full Sherriff bee suit currently (2017) around £140 to the Occasional Hat and Veil on sale until recently at Thornes sale days for £5.

The choice of gloves to protect the hands is less easy to advise on. Because of present-day concerns about apiary hygiene (see later in Chapter 6), it is not acceptable to wear leather gloves with elasticated gauntlets that cannot be disinfected adequately, if you are visiting any apiary other than a single apiary of your own. For this reason, most beekeepers in our area are now getting used to wearing disposable thin nitrile gloves which at about 25p for a pair can be discarded after a single use. Provided your bee suit has tight elastic at the wrists, bees cannot get up your sleeves and the protection you get is adequate. Slightly thicker rubber household gloves are an acceptable alternative, but in visiting someone else's apiary new clean gloves must be worn. It is perfectly possible to handle bees with bare hands without getting stung, but thin gloves to prevent getting hands dirty and sticky with propolis and honey is a good idea.

A pair of wellingtons to protect the ankles completes the outfit.

2.3 Tools for working with bees

The *smoker* and the *hive-tool* are the two things that are never long out of the beekeeper's hands when hives are being visited.

A *copper*, *stainless steel*, or *galvanised* smoker, well cared for, will last for twenty years or more. The prices are now almost the same for all these materials. The larger sizes require more fuel to start them off, but burn longer without re-fuelling if many hives have to be inspected.

The *hive tool* is used as a lever, hook, scraper, screwdriver, and even hammer when need be. The traditional design has a blade at each end, one being turned over at right angles to the main shaft. A more modern design where one end is a hook-shaped frame-lifter can be good for freeing an obstinate first frame jammed in a box. I find both designs satisfactory.

Get one painted a good bright colour (or paint it so yourself) or you will lose it in the grass, on the hive roof, under your tool-box etc. ten times in one afternoon — the authors speak from experience. Without it propolis will beat you. With it you can keep propolis at bay.

If you intend to transport hives, note that it is really a two-person job, and if you cannot get a *hive-trolley* near your hives, then a pair of *hive carriers* makes that unpleasant lifting job just about bearable.

A few simple joinery and general tools such as a ruler, a set-square, a hammer, a screwdriver, a saw and perhaps a chisel will let you do routine assembly, maintenance and repair work. If you are more ambitious and wish to build your own hive, than a rebating plane and some form of jig-saw will be needed. Making your own frames is not recommended unless you are a dedicated joiner. It is of course helpful to have access to a good work-bench for joinery work.

2.4 Equipment for handling the crops of beeswax and honey

When harvest time comes at the end of the season, after the bees have been separated from the honeycombs that you want to harvest, by using a clearer board either with Porter escapes or of some other form, as described above, in your first season it will probably be simplest for you to go for cut comb honey. In this way you will have no need to consider a honey extractor, or any straining and settling equipment, and you will have no beeswax to process. An extractor is a major outlay, particularly now that stainless steel or food grade plastic is the required material for its construction. Dunblane and Stirling Beekeepers have two for use by members, as well as two small presses for processing ling heather honey.

If you do extract honey, then as well as an extractor you will need strainers and a settling bucket fitted with a tap, and possibly also additional storage buckets. You will also need honey jars and labels which conform to the honey regulations.

Various patent devices are available for processing beeswax, but on a small scale an ordinary kitchen double boiler is helpful.

Small moulds for casting blocks of wax can be bought, but wax can be cast into a block in a pie dish or pyrex bowl with sloping sides.

Preliminary washing of honey residue from wax before it is melted down can be done in a washing-up bowl, and the washing water then strained off through an ordinary kitchen sieve or strainer. For those who wish to try making mead, the strained honey from wax cappings is usually a good starting point.

2.5 Miscellaneous and specialist items

Special marking pens for marking queens with a dab of paint on the back of the thorax can be obtained, although this is not necessary, since the bees always know where the queen is, even if you don't. However it is sometimes very useful to be able to spot her easily. In order to trap the queen for marking, a *"crown of thorns" queen marking cage* with pins for inserting into the comb where she is found is a useful and fairly cheap accessory.

One or two *nucleus boxes* which are miniature hives taking 5 or six brood frames only are convenient for rearing new queens. *Mini-nucleus boxes* in plastic with miniature frames are not too expensive, and are used to try to ensure the quick mating of newly reared queen bees, but this is probably not a beginner's job.

There are plenty of other goodies to be seen in the catalogues of the appliance dealers, but in my view most of the essentials and some useful extras have been listed above.

2.6 Appendix — other hive designs

2.6.1 Introduction

Above only the (Modified) National hive was described in detail. Other hive designs, some still available, and the Smith hive (a viable alternative to the National for a beginner), are described here.

2.6.2 The (Unmodified) National hive and the Wormit Commercial hive

Several Langstroth-type single-walled hives have been designed around the British Standard frame. The original (Unmodified) National hive, which was at one time adopted as the British Standard Hive had thickened double front and back walls to its boxes to accommodate the long top bars of the British Standard frame. A close relative is the Wormit Commercial Hive designed by the Appliance Dealers Messrs. R. Steele and Brodie of Wormit in Fife, who for many years were the principal suppliers of beekeeping equipment in Scotland, but who closed in 1998.

In addition to having double front and back walls, this hive has slots cut into the bottoms of the box walls which engage with wooden ridges set into the tops of the walls of the box below. This makes a very solid hive, excellent for transport, but whose boxes can be difficult to separate for inspection.

The original National hive has boxes which are completely compatible with the now much commoner modified National hive, where the thicker back and front walls are constructed by wooden bars at the top and bottom. Because of the ridges, the Wormit Commercial hive does not fit perfectly with the National which has no slots. The double walls in both these designs are a construction weakness which can break up after many years, so purchase of these second-hand is probably not a good idea.

Neither of these designs is available new any longer, but both are still in use by some beekeepers and can become available second-hand.

2.6.3 The Smith hive

The Smith Hive, designed by Willy Smith of Innerleithen fits the British Standard frames into a Langstroth-type box by chopping 19 mm ($\frac{3}{4}$ inch) off each end of the long top bars, reducing them from 432 mm (17 inches) to 394 mm ($15\frac{1}{2}$ inches). It is the simplest and cheapest of the British designs. It is the hive design which I used successfully for many years, and lends itself to home construction more simply than the National hive. The boxes, floors, roofs, queen excluders and crown boards for the Smith hive are unfortunately NOT compatible with the National hive, since they are rectangular, rather than square, being only 416 mm ($16\frac{3}{8}$ inches) from front to back. Although Smith frames can be rather unsatisfactorily used in a National hive, the reverse is definitely not true.

2.6.4 The WBC hive

The diversity of hive types in Britain is due to the efforts of many well-meaning amateurs near the beginning of the twentieth century. Chief among them must be mentioned William Broughton Carr who designed what is still called the WBC hive. This is the pattern of hive you see in all the pretty rural pictures. Carr's idea was that bees would fare better in Britain's damp climate if protected from the weather by double wooden walls, like the cavity walls of a house. His design is considerably more complicated than almost any other design currently available, as it consists of a number of rather flimsily constructed inner boxes that carry the frames with their ends right on the tops of the front and back walls. These are stacked up on a solid wooden floor standing on wooden legs with a specially constructed entrance, and the stack of boxes is topped either by a crown board or (more traditionally) by a cloth "quilt". But then stoutly built telescopic outer wooden "lifts" are placed around the inner boxes resting at the bottom on the outer edges of the floor, and a pitched roof covers the stack of lifts. It is an excellent hive for the bees, but uses a great deal of timber and is therefore both expensive and heavy. It is also tricky to transport with bees in it, as well as being very difficult to make completely mouse-proof in winter.

The WBC hive uses frames of a different size from those used in the Langstroth hive, and they have extra long top bars which make them very easy to handle, but awkward to fit into a Langstroth-type box, even if it is re-dimensioned otherwise. However the WBC hive became so popular in Britain in the early twentieth century that it is these frames that have become the British Standard.

2.6.5 Some more unusual hive designs

Less common patterns are the Modified Dadant and Langstroth Jumbo hives which are American designs taking larger frames to encourage big brood nests; the Glen Hive which is an enlarged version of the WBC; and the Modified Commercial (or 16 by 10) hive which is a version of the National with deeper brood boxes and brood frames. The brood frames are also wider, since the boxes do NOT have either thickened or double front and back walls, and the top bars do not have long lugs.

A new addition to the unusual designs is the Dartington Long Hive which expands horizontally rather than vertically, and works well for any beekeeper who never moves his bees. It takes the same size of brood frames as the National hive.

All these hives with extra large brood boxes require a physique something like Desperate Dan's to move them around, and are perhaps best avoided by lesser mortals, unless as a user of Dartington hives, you can manage never to move your hives (though Robin Dartington claims it is easy to move). The bees love them all!

An even more recent innovation is the top-bar hive. This is in fact a modern revival of a very ancient type of hive formerly used in Ancient Greece and also in some undeveloped countries still following traditional practices. There is now some effort at standardisation, and those wishing to use this pattern would be well-advised to investigate this. The box is much like the usual type, but is sometimes made narrower at the bottom than the top. The crucial feature is that instead of full wooden frames for the combs, just the top bar is supplied, and the bees are given only starter wax, so that the cell-size is of the bees' choosing, and the wax is all new without the use of commercially produced and possibly contaminated foundation. I would not advise this design for a beginner however.

The old-fashioned straw skep is still available from suppliers. It is now a rather expensive item, though originally it was a cheap option which any farmer could make from his own straw. When used as a beehive, it does not permit modern methods of beekeeping. It can be useful for catching a swarm, but the same job can be done just as well with a cardboard box, available free from your local supermarket.

Chapter 3

Basic Honey Bee Biology

3.1 What is a honey bee?

Honey bees are insects. They belong to the phylum *Arthropoda*, the class *Insecta*, the order *Hymenoptera*, the superfamily *Apoidea* and the family *Apidae*. The *Apidae* are characterised by a pollen basket on the third leg (on worker bees at least), and have a more or less developed social behaviour. As insects they have three components to their bodies. A head, thorax and abdomen and three pairs of jointed legs. As members of the order *Hymenoptera* they have two pairs of wings, the forewings and hindwings, connected by a series of hooks, the hamuli (a bit like Velcro).

Honey bees live in communities known as colonies that exist through the winter and can continue for many years. Many other social insects e.g., bumbles and some species of wasp, do not do this but develop their communities throughout the summer months in order to produce mated females that will build new colonies in the following year. The original colony dies out during the winter.

There are a number of species of honey bee throughout the world, but in Europe, America and Australasia we relate this to only one species: the European (Western) Honey bee *Apis mellifera*.

A honey bee colony will usually have one queen, who will lay all the eggs that produce new bees. In the summer months male bees or drones will be present in the colony but these will be ejected from the colony once autumn arrives, and be left to die. The vast majority of bees present in the colony will be the workers (females), that carry out all the duties required to maintain the colony. The queen is basically an egg laying machine while the operation of the colony is carried out by the workers, acting as a collective, rather than individually.

Honey bees in the UK are unique as they continue to live as a colony throughout the cold winter months, even when there is no food to be collected from flowers. To get through this difficult winter period the bees have evolved to store food as honey, and under the right conditions they will store more honey that they need. This 'excess' is exploited by us, the beekeepers, which we take for our own use and have done for thousands of years.

3.2 The anatomy of a honey bee

Within the colony during the summer we will find male bees (drones) and female bees (queen and workers). The following anatomical descriptions apply mainly to the worker bees, with the peculiarities of the drones and queens described afterwards.

The body of the honey bee is separated into three distinct segments the head, the thorax and the abdomen.

3.2.1 The Head

Contained on or within the honey bee's head are the following:– the eyes, antennae, hairs, mouth, mandibles, the brain and food production gland. The head is about 3 mm square and about 2 mm deep. Like the rest of the honey bee's body, the head is constructed of a number of plates, made of chitin, connected together by softer membranes.

Honey bees have two types of eye, the main compound eyes and the ocelli.

The compound eyes are composed of between 6500-9000 individual facets called *ommatidia.* Each *ommatidion* has the structure of an eye, i.e., a transparent cornea, a crystalline cone, photoreceptor cells and an optic nerve. Each facet can receive light from a narrow field of view that is different to the other facets. This gives the bee the ability to perceive the world somewhat like looking at many digital pictures, each made up of only a few pixels.

Honey bees can perceive colour, except for light at the red end of the spectrum. Instead, the bee is able to see ultraviolet light, unlike ourselves. The compound eyes are also able to perceive the polarisation of light. This gives the bee the ability to sense direction relative to the position of the sun, even on cloudy days when the sun may be obscured! The compound eyes are in a fixed position. The bee has to move its head if it wishes to look in a different direction, however it has a wide field of view to the side and vertically. The worker bee cannot see straight ahead, because of the gap between the compound eyes, but the drone has larger eyes that meet in the middle which gives it the appearance of a large fly, but it is able to see straight ahead.

The *ocelli* are three simple eyes positioned on the top and front of the head in a triangular position. They are 'light sensors' rather than true eyes, they register light intensity and duration. At dusk the *ocelli* estimate the level of increasing darkness, which incites foraging workers to return to the colony. They may also help the bee to determine which way is 'up' when flying and in turn help stability in flight.

At the front of the head are located a pair of antennae, these can be moved freely by the bee. The antennae are involved with sensory perception, and are covered in an array of sensory structures. They allow the bee to sense its environment. Smell is the bees' primary sense and there are about 30,000 sense organs on the antennae. It is thought that some of the organs are specific to the smell of one chemical compound and play a big part in the honey bee's extremely sensitive perception of pheromones. The antennae can also detect vibration, movement of air, sound, temperature and humidity.

The two antennae allow the bee to perceive smell in 'stereo'. In effect, they are able to recognise small differences in the concentration of a smell from each antenna, and therefore, work out the direction and origin of the smell.

The mouthparts consist of a pair of mandibles and a proboscis. The mandibles are adapted to chewing and the proboscis to sucking up liquids e.g., nectar. The mandibles are located each side of the mouth. They act in the same way as a pair of pliers. The proboscis is found at the base of the mouth and functions like a straw, allowing liquid ingestion, and is involved in *trophallaxis*, i.e., mouth to mouth transfer of food or other fluids among individuals within the colony.

The hypopharyngeal gland is located within the head, it is important as it produces some of the food essential to raise new bees. This very rich, high protein food is mixed with substances produced from the mandibular glands. These are the essential ingredients of royal jelly. The hypopharyngeal gland evolves as the worker bee ages and it will eventually produce the enzymes that are essential in the process of changing nectar into honey.

Contained within the head is the bee's brain. This structure consists of two lobes that process information that it receives from the compound eyes, antennae and other sensory cells. Unlike humans, the honey bee has a series of ganglia (groups of nerve cells) grouped along the body. These cells provide localised action for specific parts of the bee's body and thus reduce the load on the brain.

3.2.2 The Thorax

The thorax can be considered as the 'motor' of the honey bee, it carries the wings, the legs and associated strong muscles inside.

There are two pairs of wings, a fore pair and a hind pair, one of each on either side of the bee. The wings are constructed of a fine membrane with stiffened veins to give them shape and strength. The wings when not in use can be folded back so they do not get in the way when the bee is not flying. The forewings are constructed so that when the thorax is compressed in a vertical plane the wings move downwards, and when the compression is released they move upwards. The power for flight is therefore provided by the bee changing the shape of its thorax. Small muscles between the outer body of the thorax and the wings allow the bee to control direction of flight by changing the shape of the wing. Only the forewing is powered.

The hindwing attaches to the forewing when it is moved out ready for flight by a series of small hooks (*hamuli*) which connect with a groove in the hindwing. This gives the bee wing a larger surface area for improved flight.

The indirect flight muscles are also used by the bee to generate heat. When the bee's wings are laid back over it body, the indirect flight muscles are still able to flex, without moving the wings. The flexing of these muscles generates heat. Heat generation by honey bees is very important as the brood (eggs, larvae and pupae), needs to be kept warm in order to develop properly. The bees keep the brood nest at a constant temperature between 34 & 35° C, irrespective of what the external temperature outside the hive is.

During the winter months, when external temperatures can be very low the bees will cluster together and flex their indirect flight muscle to generate heat to ensure that none of the other bees' internal temperature drops below 8° C, as below this temperature bees become torpid and soon die.

Also attached to the thorax are three pairs of jointed legs. These not only allow the bee to walk, but they also have specialised features, especially the legs of the worker. The forelegs have a notch located in one of the lower leg joints. This notch is used by the bee to clean its antennae. When the bee is preparing for flight, it will wrap the antenna cleaning notch around the base of an antenna and draw the antenna through it. This cleans and removes any dirt and other debris from the antennae, and ensures that all the sensors are able to operate efficiently.

All the bee's legs are covered in hair. The hairs on the legs are used to remove pollen grains that the bee picks up when visiting a flower, on the other parts of its body. The pollen is mixed with nectar from the bee's mouth and she then uses her legs to pass the sticky ball of pollen backward to the rear pair of legs. The rear legs have specialised upward facing combs on the inside of the lower part of the leg. These move the pollen upwards when rubbed through the adjacent joint, where the ball of pollen is compressed and pushed outwards into a pollen basket on the outside of the leg.

The pollen basket is made from long hair that curves outward from the leg, and acts as a case to hold the pollen ball. These can easily be seen on our own bees when returning to the hive from foraging. Pollen of different colours will be seen on the rear legs of these foraging bees. The different colours will be from different plants.

3.2.3 The abdomen

The abdomen is the 'back' end of a bee. It is joined to the thorax by a narrow 'neck' called the petiole and is composed of 6 visible and 'telescopic' segments. Internally it contains the digestive tract, the wax glands, the heart, the sting and its accessory glands (in the worker and queen), and the reproductive organs of both sexes.

The bee's stomach or *ventriculus* is found in the abdomen. Here the digestion of nectar and pollen takes place. Directly in front of the ventriculus is the bee's crop, or honey stomach. Nectar gathered from flowers is stored here, and this organ can expand quite considerably. The honey stomach is connected to the ventriculus via a valve called the proventriculus. This valve filters pollen out of the nectar and passes it back into the ventriculus. The nectar can be regurgitated when the bee returns to the hive and passed on to other bees for storage within the hive.

There is another valve at the other end of the ventriculus, the pyloric valve, this controls the passage of digested food from the ventriculus into the intestine, similar to what occurs in our own bodies. Digested food is absorbed in the bee's intestine, and waste product passes into the rectum. The bee's rectum can expand enormously and hold a lot of waste matter. This helps in the long winter months when the bees are unable to leave the hive and get rid of any waste matter. Due to their hygienic behaviour bees will very rarely defaecate in their own hive.

In between the ventriculus and the small intestine, the malpighian tubules are found, on the exterior area. These perform the same functions as our kidneys.

Wax is also produced by worker bees, and is used in the hive for building comb, and capping of cells. To produce wax, bees cluster together and raise their body temperature to around 37^0 C. Each worker bee has 4 pairs of wax glands situated on the underside of the abdomen. These glands produce small flakes of wax, that the bee collects with her legs and passes them up to her mandibles, where the wax flakes are chewed and worked into shape. The wax gets fashioned as required whether this is for capping off brood cells, cells that have honey stored in them, or the familiar hexagonal shape of comb.

It is probably worth mentioning the Nasonov gland that is located at the top of the bees' abdomen near to the end segment. This gland can be exposed by the bee by bending the abdomen at the last segment. The Nasonov gland produces a pheromone (a scent that influences the behaviour of other bees) that attracts other bees to the individual with the gland exposed. Using this gland bees are able to collect together their fellow workers if the hive has been disturbed. They will also use the gland when foraging to lay a chemical scent trail to encourage other bees to follow it.

Located right at the end of the abdomen in both female caste members is the sting. The sting has evolved from an ovipositor used by the bees' ancestors to deposit eggs in a cavity or in another animal. This is why only the females have a sting. Drones do not carry a sting at all. The queen only uses her sting against other queens Should there be two queens in a colony it is usual for them to fight. And once one queen overpowers the other she will sting her rival behind the head, killing her.

The worker will only use her sting in defence of the colony. It is unusual for a worker to sting except when she panics, or becomes trapped (in hair for example). When a worker stings a large mammal such as ourselves, she dies. The worker honey bees sting is barbed, unlike the queen's which is smooth. The barbs on the worker's sting lock it into the skin of the victim. If the bee tries to fly away the sting, nerves and muscles that operate it are torn away and out of the abdomen, and the worker usually dies a while later. This also means that the sting will still operate without the bee! The shaft of the sting is constructed out of two semi-circular canals that form a central tube. It is through this tube that the venom is pumped into the subcutaneous area under the victim's skin. Each of the canals has barbs on the outside and each canal will move up and down. This action pushes the sting deeper into the skin. So after the bee has flown away, the sting continues to penetrate the victim's skin, and venom is pumped down the central tube.

The sting is also equipped with its own pheromone gland that attracts other workers to the area and encourages them to sting in the same place. This mechanism allows a colony to repel most animals that may attack the hive.

3.3 The Colony

Honey bee colonies are often referred to as 'superorganisms'. The reason for this is that as individuals honey bees are unable to live alone, or indeed support themselves. But as a group, as a colony, they are able to organise themselves to behave as a single efficient organism.

Some of the traits that honey bees exhibit, as well as other social insects, include the following:–

- Adult workers actively leave the hive to find and collect food for the needs of the colony, not just for their own requirement.
- Inside the colony, young bees will look after and feed the young larvae in the brood area.
- There are also cleaning duties performed by bees inside the hive.
- The colony is defended by guard bees to stop invaders from entering the hive and robbing its contents.
- Communication between bees in the colony occurs via pheromones and trophallaxis (food sharing).

Interestingly enough, honey bees as well as other animals that demonstrate these social traits are invariably dominated by females that have given up the role of procreation to a single female (Queen) and work together for the benefit of the community or colony.

For a honey bee colony to survive it must have the following four components:–

- A Queen
- Worker bees
- Drones (during the summer months)
- A nest with brood (eggs, larvae and pupae)

If any one of these essential components is missing, it can lead to an imbalance in the colony, which in turn can lead to the colony becoming stressed and this invariably makes the colony vulnerable to disease. If the colony does become unbalanced, then the worker bees will try to re-establish balance as soon as possible by:–

- Making a new queen.
- Encouraging the queen to lay more eggs.
- Encouraging the queen to lay more drone eggs.
- Creating a new nest or repairing the old one.

At the heart of any honey bee colony is the brood nest. Here new bees are produced and nurtured as eggs, larvae and pupa. Unlike many other insects, the honey bee larvae remain in cells in the brood nest and are fed by adult bees. The temperature of the brood area is kept at a constant $34 - 35°$ C with a humidity of approximately 40%. These are ideal conditions for larval growth and development time of the larva and pupa is shortened.

3.3.1 The queen bee

Under normal conditions there is usually only one queen in the honey bee colony. She lives longer than the workers, anything up to 5 years in ideal conditions. Her head and thorax are of a similar size to that of the worker bee, but her abdomen is almost twice the size, and her legs are longer too. Her main task is to lay eggs. She is fed by the workers and is given a diet of brood food. This is a mixture of secretions from the workers' mandibular glands and hypopharyngeal glands, with some honey added as a supplement. Brood food is high in energy, and the more the queen is fed, then the more eggs she will lay. The colony expands rapidly during the spring and into the summer. At this point the queen may be laying anything up to 2000 eggs per day. The weight of the eggs is more than her bodyweight.

The queen does not have enough time to feed herself or to digest pollen and nectar (normal adult worker bee food). This is why she is fed brood food by the workers.

As the season progresses through the year the queen will slow down her laying rate, and in winter may even cease to lay altogether. As the need for new bees starts to diminish, the workers will reduce the amount of food the queen is given, and this will in turn reduce her laying rate.

The queen also produces pheromones that control the activities of the worker bees. One important effect of the queen's pheromones is to prevent the workers (females!) from laying eggs. The pheromones also let the colony know that they have a queen. The pheromones are spread throughout the colony by workers touching the queen with their antennae and then by them touching other worker bees. The queen is usually surrounded by attendant workers, who feed her, and gently guide her around the brood nest and encourage her to lay eggs.

There can sometimes be more than one queen in the hive. This usually occurs via a process called supersedure. Here a mother and young daughter will happily lay eggs as they move around the brood nest.

The mother usually dies or leaves the nest. On other occasions there may be two or even more queens raised by the colony. When this occurs, the new virgin queens will actively seek each other out and fight to the death unless prevented by the workers.

Development of the queen

Queens are produced from a normally fertilised egg, but one which has been laid in a special *queen cell* separate from the main comb. These queen cells hang vertically down rather than being horizontal. They start off as queen 'cups' that are similar in appearance to small acorn cups. Once an egg has been laid in a queen cup, the workers will expand the sides of the cell to accommodate the larger, rapidly growing larva[1]. Once hatched, the emerging larva is fed with an exceptionally rich food called royal jelly. The larva is over-provisioned with food and literally swims in a bath of royal jelly. This means that larval development is rapid, and within 5 days the larva is 2500x the weight of the original egg. The larva also has high levels of juvenile hormone. It is assumed that the high levels of juvenile hormone present in the queen larva, causes different genes in the DNA to be activated resulting in a queen rather than a worker bee. Pupation takes only 8 days and a queen emerges after this period.

Worker bees can control the timing of the queen's emergence from her cell by making the capping too thick for the queen to chew her way out. The workers thin this capping when they are ready to release the new queen.

Once the queen emerges from her cell after pupation she spends the next 4 days or so feeding. It takes this time for the queen pheromones to be produced, and she is usually left alone by the worker bees during this time. Once her pheromones start to be released the worker bees will begin to notice her and will begin to feed her as well as starting to encourage her to leave the colony and get mated.

Mating and reproduction

A virgin queen will leave the hive on her mating flight, usually on a warm sunny day, accompanied by a small number of worker bees. She usually heads to an area where there will be a congregation of male bees (drones) on the wing. Once she is there the drones will chase the queen in an attempt to mate with her. The strongest and fastest drones will catch and mate with the queen on the wing. This is unique amongst social insects, which usually mate on the ground. The queen will mate with anything up to 20 drones and their semen is stored in a special gland within her abdomen called the *spermatheca.*

She may make more than one mating flight. Mating must occur within about 21 days of the queen reaching maturity. After this time if she hasn't mated for reasons of inclement weather etc., she will become sterile and only lay unfertilised eggs (which will develop but only produce drones). This is a disaster from the point of view of the colony. This condition will usually lead to the colony dying out.

Once mated successfully, the queen will remain with the colony for the rest of her life (anything up to 5 years). About 8 million sperm will be stored in her *spermatheca*, and this is enough to enable her to lay fertilized eggs for many years. The queen will normally only leave the nest when the colony decides to swarm. When this occurs, the queen will leave with approximately half of the colony and find a new site to establish a new colony. The old colony will produce and raise a new queen and carry on as before. Swarming is the natural process of colony reproduction.

3.3.2 Drones

The male honey bees are called drones. They have one real purpose during their existence and that is to mate with queens. They will be accepted into any hive and will freely move between different colonies in any given area. Drones develop from *unfertilised* eggs laid by queens (or occasionally workers).

[1] Once fully grown and ready to pupate, the queen cell is sealed with a porous capping made from wax and pollen like the capping on other brood cells.

How does a queen make the decision to lay an unfertilised egg to produce a drone? When a queen lays an egg, she will initially measure the cell with her antenna and fore legs. Drone cells are larger than worker cells and the queen is able to distinguish between the two.

When presented with a large drone cell the queen will size the cell and then reverse her abdomen in and lay an unfertilised egg. If she senses that the cell is a smaller worker breeding cell, then she will deposit sperm on the egg before she lays it. The sperm penetrate the egg lining and fertilise it.

As the workers build all the comb present in a hive, they therefore determine the sizes of the cells being built. In this way it is the workers who regulate the ratio of drones to worker bees in the colony.

Drones are larger in size compared with a worker bee, and their development from egg to emerging adult takes longer in time. After the egg hatches, the drone larva is fed a mixture of the secretions from the mandibular and hypopharyngeal glands for two days. After this time period the larva is fed pollen, honey and a reduced feed from the workers' glands. It takes 7 days for the larva to reach full size, and it then spends a further 14 days as a pupa, sealed in its cell capped with a mixture of pollen and wax by the workers.

Drone development and lifespan

For a few days after emergence from its cell, the adult drone is fed with brood food from the workers. The drone then learns to feed itself with pollen and honey from the nest. Drones never fly from the nest to forage for food. After 10 – 11 days the drone becomes sexually mature and will leave the nest to congregate in flight with other drones in specific areas and wait for virgin queens.

The lifespan of a drone is approximately 40 days, but this figure is dependent on weather conditions and the level of activity that the drone undertakes. When autumn approaches and the temperatures start to drop, usually around September, any drones still in the hive will be forcibly ejected by the worker bees. This is to help to conserve food stores over the winter months. Any drones left at this time of the year will not be mating with any queens. Once removed from the colony the drone soon dies from starvation. The colony will go through winter and early spring with no drones at all in the hive.

Drone raising starts in the late spring the following year, when the workers will guide the queen to the larger drone cells to lay unfertilised eggs. At the height of summer there may be 200 drones in the colony, although there could be as many as 1000. When a colony is preparing to swarm there is a tendency for more drones to be present, and more drones produced. Other drones may be attracted to the swarming colony in readiness to mate with any new queens.

3.3.3 Workers

All the worker bees present in a colony are sterile females. They are produced from fertilised eggs in laid by the queen. Once the larva hatches from the egg it is fed by other workers a mixture of secretions from their glands. This food is not as high in sugar or as nutritious as the food that is given to developing queen larvae. After 2 days the worker larva is fed pollen and honey. The larva is fed regularly, but isn't given as much food as a queen larva. The worker larva takes 6 days to grow and is not as big as either the drone or queen larva. After 6 days the larva prepares for pupation and is sealed in its cell by other worker bees. She remains in this cell for a further 12 days, after which she cuts her way out of the cell using her mandibles and emerges as an adult worker bee. The worker bees are the most numerous caste present in a honey bee colony, with anything up to 60,000 individuals at the height of summer, but this reduces to around 10,000 during the winter.

All the work done in the colony to maintain it is undertaken by the worker bees. This means that in the summer the life expectancy of a worker is approximately 6 weeks. They literally die from hard work. During the winter however, the workers can live for around 6 months. They keep the queen and other members of the colony warm and get ready to care for the new brood once the queen starts to lay again, which is usually in the spring. Foraging will recommence once the first plants bearing pollen and nectar start to flower.

Stage	Queen	Worker	Drone
Egg	3 days	3 days	3 days
Larva	5 days	6 days	7 days
Pupa	8 days	12 days	14 days
Emerge as adult*	16 days	21 day	24 days
Fully developed**	20 days	42 days	34 days
Lifespan (as adult)***	2 to 5 years	6 weeks (summer) 6 months (winter)	3 months

* Emerge as adult: time from egg laid to emergence from pupa as adult insect.
** Fully developed: time from egg laid to the adult insect being sufficiently mature to carry out all duties.
*** Lifespan: the expected age of an adult bee before death.

Table 3.1: Table of lifecycles of the honey bee sexes and castes

Division of labour

A newly emerged worker bee will not immediately be able to carry out all of the tasks that are required in the colony. Her first task is to feed herself to restore any energy lost when emerging from the breeding cell. Following this she will start by cleaning the hive, removing any accumulated debris. As she grows older she will be able to do other tasks in the hive and in a loose chronological order these will include:–

- Cleaning duties
- Cleaning of cells and polishing
- Feeding the larvae
- Feeding the queen
- Producing wax, building honeycomb and breeding cells
- Receiving and processing nectar from foraging bees and storing in cells
- Guarding duties at the hive entrance
- Foraging for pollen and nectar
- Foraging for propolis and water

The tasks where the worker bee is mainly confined to the hive, take place in the bee's first 3 weeks of life. The foraging work takes place for the last 3 weeks. The advantage of this is that the majority of bees die while out on foraging trips so the numbers of dead bees in the hive is reduced. Retirement is not a concept that occurs in a honey bee colony!!

With the change of task that occurs during the lifespan of the worker bee, there is a direct correlation with the development of the bee's glands. After emergence from pupation the young bee must feed on pollen and nectar so that her body can develop. The hypopharyngeal glands are the first glands to mature. These are located in the bee's head and will produce food for the larvae and the queen.

As the worker bee gets older then the wax glands develop so that cell building and repair work in the nest can take place. The hypopharyngeal glands develop further and they start to produce the enzymes that are needed to convert nectar into honey.

Finally, after 3 weeks the venom and sting glands become fully functional and the worker is able to take on guard duties at the hive entrance.

Once she becomes fully functional the worker is able to leave the nest and progress from being a 'house' bee and become a 'forager'.

Because the queen mates with many drones, the genetic diversity or genetic mix is maintained throughout the colony. Some workers will be more adept at some duties than others. Not all the workers will carry out all the jobs in the hive, and in times of emergency foraging bees can revert to being house bees.

The worker bee takes on a remarkable variety of roles both inside the colony and outside, in a relatively short lifespan.

3.4 Honey bee communication.

Communication is an important part of the honey bee colony and there are a number of ways the bees communicate with each other in the hive environment. The management of the colony is almost exclusively done by the workers, so they must have efficient mechanisms to ensure that there are enough bees recruited to carry out necessary duties within the hive.

The principal means of communication is by chemical messengers called pheromones, but they also communicate with each other via dancing and sharing of food. Dances are performed to inform other bees of food sources, and when it's time to swarm. Such mechanisms have evolved to be highly efficient and effective to ensure the stability of the colony.

3.4.1 The importance of pheromones in honey bee communication

Although the queen may not make the decisions in the day to day running of the colony, she has a strong role in maintaining a level of stability within the hive. The queen produces pheromones that let the workers know she is present amongst them in the colony. Her pheromones also play a crucial role in preventing the development of the workers' own ovaries, and therefore stops them from laying their own eggs. The young larvae and pupae present in the brood neat produce pheromones that help to keep the colony on an even keel.

The way that pheromones work is as a highly sophisticated control mechanism that ensures that while there is a queen and brood present the workers will carry on with their duties of colony care and food provision. This control system also maintains a healthy balance between 'house' bees and 'foragers'. Research has indicated that if one removes all the forager bees from a colony, the development of the house bees is speeded up, so they can take on the foraging duties, and vice versa, if all the house bees are removed from the hive, the foragers will revert to duties within the hive. Some of the prominent pheromones produced by honey bees in the colony are tabulated in Table 3.2. This is just a small selection of perhaps the most important ones, there are of course many more. Pheromones themselves are a mixture of volatile and oily chemicals. For a long-term effect, the chemicals tend to be oily, whereas the pheromones that require an immediate action are volatile. Our knowledge of these chemical messengers is not complete and there are large gaps in our knowledge of their form and function. What is clear, is that honey bees have highly developed sense and taste organs on their antennae, and each pheromone may have a differing number of effects depending on the situation or circumstance in which they are being used.

Hive odour is a specific mix of pheromones combined with food that has been foraged and the state of the colony. Every colony has a distinct hive odour that allows the bees to recognise their own colonies, and for the guard bees to recognise their colleagues.

3.4.2 Trophallaxis (Food sharing)

Within the hive, honey bees spend a lot of time exchanging nectar between themselves. Foraging bees returning to the hive will pass her collected nectar load to another house bee who will process the nectar before storing it in combs.

Pheromone	Produced by	Signal
QMP Queen mandibular pheromone	Queen	(i) Q is present (ii) Do not make other queens. (iii) Inhibits workers' ovaries.
Brood pheromone	Brood	Stops workers' ovaries developing
Nasonov	Workers (Nasonov gland)	Join me or follow me
Alarm	Workers (mandibles)	Help defend the colony & attack
Workers	Sting	Attack and sting this object

Table 3.2: Some of the principal bee pheromones and their known actions

If a forager finds a particularly good source of nectar, she will inform other bees in the hive by using specialised dance, as a form of communication. She will also pass a taster of the nectar around the other bees who attend the dance. The other bees are informed of the position of the nectar source, its flavour and sugar content. This way the colony recruits many bees to collect pollen and nectar from sources rich in both.

Trophallaxis results in bees from the same colony having the same or similar odour.

3.4.3 Bee dances

One of the most spectacular, and perhaps well-known forms of honey bee communication is the various bee dances. The bees create a 'dance floor' on a patch of comb within the hive. They choose an area of the comb that has no stores or brood in so that the comb will vibrate and shake as the bee dances. A honey bee returning from a source of forage that is rich in nectar and pollen, will head to the 'dance floor' and perform a 'waggle' dance. In this dance she shakes her abdomen and aligns her body in a particular direction. She then circles to the right, returns to her start point and repeats the dance. She will then circle to the left and repeat until she has communicated her message in full to the other worker bees. The objectives of the dance are to inform other foraging bees how far the forage is away, and in what direction. Although this is easily observed, up until the 1940s no-one had guessed its purpose. At that time Karl von Frisch of the University of Graz in Austria first investigated it, and worked out that the direction to the vertical on the comb equates to the direction of flight relative to the position of the sun, and the intensity of the waggle is relative to the distance the bee has to fly.

It is important to remember that these dances are performed in the relative darkness of the hive. So potential foragers must have to touch the dancing bee to determine direction and distance. While the interpretation of direction is quite well understood, the measurement of distance as described by the dancing bee is not that clear. It may relate to flight time, or markers the bees have to pass, e.g., trees etc., or even the amount of energy the bee has to expend to reach the source of forage. Whatever it is, it works well, for once a rich source of nectar and pollen is found it will only take minutes to recruit more foragers from the same hive to exploit it.

Chapter 4

Basic handling skills: spring and summer management including swarm control

4.1 Beekeeping — basic handling skills

4.1.1 Introduction

The foundation of the enjoyable working of bees is to work in co-operation with the bees as far as possible. Beginners are always tempted to open the hive to look in to see how the bees are doing. It is necessary to do this periodically, and it should then be done quietly, quickly and efficiently, but unnecessary disturbance is as foolish as digging up one's potatoes to see how they are growing.

In approaching a beehive, as far as possible keep out of the line of flight of the bees to and from the entrance, and stand behind the hive, or to one side. If there are trees or bushes nearby which force the bees to fly high when approaching the hive, it can help the beekeeper in this respect. Any stamping on the ground or vibration — e.g., from a lawnmower — will be felt by the bees and may trigger their alarm reaction, so avoid it if you wish to inspect the hives, and if you are prudent you will wear your veil if your work near the hives necessitates such disturbance. The scent of cut and bruised vegetation is also alarming to the bees, so lawnmowing is doubly disturbing.

Bees keep the interior of their hive very warm, and they do not enjoy having the roof removed on a cold, wet, windy or thundery day any more than you would. They show their annoyance in the only way they can. So except in dire necessity, wait for warm quiet weather before opening a hive. If you must do so on a bad day, plan carefully what must be done, and work fast.

4.1.2 Opening a hive and inspecting the combs

This is the basic skill that must be acquired, so I shall describe it in detail. I shall assume that a National hive is in use. Common sense should tell you how the routine must be varied for a different hive design.

Make sure you have at hand all the equipment you will need. Here is a basic list, but extras will be needed for special jobs:– **protective clothing, smoker, matches or lighter, smoker fuel, hive tool, rubbish container for scrapings of honey, wax and propolis (which should not be left lying around the apiary where they will encourage robbing and may spread disease).**

BEFORE YOU START, HAVE CLEARLY IN MIND — EVEN WRITE DOWN IF YOU ARE INEXPERIENCED — WHAT IT IS YOU ARE PLANNING TO FIND AND DO.

- Before approaching the hive, light the smoker, and put on protective clothing. Don't put on your veil before lighting the smoker or you may burn a hole in the veil if a stray spark gets on it. Among the best fuel is a rolled up cartridge of hessian sacking. Another good fuel is well dried rotten wood from dead trees. A roll of corrugated cardboard is also a possibility though it burns rather quickly. I have often used a supply of dried grass (available free from any piece of rough ground), started off with half a sheet of newspaper. It too burns rather too quickly. Make sure you have plenty of spare fuel in reserve and that the base of the fuel is well alight, and use the bellows until you are sure the smoker is producing plenty of cool whitish smoke. When the smoker starts to produce darker bluish smoke, it is a sign that the fuel is burning through. Re-fuel it before it turns into a flame-thrower!

- Before opening the hive, give one or two good puffs of smoke into the hive entrance, and leave the bees for about a minute for the smoke to take effect. No-one knows exactly why smoke pacifies bees, but its effect is that when there is unsealed nectar in the hive, the smoked bees rush to gorge themselves and thereafter become much more placid. Smoke can also be used to drive bees from a particular area so that bees are not inadvertently crushed. Crushing bees, as well as being bad management, causes large quantities of alarm pheromone to be released and quickly puts the hive out of temper. If you have the misfortune to be stung at any time, then freeze for a moment and take stock. Scrape out the sting and then smoke the place vigorously to kill the sting scent and inhibit further attack. This routine should be followed even if the sting is received on a glove or other piece of clothing and causes you personally no inconvenience at all.

- After a quick reminder puff of smoke at the entrance, remove the roof, being careful to avoid bumping and vibration as far as possible. The roof can be laid down upside down on a level place somewhere conveniently within reach but out of the way. Honey supers above the queen excluder are not usually examined. They should be removed bodily and stacked inside the upturned roof. If there are several, take the crown board off the top one on the stack, after placing that super, shake the bees off it down into the next super down by *bumping* the edge of it on your hand and put the board on top of the next super before you lift that on to the top of the stack of supers. When the supers are restored at the end, make sure they go back the correct way round and in the correct order on to the hive.

  Removing a super (or any box) that has been on the hive for some time is more than just a matter of lifting it off. First the seal of propolis at the junction of the boxes has to be broken by levering the boxes apart with the hive tool. As you part the boxes at one corner, puff smoke into the gap to keep bees away from the working area, so they won't be crushed as you withdraw the hive tool to move to the next corner. After all four corners have been freed, you may still find the tops of some of the frames in the lower box adhering to those in the upper box. If so, *twist* the boxes apart and they should come free. This adhesion is usually worse in bottom bee-space hives (Nationals), which is why some prefer top bee-space (Smiths). There is quite a knack in doing all this with the minimum of bumping and vibration, particularly if the super is full of honey and therefore heavy. Whenever bees are exposed during this process, give them two good puffs of the smoker. If boxes have been undisturbed for many weeks or months, the frames in the upper box are sometimes so firmly fixed to those in the lower box that the upper box is physically impossible to separate as a unit. In that case the only remedy is to obtain an empty box, and to lift out the frames from the upper box one by one, placing them in the empty box in order with the bees adhering. These are desperate measures, not needed if your hives are regularly inspected, *provided the boxes have a proper bee space between them*. It is prudent to remove the propolis and brace comb from the bottom of each frame as you take it out, depositing the scrapings in the rubbish container, so that when the boxes are put back together again, there is restored a proper bee space for the bees to respect. Once the upper box is lifted clear, you can also scrape the propolis and brace comb from the top bars of the frames in the box below, again disposing of it tidily.

- Remove the queen excluder if there is one and examine it carefully to be sure the queen is not on it. Bump bees on it into the brood box, then lean it up in front of the hive. Returning foragers will be confused by it and not bother you.

- If the queen is found at ANY time, her safe disposal must be your first thought. She should be safely escorted from any unusual position like on a queen excluder, by hand if necessary, to run down between two brood combs, or simply left on the brood comb where you find her, and carefully replaced when that frame has been inspected. Until you have found her and know where she is, assume she is on every frame you handle, and treat it with appropriate care. If you injure or lose the queen, you have destroyed the value of your stock.

  A laying queen will hardly ever take wing except with a swarm. If you do ever have a queen fly off, then leave the frame tops exposed and wait ten minutes with no smoking. She will almost certainly return to the scent of the hive. If not, bad luck!!!

- Sometimes a hive has two boxes for the queen to lay in. In general if two boxes are to be inspected, it is best to lift off the upper one, and to start by inspecting the lower one, as then bees are not driven down as the upper combs are inspected, making a very crowded lower box when you come to it. However if the two are badly stuck together with propolis, you will have to start with the upper one (see above).

  If the upper box is lifted off first, stack it separately from the supers to avoid the risk of letting the queen get into the honey supers, preferably in another hive roof, and cover it with something else. Never leave unattended frames exposed. The bees become agitated, and in cool weather the brood may become chilled. It also tempts bees from other hives to start robbing the honey which soon leads to PANDEMONIUM.

- In lifting combs from a box for inspection, it is best if possible to stand with one's back to the sun, as it is then easier to inspect the comb than if one is facing the glare of the sun. One may start lifting combs from either end of the box, though it is probably more usual to start at the near end.

- Smoke the tops of the frames in the box to be inspected, but do not puff too much smoke down between the frames — just enough to keep the bees down — and scrape off any brace comb built on the tops of the frames with the hive tool. There may be some drone brood among it if your inter-box space is a little too wide, but its loss is of no great importance, but dispose of this in the rubbish container.

- While actually inspecting, use as little smoke as necessary to keep the bees subdued. With the bent end of a standard hive tool, free the end frame by a horizontal twisting movement, or using the frame-lifter if you have it, lever one end up. If there is a dummy, then instead free that. Then lift it slowly and carefully out to avoid crushing bees. Inspect it carefully to be sure the queen is not on it — she will usually be found on a central frame where egg-laying is actively going on, but you never know. Provided she is NOT there, then this frame (or preferably the dummy) may be propped beside the hive. If it is a frame and contains brood, remember it must not be left out long enough to become chilled.. Alternatively the dummy, or first frame if it contains little brood, may be laid horizontally across the tops of the central frames to keep the bees down and the brood nest warm. Its position can be adjusted as the inspection proceeds, to expose just what is currently being inspected.

- Now free and lift the second frame, inspect it and return it to the place of the first frame or the dummy, without turning it round. In inspecting a frame, try not to hold it out horizontally, but turn it so that it is at all times supported by its wooden frame. This is especially important with new "green" combs full of honey which can sometimes drop out of the frame under their own weight. Also as far as possible hold frames over the hive in case the queen should drop off and be lost in the grass.

- Continue in this way frame by frame, packing each frame away from the working gap as you proceed, to preserve your working space.

- Use only what smoke is necessary to keep the bees quiet. If you see a mass of them starting to pour out of the hive entrance and crowd up the face of the hive, you know you are over-smoking them.

- The *last* comb can be replaced in its own place. Then expose the side of the box where you began, adjusting the position of the covering frame or dummy if necessary, smoke there, and, using the hive tool as a lever, move the whole block of combs away from you back to its proper place. As the gap at the far end closes, smoke it to drive bees away before they are crushed. If the combs jam, they must be replaced one at a time. This is more disruptive to the hive so should be avoided if possible. There will now be space to replace the first frame or the dummy in its proper place, again using smoke in the gap so that bees are not crushed. Note that if a dummy is in use, this last stage can be avoided, by simply placing the dummy at the other side of the box beyond the last frame. No *combs* are moved by this operation and next time you simply start at the other side. Finally use the hive tool at each end of the block of combs to lever them close together into a solid block and to ensure that there is a bee space at each end of the block.

- If there is another brood box, it may now be replaced and examined in its turn — or the top one removed, stacked and covered if the inspection is top down. However if a primary objective of the inspection is to find the queen, then the top box, if stacked initially, should be examined *where it is* if the queen was not found in the bottom box, or the queen may run down from the top box into the bottom box before she is found.

- After all the brood boxes have been inspected and replaced, bump any adhering bees off the queen excluder over the frame tops of the brood box by knocking the edge of it against the palm of your hand. Place the excluder on a flat surface such as a hive roof which is NOT on top of an occupied hive, and clean any brace comb off the excluder with the hive tool, being careful not to bend the wires or open up the slots, or it will no longer exclude the queen. Tidy up the mess.

  Then give a puff or two of smoke over the frame tops to clear them of bees, replace the excluder, and on it stack the honey supers in the order they were in before they came off. Lastly bump any bees off the crown board into the top super and replace it, using a little smoke if necessary to avoid crushing bees.

I have described this in great detail. Your own working practice will almost certainly vary from this a little, but it is important to develop a well-organised systematic routine that becomes second nature, so that you can concentrate on the *objects* of your inspection. As a beginner you will want to practise this for its own sake, but remember that it is disruptive to the colony, and you should in general not look into a hive more than once a week unless it is really necessary.

4.2 Spring and summer management

Spring is supposed to start in March in Scotland, but for the beekeeper spring only starts when the weather warms up. The bees must not be neglected before then, but their management must continue to follow the winter regime that I shall not present here.

The true spring inspection should take place on the first day you are free when the sun shines and you are comfortable without a jersey — temperature over 16^0 C (60^0 F) — and when there is not too much wind. There will be no honey supers on yet.

Have a clean spare floor with you. Lift off the roof after smoking at the entrance as usual. As you lift off the roof, look inside it to see if it has been leaking rainwater in. If so, then its repair is urgent, and as soon as possible a dry replacement roof must be provided for the hive. Then put the roof upside down to receive the brood box or boxes.

Quickly stack ALL the brood boxes of the hive inside or diagonally on the roof. Carefully remove the hive floor from the stand, but do not shake off the adhering bees or the debris. Clean away quickly any rubbish from below where the floor was. Take care to remove as many chalk-brood mummies as you can, as they spread spores of the infection Then place the clean floor on the stand, and by wedging it up if necessary, make sure it does not rock, and that it is level from side to side and slopes slightly from back to front, so that any rain that blows into the entrance will drain out. If you are using open mesh floors, this slope is less important as water will drain through the mesh. Replace the bottom brood box on the clean floor, and if there is more than one, cover the other(s) with the crown board. Now begin an orthodox inspection of the brood boxes as described above. You have four questions to settle, all related to one another:

1. Is the colony queen-right?
2. Is the colony healthy?
3. How far developed is the colony?
4. Is there sufficient food for the colony?

1. To anwer this question, you do NOT have to find the queen, though it is always reassuring if you do. The real proof of this however is the presence of developing brood in all stages including SEALED BROOD WITH WORKER CAPPINGS, and a HEALTHY PATTERN OF EGG-LAYING, with brood spreading out in concentric ovals from the central area where egg-laying started, so that the open brood is on the outside with eggs beyond that — unless the "first round" is already emerging as young workers, and the queen is starting again from the middle.

2. Pests and diseases of bees are a large topic dealt with at length in Chapter 6. Here is only a brief description of what is to be expected in a healthy colony; of some common but not too serious problems that are often found; and a brief indication of how to look out for the few really serious problems that need to be watched for.

   Healthy **brood** will appear in the spring as concentric ovals of brood in all stages of development as described above. Look for *eggs* in particular to be sure a laying queen is present. The *open brood* should consist of pearly white larvae lying curled up in the bases of the cells with a small amount of whitish liquid bee milk. The *sealed brood* should be in even slabs of pale brown roughish cappings all of uniform appearance. At the end of its development phase there will be gaps in the pattern where bees have emerged, and you will probably see young adult bees emerging as you look at the comb, looking rather under-sized and covered with greyish downy hair. If the pattern contains too many gaps early on, it may be a sign of a failing queen.

   The most common but not too serious problem with the brood is *chalk brood* where isolated uncapped cells among the sealed brood contain chalk-like mummified dead larvae. Try to avoid damp, and scrap old combs to reduce the level of this fungus infection.

   After winter there will inevitably be some dead bees on the floor and outside the hive, but the living **adult bees** should all be active and healthy looking. Watch out for brown fouling of the combs and frames indicating *dysentery* which may have several different causes.

   If *wax moths* get into a hive (looking something like clothes moths) their larvae can quickly wreck large areas of comb which they reduce to a crumbly brown frass. They are usually more of a problem in combs (particularly brood combs) stored away from hives. Stored combs which become infested should be burned, and any wax moth pupae adhering to and concealed in crevices of woodwork destroyed. Wax moth infestation in a working colony is usually a sign of a weak colony. Get rid of the worst of the infestation, and try to clean things up as best you can.

   If *mice* get into a hive, it is obvious, as they wreck the combs, eat the honey and kill the bees. Fit mouse-guards in autumn to avoid the problem in future. If any bees are still alive, they need to be fed, and urgently given clean combs (not foundation) to try to rescue them. This is not easy to achieve and usually mouse-infested stocks die.

Slugs often take up residence in damp hives with weak stocks. Kill them, don't just throw them out, or they will return. Try to keep hives dry and strong. The use of a beer-baited slug trap can reduce the slug population in a damp area.

Since 2009 outbreaks of the two serious conditions American Foul Brood (AFB) and European foul Brood (EFB) have occurred every year in Scotland, changing radically what we need to watch for. AFB shows as dark sunken cappings among the sealed brood covering rotting smelly remains of dead larvae that can be drawn out into a slimy "rope" with a matchstick. EFB usually shows as contorted "melted down" dead larvae among the open brood.

These two and two other infestations which have thankfully not yet appeared in this country are legally notifiable diseases. If you find or suspect you have any of them, you are legally obliged to notify your local office of the Scottish Government Rural Payments and Inspections Directorate (SGRPID). The contact details are given in Chapter 6.

If you find suspect brood comb or unhealthy looking bees, then send a 5 cm square of comb, or a sample of 20 to 30 adult bees (killed by an hour in the deep freeze) or as much floor debris as you can collect in a *cardboard* box or *paper* envelope (NB NOT plastic which rots the sample) to Science and Advice for Scottish Agriculture (SASA). Their full contact details are given in Chapter 6 later. Remember to enclose a covering letter giving your name and address, explaining what the sample is, what problem you suspect and saying where the bees are kept. You will be sent a FREE EXPERT DIAGNOSIS. This is a valuable service, so use it sensibly. If they diagnose one of the notifiable conditions, they will take the necessary steps of notifying SGRPID which takes that responsibility away from you.

Infestation by *Varroa* mites is now endemic in virtually the whole of Scotland apart from some of the outlying islands and a few isolated regions in the north-west. Because it had become so widespread, it was in 2007 removed from the list of notifiable diseases by the Scottish Government. Its control is now a continual necessity, but not something to be dealt with at a spring inspection. It is covered later in Chapter 6.

3. The development of the colony can be assessed by noting how many combs are occupied by the brood nest as it spreads out from its winter centre. I sometimes liken its development to the spread of a fire through the kindling and fuel laid out in a grate. Once it occupies all but the two outside combs on each side, the time has come, if the weather is fair, to put on the first honey super over a queen excluder. Do this too early rather than too late, or your hive may swarm before the end of May. Always ensure throughout the summer that you give ample room for the storage of honey.

4. A *full* brood comb of honey holds about 2.5 kg (5 lb). A *full* shallow comb holds about 1.5 kg (3 lb). Total colony reserves should never be allowed to fall below 5 kg (10 lb), and if they are falling to near this level, the beekeeper must be prepared to feed if the weather turns cold or wet, especially if this happens in the middle of summer when colonies are large and active and can soon use up a small reserve. Assess by weight and by eye how much is in each comb, and ensure the total is adequate. Be ready to give liquid feed if it is needed. Bees without food die immediately!

   On the other hand if excessive reserve slabs of sealed honey or sugar syrup in the brood combs are restricting the queen's laying space, an excellent way of stimulating rapid development is to break with the hive tool the cappings over these slabs in two combs adjacent to the brood nest. The bees will then clean out these cells and prepare them for the queen, re-storing the honey elsewhere, provided you have given them room to do so, which you should have done. The extra feeding also stimulates the workers to greater activity.

After completing your spring inspection and closing up the hive, examine the old floor if it is a solid one. Quite a lot can be learned from the dead bees on it, and any sign of other creatures or of damp patches. An open mesh floor is less informative but will still yield some information.

Then clean the old hive floor thoroughly by scraping it with the hive tool or brushing the mesh with a wire brush, and if possible scorching it with a blow-lamp to disinfect it. Put the scrapings into the rubbish bucket to be destroyed preferably by burning, especially any chalkbrood mummies to avoid spreading the infection around. It can then be used to replace the hive floor from the next hive that will be inspected.

Finally write up what you have found and add it to your running *hive record* being sure to state the answers to the four key questions listed at the start.

4.3 Prevention and control of swarming

More has been written in modern beekeeping books about the control of swarming than about any other topic. Swarming is a natural part of the bees' reproductive process and is therefore an impulse that is very hard to suppress altogether. However modern hives make it very easy for the beekeeper to increase the number of stocks in summer as and when it is desired to do so, and the bees' inclination to do so naturally, at a time of their choosing, to a place not usually in the beekeeper's apiary is now reasonably regarded by beekeepers as a nuisance which unnecessarily divides and diminishes their honey-gathering stocks. Add to this that a swarm which absconds and sets up home in the disused chimney of a house — a very common destination of a swarm left to its own devices — often becomes a severe nuisance to the householder, as the worker bees usually find their way behind the plasterwork of rooms in the house and emerge into the rooms where they cause alarm and confusion, and you will understand that a beekeeper who allows swarms to fly at will these days is not the most popular person.

4.3.1 Finding, clipping and marking the queen

In order to implement a satisfactory swarm control system, it is important to be able to find the queen in the stock that is preparing to swarm. This is made much easier if the queen is marked, since it is usually fairly easy to spot the single bee in a stock which has a conspicuous dot of paint on its thorax, whereas finding an unmarked queen in a populous stock is often very hard even for an experienced beekeeper. Also if one of the queen's wings is clipped, she will be unable to fly away with a swarm, and should you miss the opportunity to check swarm preparations in good time, the most likely outcome is that the queen will get lost in the grass near the hive when the swarm tries to leave. The swarm will then return home, and you will have a few days' extra grace to bring things under control, before the swarm flies off successfully with a newly emerged virgin queen. But remember that it is only a few extra days you win, not a sufficient measure on its own to control swarming.

My own current practice is to mark, but not clip my queens and I would recommend this for a beginner.

In April or early May most stocks of bees have not got large worker populations, and at that time of year queens are usually easily found, and then is the opportunity to find and mark them, and to clip them if desired.

Before starting to look for the queen, make sure you have all necessary equipment at hand. For marking, I use a "crown of thorns" queen marking cage which is a circular frame, about 5 cm in diameter, covered with a mesh of cotton threads too closely spaced for bees to squeeze through, and with a circle of steel spikes round the edge on one side, at queen excluder spacing, so workers can escape between them, but a queen cannot. Also you need to have a marking pen or marking paint at hand, opened up and ready for use. You may wish to use the appropriate year colour for the age of the queen — blue, white, yellow, red or green according as the year of the queen's birth ends with 0 or 5, 1 or 6, 2 or 7, 3 or 8, 4 or 9, the pattern repeating every 5 years. I currently use the marking pens supplied by the appliance dealers.

For clipping the queen (if you choose to do this) you need a good quality pair of small scissors with pointed blades, kept very sharp.

To find the queen, go systematically through the brood combs, and remember that she may be anywhere, though the most likely combs are ones in the centre of the brood nest where recently laid eggs are present. Scan each face of the comb generally first, and then systematically scan the face from the centre out in a spiral pattern. Do not work too slowly, or the queen may start to panic because of the long opening of the hive, and then she is likely to run away into an odd corner where you will fail to find her.

Once you have spotted her, pick up the queen marking cage without taking your eyes off the queen — did you lay it in a place from which you can pick it up without looking? — and gently place it over the queen, inserting the spikes into the wax of the comb without injuring the queen. Then press it down gently until the queen is lightly trapped. At this point you may move away from the hive, carrying the frame with the trapped queen with you, so that guard bees hassling you will be fewer in number. Take all necessary equipment — marker pen, and or paint, and scissors if you are going to clip — with you.

If you are going to clip the queen it is best to do this first. To *clip* the queen, lift the cage a little till the queen can again move around, then press down slightly on the side where the queen's head is. She will back away, and with luck one of her pairs of wings will emerge between the threads on the cage. In this position, you can safely clip off about one third of the outer end of that pair of wings, without damaging her legs which MUST remain intact if she is to survive.

Incidentally, NEVER clip a virgin queen, since she must go out on her mating flight before she starts to lay, otherwise she will never be any use.

To *mark* the queen, press the cage down gently till the queen is trapped lightly but so that she cannot move, and then put one clear dot of colour in the centre of the back of the queen's thorax. Wait a minute or so for the paint to dry, and then return to the hive.

To release the queen, first return to the hive, then hold the frame over the hive, so that if the queen falls off she will fall into the hive. Gently lift the cage to release the queen, and replace the comb in the hive, taking care the queen goes safely in.

4.3.2 Principles of swarm prevention

There is no doubt that the best honey crops are obtained from those stocks which choose not to swarm during the summer. The trick then is to persuade your bees that it is best not to swarm this season. That is impossible to achieve all the time, but the following factors are known to be ones which will almost certainly trigger the swarming impulse:–

- **Lack of space.** Always ensure that the bees have room to expand. Put on supers early rather than late. Also ensure the queen always has plenty of laying room. If most of the brood frames are fully occupied by the brood nest or honey, then more room there must be provided. The easiest way to do this is to give the queen a second brood box, preferably above the first, so that the warmth from the nurse bees rises up into it. Also if super room has been provided, but there are full combs of honey in the brood nest, they can be uncapped by scoring the cappings with a hive tool. Workers will then empty these cells and take the honey up into the super, making these cells available for nurse bees to clean out and for the queen then to lay in. Check how much laying room there is at every inspection durng the summer, and be prepared to take appropriate action immediately.

- **A failing queen.** A queen more than two years old is past her prime of life, and frequently the stock she heads will swarm so that the parent stock gets a new queen. The swarm, if it survives, will usually soon supersede its old queen so it too will then be headed by a young vigorous queen. So as far as possible ensure your stocks are headed by young queens, and if an older queen is failing and you have any new queens available from other parts of the apiary, use them to re-queen any weak stocks.

- **A swarmy strain of bees.** This is the hardest matter to deal with. There is no doubt that there is a genetic component in the readiness of different strains of bees to swarm. As far as possible ensure the bees you acquire are not from a *swarmy* strain. This is one point at which a stray swarm picked up is likely to be a disappointment, since by definition it has just swarmed before you got it, so has some inclination to swarm. If you are breeding your own queens, you should aim to breed from queens heading colonies with desirable traits. The ones in my list are:–

    - Mild temper.
    - Ability to gather a good honey crop.

- Resistance to disease.
- Lack of inclination to swarm.

One way as a long term measure to try to ensure the queens from which new queens are bred are not of too swarmy a strain is *never to breed from a queen less than two years old.* By definition any queen which you have had for two or more years, has not swarmed for that length of time, and so is a winner on that score. Sometimes however one has to depart from this counsel of perfection, but stick to it as far as possible.

4.3.3 Principles of swarm control

The first step in swarm control is to detect when the bees have decided to swarm. It is most unusual for a stock to make swarming preparations before drones are flying in plentiful numbers, so this is the first thing to watch for. That time is very variable, and can be as early as mid-April in warm springs, but as late as the end of May in cold springs. Thereafter regular inspections at intervals of not more than 9 days are needed if the beekeeper wishes to be sure of preventing a stock from swarming. Often it is convenient to inspect at the week-ends, but if the week-end is cold and wet, then an inspection on another day will be essential, or you may well have a colony swarm before you can prevent it.

During May and June all stocks will construct *queen cups* protruding from the faces of combs, or hidden away in corners. If they are empty no action is needed, but they must all be carefully checked, so look carefully in all those holes and crevices. If you cannot see whether there is an egg or larva in a particular cup, then break it open to be sure.

As soon as you find an *occupied* cup, you should assume the bees have decided to swarm. It is not an immediate crisis, as they will not swarm till they have a *sealed* queen cell. There is an 8 day interval between the laying of the egg and the sealing of the cell, but you must assess how old the egg or larva in each loaded cup is to know how much time you have.

All methods of swarm control are based upon the fact that a colony needs to have three things present within it if it is to swarm. They are:–

1. A sufficiently large number of mature flying workers, i.e. workers beyond the age of just doing nurse duties etc within the hive, who will make up the bulk of the swarm.

2. A queen bee capable of flying off with the swarm.

3. A large enough brood nest containing at least one sealed developing queen cell which will be left to re-queen the temporarily queenless colony after the swarm has left.

If the colony that is preparing to swarm is deprived by the beekeeper of at least one of these three things, then it will not swarm until it has succeeded in once more having all three present. The very large number of different swarm control systems that have been devised by beekeepers differ only in the choice of which of the three to take away from the colony, and how. But however the initial move by the beekeeper is made, the crucial point is how that initial action is followed up, so that the colony can be persuaded to move on to the post-swarming phase, whether with a new queen, or with the old one still in place, or else so that it can be broken up into a number of small nucleus stocks each provided with a developing queen cell thus making increase in the number of the beekeeper's stocks.

The breaking up of the colony in the last way however should only be followed if the colony preparing to swarm is of a desirable strain, since by taking this route one necessarily propagates more colonies of that same strain. This is not a good idea if it is (for example) a bad-tempered or a very swarmy strain.

Here I shall present only one very simple system of swarm control in detail, but a small number of others are briefly outlined in an appendix. If you wish to try one of these other methods, then read more detailed text-books, and/or take advice from a beekeeper experienced in using that technique.

4.3.4 Queen removal as a method of swarm control

We assume that we have found a colony making swarming preparations. We assess that we have a day or two left before the colony can swarm, since the only queen cells we find are still unsealed.

The first thing to do, after reassembling and closing up the hive, is to collect together and prepare all the equipment needed to carry out the swarm control procedure. The things needed are:–

- A spare position on a hive stand. Have you always got one in reserve?
- An additional basic hive, consisting either of a complete small nucleus hive taking the same size of frame as your main hive, or a spare floor, brood box with a dummy, crown board and roof of the same design as the main hive.
- Some method of feeding sugar syrup or proprietary liquid feed to the bees in the new hive.
- Three brood frames of drawn comb (this is best if you have them) or fitted with foundation.

Any beekeeper entering the swarming season must have the ability to provide at least this if swarming is to be controlled satisfactorily.

Initial moves in swarm control by queen removal

1. Set up the new hive, and remove its roof and crown board.
2. Subdue and open the colony preparing to swarm, go through the brood nest carefully, and *find the queen.* This is essential and the only hard part of the operation.
3. Transfer the queen on the frame she is on carefully into the centre of the new hive box, removing any queen cells from that frame as you do so. Hold the frame over the new hive while you look for them, so if the queen drops off, she will be where you want her. Look carefully for them.
4. Transfer two more frames from the old colony into the new box, and place one on each side of the original frames, after removing any queen cells from these also. Choose frames with *very little brood, but with as much honey as possible.* The colony will be weak in bees at first and unable to forage for more honey.
5. Shake all the worker bees off two more brood frames in the original colony into the new box. All the flying workers on them will go back home, and only the nurse bees will stay with the queen, since when they fly, the flying bees will go back to the site they know.
6. Pack the three frames carefully up to one side of the new hive, ending with a dummy if it is a full-sized hive, or probably a frame feeder if it is a nucleus hive.
7. Restrict the entrance of the new hive to a maximum of a one-inch wide gap. As it will have very few mature workers it must have only a small entrance to defend against robbers.
8. Provide the new stock with a liquid feed using whatever method it is you have available.
9. Fill the gap in the brood box of the old stock with the three reserve frames you have provided. Do not split the brood nest when you do so, but put them at one end or the other, so the brood does not get chilled.

The original hive now has no queen, so cannot swarm. The new stock has no flying bees and no queen cells so it cannot swarm either. However we must ensure swarming conditions do not arise again. This is the diffifult thing and is the reason that all swarm control systems sometimes fail. This in turn is why new methods are always being devised, but occasionally the bees will swarm despite our best efforts.

Follow-up moves in swarm control by queen removal

1. Go through the remaining brood nest of the original stock on the start day, and if possible select *one good developing open queen cell* containing a *healthy developing queen larva* in a place where it will *not get damaged when combs are manipulated.* Carefully remove all other queen cells and cups from that frame, and mark the frame by sticking a drawing pin into the top bar.

2. Shake the bees off every other frame and remove every other queen cell. Do not miss any.

3. Four days later check that stock again and, after checking that the *selected queen cell is still developing satisfactorily* (or selecting then a good cell to keep), go through the brood nest again and remove any new developing queen cells. Be very careful and thorough with the frame containing the selected queen cell — that must not be damaged in any way — but bees should again be shaken off every other frame, to ensure no other queen cells are missed.

4. Another four days later do the same again. This stock can then be left in peace to re-queen itself in due course. When the new queen emerges the bees will not swarm away with her as there was only ONE queen cell and so they cannot have any developing queen cell to leave behind, since after the last destruction of queen cells, all brood will be too old to convert into a queen cell. You will have kept most of your foraging force to gather honey, and will with luck end up with a new vigorous young queen heading a powerful stock.

5. The small stock with the queen but very little brood and few bees can be left with a weekly check that its food supply is still all right, as it will have few foragers able to bring in new nectar and certainly will have too few workers to make up a swarm. Eventually it will start to build up and can then develop into another stock, or, if the re-queening of the original stock fails, the two can be re-united with the old queen after about six weeks.

An after-thought

If the stock preparing to swarm was from an unsatisfactory strain of bees, and you have access to the brood nest of a better strain, then a good move is at the second removal of queen cells to remove ALL the queen cells (including the selected one) and to replace one frame from the centre of the original brood nest with a frame of eggs and developing larvae from the better strain. Be very careful to transfer as few bees as possible, but only the frame of brood and certainly NOT the queen.

The workers in the queenless stock will immediately build some emergency queen cells on the young eggs and larvae they have been given, and you can with two successive 4-day-apart visits ensure that only ONE of these is left, so that again the stock will re-queen without swarming. You will lose almost another week of egg-laying, but should end with a queen of a better strain.

4.4 Taking a swarm

When you find a swarm — your own or somebody else's — it is one of the most delightful parts of beekeeping to deal with it, if it is in an easy place. This is particularly so if it is in a stranger's garden who doesn't know about bees. All sorts of passers-by are willing to stop and watch from a distance while you work what looks like big magic, when in fact with a placid newly-emerged swarm it is child's play.

In a hard place — up a high tree, in a chimney, under the eaves of a roof — it is less fun; and you may break your leg or your neck, although the bees still won't hurt you.

However if the swarm has been out for a few days and is stale, they will have used up their reserves of honey and be far less amiable. Then be sure your veil is secure.

A swarm can only be taken when it has clustered. Ideally it will do so as my first one did from a few slender twigs low in a privet hedge, hanging there like a bunch of exotic fruit, with a few bees buzzing around it.

Necessary equipment:–

- veil and protective clothing;
- smoker, fuel and matches;
- a cardboard or other open box at least 30 cm (1 ft) cube (not smooth plastic — the bees hate that);
- a dustsheet;
- secateurs;
- a small stone;
- a piece of string;

Method: Light the smoker. Put on protective clothing. Approach the swarm quietly with *no* smoke. Place the dustsheet on the ground below the swarm cluster. Place the box on the dustsheet. Gently grasp the twigs above the swarm cluster and support its weight — up to 3 kg (6 lb) of bees, so quite heavy. Cut the twigs with the secateurs *above* your supporting hand. Lower the swarm gently into the box. *Slowly* and *gently* invert the box on the sheet and prop up one corner with the small stone, so that there is a gap for bees to fly in and out. Most of the bees will cling to the inside of the box and cluster there.

By now quite a few bees will have taken wing. Smoke their old clustering place *heavily* and use smoke to break up any clusters forming away from the box. KEEP SMOKE AWAY FROM THE BOX. Provided the queen is in the box — which she almost certainly is — the bees in and around the box will start to fan out scent from the box at the propped up corner wth their tails up exposing the scent-giving *Nasonov organ* at the tips of their abdomens. As they do so more and more of the flying bees will re-join the main cluster in and around the box and gradually enter the box to join the rest of the swarm.

Wait till you are satisfied that you have 90% or more of the swarm in the box, gently remove the stone, fold the sheet up over the box, tie it securely with the string, and put your prize in a cool sheltered spot until evening, making sure they have adequate ventilation.

If the cluster is in a slightly harder place like a wall or a large tree branch, then as much of it as possible must be *knocked* or lifted by handfuls and *thrown* firmly into the box, which is then inverted as before. If you find the queen, cage her in an empty matchbox, just open a crack, and place her in the cardboard box beside the bees. The rest of the swarm will then join her.

Having got as much as possible of the swarm into the box, proceed as before. The bees will *always* return to the queen, so you *must* get her in. Until the cluster in the box is well-established with the queen there too, the swarm will keep trying to re-cluster where it first was, because the queen's scent clings there, and even after the main body are settling down in the box, clusters will keep trying to re-form on the old place, and there is always the danger that they may entice the queen back to join them. If it is feasible to give that place a dab of old car engine oil, it quickly cures that problem.

4.5 Hiving a swarm

In the evening the swarm must be hived, which is another fascinating operation. Prepare an empty hive (have you got a spare one?) on what is to be its permanent stand, with a floor, brood box fitted with sheets of foundation, a feeder, a crownboard and a roof. Put liquid feed into the feeder before you hive the swarm.

Sloping *up* into the entrance with *no gap* lay a board of plywood or hardboard or other convenient material (hiving board), about 45 cm by 60 cm (18 in by 2 feet), and lay a white sheet over it.

As the sun is setting bring the swarm to the hive, carrying it gently in its wrapped up box. Put on your veil and protective clothing, open the box and bump the swarm out firmly on to the hiving board, making sure that you have knocked all the bees out of the box. They will not fly much at that time of day, which is the reason for waiting till evening, but will spread out like liquid on the board. Gradually a few leading bees will start to run up the board and when they find the hive with its inviting smell of beeswax, will start to fan scent to call the others. Like an orderly army on the march the swarm will walk in and take possession. It may take two hours for all to enter. If you watch carefully you may see the queen go in. Once you see them beginning to march in in a body you may leave them. Next day remove the hiving board.

A newly hived swarm should be fed generously with sugar syrup. They will repay you by drawing out beautiful straight combs of worker cells on the frames of foundation you have given them.

After a day or two, look in quietly and remove any frames the swarm is not covering. Put a dummy at one end of the remaining block of combs and move the block gently over to the opposite side of the hive. Fill the resulting empty space with loosely folded rags or crumpled newspaper to prevent the swarm from clustering there and drawing wild unframed comb hanging directly from the crownboard. Swarms love empty spaces so this is a very necessary precaution. The frames removed can later be replaced one at a time as the new colony develops and needs the space.

An inspection after a week or two should show a healthily developing brood nest. Remember however that not a single new worker can emerge from it until three weeks have passed, and that until then the swarm will dwindle through natural losses.

4.6 Dealing with a swarmed stock

If the swarm came from one of your own hives, then you must at all costs prevent the issuing of *casts*. Sometimes a swarm may have gone without your knowledge. If an inspection shows a depleted hive and several queen cells, some sealed, you will know that they have gone beyond recall, and that your hive is for the meantime queenless. While it remains queenless it will be short-tempered. There are two possible courses of action.

The first is to write off the hive as a production unit of honey for the season, but to treat it as a potential source of young queens. It may be possible to make up from its brood frames 3 or 4 viable nuclei, with one queen cell each. This should only be done if the hive had proved itself earlier as having a strain of productive and gentle bees. If this course is taken, the honey supers can perhaps be given to other hives to finish, after shaking off most of the bees into the nuclei.

The second course is to see that at least the hive re-queens itself as fast as possible, and builds up again for the later part of the season. Note however that a new queen hatching in a well-populated stock takes a very long time to get mated. The natural order of things after a hive has finished swarming without interference, is for a new queen to emerge into a depleted hive, and in these circumstance it is found that she is much quicker to go out on her mating flight and to start laying.

To achieve the re-queening of a full stock after it has swarmed, the brood combs should be inspected until a well-formed but preferably *unsealed* queen cell, well placed in the middle of a comb is found. The bees should then be gently *brushed* from this comb, and any other queen cells on it destroyed. The top bar of this frame should then be marked with a drawing-pin and the comb gently and carefully replaced in the hive. That queen cell is your precious new queen and must be handled with care.

Next the bees should be bumped off every other brood frame in turn into the hive and *all* other queen cells destroyed. Don't miss any.

N.B. Always locate and mark the queen cell you are going to KEEP before any queen cells at all are DESTROYED.

If in going through the hive you come across a newly emerged virgin queen, or, as quite often happens, one issues from a cell when you break the top with your hive tool, ALL other queen cells should be destroyed. It actually doesn't matter if more than one virgin gets loose, since without a sealed cell to leave behind, the hive will not swarm. Instead the workers will let the virgin queens settle their differences in the usual way.

If there is still open brood in the hive at this stage, further inspections four days and eight days later are needed to make sure the bees have not constructed new emergency queen cells on some of the young larvae. If they have, these must also be destroyed.

The stock should now be left for ten days or so, and then the marked queen cell sought out to make sure that the new queen has emerged as shown by a neat round hole at its lower end. The stock must now be left for the new queen to mate and begin laying.

As stated above a virgin queen in a small nucleus usually mates and begins laying much sooner than one in a large prosperous colony. Initially the swarmed stock will in fact recover strength quite quickly as the old queen's remaining brood matures and emerges. However after three weeks this is followed by a steady decline, since the gap in egg-laying after the swarm's departure means that there is then a corresponding gap in the emergence of young workers. If you have available a young mated queen in a nucleus to re-queen the swarmed stock immediately, this will avoid the long decline caused by a long gap in egg-laying. Note however that if you are going to re-queen with a young mated queen, you should destroy all queen cells, wait five days and destroy any further late queen cells, then wait another five days and check again for queen cells, at which point you may unite the stock with the nucleus (see later on uniting stocks). If you unite them earlier, the old stock may still have the swarming fever and fly off with your lovely new queen.

A swarmed stock that has re-queened itself or has been re-queened will not usually swarm again that season, but needs to be nursed back to strength.

4.7 Hiving a swarm on the site it came from

If the swarm that emerged was caught, a slightly different plan often works well.

In the evening remove the hive that has swarmed to a new site, and on the old site place a new brood box with empty combs or frames of foundation, but with an extra queen excluder placed *beneath* the brood-box above the floor. Hive the swarm in this new hive on the old site, by bumping the swarm in from the top through a completely empty super used as a funnel. Then smoke the bees down and cover them with a queen excluder.

Top it up next day with the queen excluder and the supers from the old hive. Usually the swarm will settle down and do well, as they will be joined by all the foraging workers from the old hive who of course make their way home to the old site. After a week or so remove the queen excluder from under the brood box of the new hive, which was put there to prevent the swarm from absconding a second time, before the swarming queen had established a new brood nest.

Watch food supplies in both stocks and give liquid feed to either if it is needed.

The old brood box on its new site should be treated as a swarmed stock in the usual way, and when its new queen is laying, the old queen can be destroyed and the two stocks re-united (see on *uniting* later on). With luck this will become a really powerful stock for late sources such as heather.

4.8 Moving bees: the heather flow

Foraging worker bees have accurately memorised the site of their home. If it is moved more than about 1 metre (3 feet), they will not be able to find it and will cluster on the old site when they return, become chilled at night, and die.

The only exception (apart from when they swarm) is that if their home is moved more than about 5 km (3 miles), they will be in completely unfamiliar territory where they are forced to re-learn everything, and will not return to their old home. Hence the rule for moving bees — "Less than 3 feet or more than 3 miles". When nuclei are set up in the home apiary it must be remembered that by this mechanism they will lose most of their foraging workers, retaining only the young nurse bees, who will gradually mature into foraging workers with a new base. Apart from their small size, this is why such nuclei are weak in guard bees and tend to be robbed by other colonies unless they have small entrances, easy to guard.

The main blossom honey month around Dunblane and Stirling is July, and unless they can forage on Himalayan Balsam, a fairly new arrival in this area, after the end of July, there is little for the bees at low level. However the ling heather on the upland moors provides plentiful and much-prized heather honey in good seasons, and going to the moors in August is often well worth while provided you have strong stocks of bee to take there. Weak stocks make little of it.

The first step in going for this honey is to obtain permission to place your bees on the moor. Dunblane and Stirling Beekeepers have a long-standing arrangement to be allowed to place bees on Sheriffmuir, and if you sign up for that, it is an easy option.

Prudence then demands that you go there a week or so before you move the bees to reconnoitre and prepare hive stands. The last week in July is the best time for this.

Moving hives single-handed is perfectly possible, but it is much easier with two who can use a pair of hive-carriers between them. For long moves such as are made to the heather over distances greater than three miles, motor transport is obviously needed. On the day *before* the move, the hive boxes should be arranged with adequate empty super storage space above, but with enough stores in the hives to ensure that the bees do not starve if the weather turns bad. The crown board should be replaced with a travelling screen of perforated zinc or wire mesh to give complete top ventilation. The boxes should then be securely fastened together with ratchet straps, or by nailing battens to them, or by some other method. Whatever method is used, it must also ensure that both the floor and the screen board on top are secure. Means should also be laid ready for the final shutting of the hive entrances. A strip of foam rubber is extremely effective and is less trouble than the traditional wooden entrance block. Then the hive roofs should be replaced on the hives and the bees left to fly until the actual time of the move.

Next evening, as soon as the bees have stopped flying, the hive entrances should be closed and the roofs removed to give top ventilation through the travelling screens. In hot weather a powerful stock completely enclosed without adequate ventilation can in its panic quickly raise the temperature inside the hive above the melting point of beeswax. The bees and brood will then be engulfed and drowned in the collapsing mess of honey combs.

Hives are then loaded up for transport ready to be driven to the new site. There is much to be said for leaving the actual move until early morning since placing of the bees on the heather site can then take place with dawn breaking, rather than with the sun setting to leave you to blunder about in the dark. Place ALL the hives on site before releasing ANY. You must aim to have this completed before 10 a.m. at the latest. Then put on your protective clothing and quickly open each hive, immediately replacing the roof so that the flying workers do not cluster on top of the screen and become trapped. Then leave the bees to settle.

A later visit can be made and warm packing placed above the travelling screen to conserve heat. Bees at the heather are notoriously ill-tempered so be prepared!

The return from the moors is just the same operation in reverse, but is less fun as the days are shorter by September, the weather is usually worse, and if you have been successful the hives are much heavier.

Appendix: some other swarm control methods outlined

The method of swarm control explained earlier in detail aimed to prevent the colony from swarming by *removing the queen.* Many of the other methods in use instead rely on *removing the brood nest and developing queen cells*, but keeping the queen and foraging bees on the original site. Among these are the **Pagden, Demaree, Snelgrove** and **Horsley Board** methods.

All these methods require the provision of an extra brood box fitted with a full complement of frames, with drawn comb if you have it, or if not, then fitted with foundation. This is placed on a floor or a board on another hive stand initially, and two central frames are removed.

Initially the queen is found in the stock preparing to swarm, and is transferred on that frame into the gap in the new brood box, with queen cells carefully removed from it. The frames are closed up in that box, and one of the frames originally withdrawn is returned, the other being used to fill the gap in the brood box of the colony preparing to swarm.

The brood box of the stock preparing to swarm is then removed to a temporary stand, and the new brood box placed on the original floor, with the queen excluder and supers of the original stock above it.

The difference between these methods then appears in the treatment of the brood box with the developing queen cells, but now with no queen.

In the Pagden method this is set up on its on floor on an adjacent stand, as another indpendent hive.

In the other methods it is placed *on top of the hive with the queen* so both stocks remain under one roof. In the Demaree method, the top stock is on a second floor placed above the crown board of the lower stock. In the Snelgrove and Horsley Board methods, the two stocks are separated by special boards with various openings in them.

The follow-up moves are the tricky part of these methods, and I shall say no more about them here. If you are interested, then look them up in one of the text books available in our Library. As always with swarm control, success depends on preventing swarming conditions from appearing again, by careful systematic follow-up moves.

Chapter 5

Autumn and winter management

5.1 Removing honey

The first task to be undertaken in preparing the bees for autumn and winter is to remove what harvest of honey has been gathered by the end of the season, though sometimes this can be done earlier.

As soon as a honey super is full and the cells are capped it is ready for harvest and may be removed. A glance inside heavy supers will show when this is so. If the honey is even in part from the Oil Seed Rape crop, and you wish to extract it by spinning, it is vital to take it off promptly, since this particular honey granulates very quickly and very hard in the comb. If you leave it too long, you will have no option but to break up the combs and soften the honey again with gentle heat, or else to sell or use the honey as honey in the comb. It is worth while emptying and replacing supers if they are filled before the last flow, and of course this should be done before moving to the heather. Note however that you must at all times ensure that you leave on the hives a sufficient reserve of honey to tide them over a few weeks of bad weather when they cannot forage for more. As was said earlier, bees in their active summer mode use much more food than when they are clustered for winter, and can quickly starve if this precaution is not observed.

To remove a super, lift it off the hive, replace all the other boxes if it was not the top super, place the crown board on next with two Porter bee-escapes fitted into the two feed holes, or instead use another type of clearer board. Then put on the full super and finally the travelling screen to make the super bee tight apart from the way down through clearer board. Then replace the roof. In twenty four hours almost all the workers in the full super will have gone down through the clearer board to re-join the queen and the rest of the colony and the super can be removed without further disturbance of the colony. Do not wait longer than this, or the honey may start to granulate in the comb, or robber bees may find a way in and remove the honey. Also if Porter escapes are left on the hive too long, the bees will jam the springs with propolis rendering them ineffective, or else, if another type of clearer board is in use, the bees will learn how to get back through the maze and will rob out the honey.

When Porter escapes are removed, and feeding is not going on, the holes in the crown board should be covered with pieces of scrap wood, or something else convenient, to prevent the bees from accessing the space under the roof and building wild comb there, which would make it difficult to lift the roof off.

5.2 Uniting stocks

It is often desirable to unite together two stocks, particularly in autumn, so that a weak stock need not be wintered. If a young queen has been raised in a nucleus, this is the way to use her to replace an older queen, particularly one that has been involved in swarming.

Bees from different stocks will fight one another if indiscriminately mixed, so precautions must be taken.

The job is most easily done if no honey supers are involved and the best time is in the autumn after all these have been removed. The stock with the new queen must be housed in a full-sized brood box able to sit above the original hive. It does not need to have all the space in the box filled with empty combs if it was a nucleus, but the last comb should have a dummy outside it, the combs being packed to one side of the box.

If the stock being re-queened is not queenless, the queen to be replaced must be found and destroyed, preferably in the early afternoon, and then all left quiet until sunset. At sunset, quietly and with as little disturbance and smoke as possible, remove the roof and crownboard from the now queenless stock, and cover it with a single sheet of newspaper, which can be secured with drawing pins if it threatens to blow away.

Then take the roof quietly off the other stock, but leave the crown board on. Lift its box away from its floor and place it gently on the newspaper, taking care not to tear it, but squaring the boxes together. Then replace a roof and leave them alone for a week.

The bees will chew their way through the newspaper and unite peacefully, as their scents will be mingled by the time they can get at one another. A mess of chewed up newspaper outside the hive entrance next day is a sign of success.

After a week combs may be readjusted as you please between one or two boxes to give good wintering conditions.

If uniting when honey supers are on, then the excluder should be placed *above* the supers when the old queen has been destroyed, and the newspaper should be laid on it or under it. At the readjustment a week later, the new queen with her brood nest should be moved below the supers and united with the other nest, and the normal pattern restored. It may be necessary at that time to remove a few emergency queen cells from the old brood nest, since the new queen was so widely separated from it for a week that bees below may have started queen cells.

5.3 Feeding bees

If remaining stores are inadequate in September, or if stores are short in spring, or if a swarm is hived, bees should be fed with proprietary liquid feed or sugar syrup.

Feeders for feeding syrup are of several types. A *contact* feeder consists of a jar or pail with a lid perforated by several small holes. Inverted over a hole in the crown board it will be slowly emptied by the bees as long as the holes are small enough to allow a partial vacuum to form in the pail so the feed doesn't all run out at once. It must be protected by an empty super which holds the roof clear.

Much more rapid feeding is achieved by various patterns of *rapid* feeders of which the best and most capacious are the overall Miller and Ashforth designs that need no super to house them. Many small feeders of other patterns are rather footling, but the large "English" rapid feeders are satisfactory, though requiring to be placed inside an empty super above the occupied hive. They must also be carefully positioned so bees can access the feed hole and so that they sit level or nearly so.

Bees will take down and store in one or two days a 3 kg feed from an Ashforth feeder which allows stores to be rapidly brought up to an adequate level and ripened by the bees in September. The principle of all these rapid feeders is that the bees are allowed access to the surface of the syrup through a *narrow* slot, so that they don't fall in and drown themselves. Those rapid feeders in which the round access hole has a plastic cup over it must *always* have the cup in place when they are given to bees, since otherwise they are a lethal death-trap for the bees.

For spring feeding or the feeding of a swarm, such rapid feeding is less desirable, since it is not the aim to fill the combs then with sugar syrup, or the queen's laying room may be restricted. Feeding smaller amounts over a longer period is then better, and a contact feeder is probably best.

If bees are found by a quick glance under the crown board in mid-winter to have eaten their way up through their stores, *solid* food must be given in contact with the bees, since they will not enter a feeder at that time of year, and any syrup given will not be ripened, but ferment and give the bees dysentery. The traditional solid feed is candy made from sugar, for which a recipe is given in the Appendix to this chapter. Alternatively Archie Ferguson's trick with sugar bags may be used. That too is described in the Appendix. Special bee fondant can also be purchased, and makes an excellent late feed. It can be left in its plastic bag, with an access hole cut in the lower side in contact with the bees.

The solid feed must be placed in direct contact with the bees at the top of the cluster, either by placing it over the feed hole in the crown board if the bees are under that hole, or by removing the crown board and placing the candy directly over the bees. If the latter technique is used, then the feed should be covered with an old piece of blanket or an old jumper to keep heat in, and if necessary an empty super placed between the cluster and the crown board.

5.4 Preparing bees for winter

During September all colonies should be prepared for winter. Weak stocks should be united with others so that all have large enough worker populations to form viable clusters. If possible all should be headed by queens under three years old.

Every colony should have its stores checked and be fed if necessary to bring the weight of sealed stores up to at least 15 kg (30 lb) and preferably 20 kg (40 lb).

If any honey supers are being left on over winter be sure to *remove the queen excluder*, so that the queen can move up with the cluster if necessary. The workers will not abandon the queen and will stay down and starve with her if she cannot get up.

Make sure all hives are water-tight and will not blow over and that they are not rocking on their stands. Bees dislike a hive which moves when they are sleeping. Also be sure each hive slopes from back to front a little, to help any rain-water that blows in at the entrance to drain out again. If an open mesh floor is in use, this is not such a necessary precaution, as water will drain out through the open mesh.

By the first week of October fit *mouse-guards* to all the hive entrances. Mouse-guards can be bought and are fairly cheap. They should be pinned securely across the hive entrances with drawing pins. Alternatively a closely fitting entrance block can be used, provided its entrance slot is NO MORE THAN 6 mm ($\frac{1}{4}$ in) HIGH. The bees thoroughly dislike these operations at the hive entrance, so wear your full protective clothing while you do it, and have the smoker going and use it as necessary, or you will bodge the job.

If mice get into a bee-hive in winter they can very effectively kill it by eating the combs — honey, wax and brood. They will also eat the bees. They then nest, as they find a warm dry beehive an ideal nesting box, and they will then produce more mice to trouble you next year.

5.5 Managing bees in winter

Managing bees in winter is for the most part best done by leaving them alone. However every two to three weeks certainly from December on it is prudent to check that they still have enough food. This is particularly important if the colony is small and/or was light on stores in autumn. With experience the weight of stores can be well assessed by "hefting" the hive — i.e., lifting each of two opposite sides gently in turn an inch or so and gauging the weight. If you are not confident about this, then a quick peep under the crown board (with your veil on!) can tell you a lot. If no bees are to be seen, then either all is well and the bees are still well down, or they are already dead (let's hope not!) and there is nothing to be done. If the bees are visible on top of the frames, they are short of food and must be given candy or fondant as described above. After feeding with this starts, it must be checked every 2 to 3 weeks, and topped up as necessary. A few pounds spent on feed is money well spent to keep the bees alive.

There are some *Varroa* treatments best carried out in mid-winter, but that will be covered in Chapter 6.

5.6 The end of winter

The period when bees are in greatest danger of starvation in Scotland is from February till the end of April. Meteorological Spring starts on March 1st and astronomical spring at the spring equinox on March 20th or 21st, and in some seasons it is true that by that time early sources of pollen such as snowdrop, crocus and dandelion are available, and if gorse is in bloom and/or the willow catkins are out and also the weather is fine, the bees will be replenishing their honey stores with fresh nectar. But not too many years ago we had a spring in Dunblane when we had a major snow-fall at the beginning of April which did not thaw till the start of May. The start of spring for the beekeeper is determined by the thermometer, the anemometer and the rain gauge and not by the calendar.

Early checks described in the section on preparing for winter will ensure that all stocks have enough stores to last till mid-February, but with queens starting to lay again then, and cluster temperatures being raised, the last of the stores can melt away as fast as the snow is thawing on the ground.

In March, even if it is cold, each colony's food supply must be regularly checked, but unless the weather is really warm this must still be done without inspecting the combs.

Hefting , once you have practised it a number of times becomes a good way to check the stores of those hives which have not needed fondant or candy, so do that regularly to develop the skill.

Also as described above, if candy or fondant has been provided over the cluster, a quick check of the cake(s) of candy or bag of fondant, with veil on and the crown board briefly lifted if necessary, will show whether it is nearly all eaten, and more can be supplied if necessary.

If the weather is starting to warm up you might consider putting on a feeder to feed spring syrup. See the Appendix to this chapter for feed recipes. Do not over-feed syrup at this stage, or you will encourage the bees into excessive early activity which is self-defeating, and more importantly you will clog up with syrup all the empty cells in the brood frames where the queen should be starting to lay, and you will make the bees feel the hive is congested very early. This is likely to encourage early swarming which you do NOT wish. A maximum of 2 to 3 kg of sugar as syrup should allow the bees to survive until the weather warms up, unless the spring is very late and cold. Be prepared for that however, and if you have to feed candy or fondant again, then do it. Bees without food die, and cannot be resurrected. Be especially watchful if a warm spell is succeeded by a return to winter weather which happens all too often in Scotland.

Any hive where bees are not "up" by mid-March should on the first reasonably warm day be investigated by lifting combs up till the bee cluster is found. If it is a small living cluster and has got trapped below an area of empty comb there is danger of *isolation starvation*, so somehow you must get candy or fondant into contact with them urgently, even if that means wedging it somehow between combs, maybe removing an end comb. On any occasion when the crown board is briefly lifted, it is always reassuring if at least one inquisitive live bee pokes its nose up to show they are still alive.

If they are dead, the sooner you clean up the mess, the better!

However if you keep watching and feeding as necesary, then when spring finally does arrive you will find at your hive one sunny day the welcome sight of many busy workers bringing in abundant fresh pollen, and on that nice warm day you can do the all-important spring inspection to launch the new active season.

Appendix — providing food for bees

Commercially prepared bee food

Many local Associations purchase trade quantities of commercially prepared liquid and fondant and dispense it to members, selling it at competitive prices. The real advantages are that invert syrups and fondant are much easier for the bees to digest, to process and to store for winter use. Home-made sugar syrup can ferment and requires considerably more effort on the bees' part, to ready it for Winter. Care needs to be exercised when feeding home-made sugar syrup, that you do not give your bees dysentery problems from un-ripened or mouldy sugar syrup.

Purchase of commercially prepared products gives beekeepers products that are ready to use and can be stored successfully for several months, in a cool dark place. Fondant can be re-wrapped and used the following year. Invert syrups have added vitamins and are a close approximation to honey in the nutrients that they contain.

You are able to feed honey bees with invert syrups for longer, during mild weather, as long as it is warm enough for the bees to go up into a feeder, long after you should stop feeding home-made sugar syrup.

Visiting the Association Apiary during the lead up to Winter preparation, you will see the feeding and the products that are used, to give the bees the best chance to survive Winter. Feeding is often needed throughout the year, if forage is scarce, and invert syrups can be used, with different types of feeder, depending on the season; they can be stored for ready use all year round.

Recipe for sugar syrup

If you choose to use your own home-made sugar syrup which is cheaper than commercially prepared feed, here is the recipe.

For a *light* syrup for stimulative feeding or to feed a swarm, to each 3 kg (about 6 lb) of ordinary granulated sugar, use 3.5 litres (6 pints) of water.

For a *heavy* syrup, best for autumn feeding, for each 3 kg (6 lb) sugar use 1.7 litres (3 pints) of water.

Put the sugar into a plastic pail with a snap-on lid or other convenient receptacle. Bring the water to the boil and pour it over the sugar. Stir till the sugar is dissolved, snap on the lid and take the feed to the bees. The actual quantities can be varied to suit the capacity of your feeder, but keep to these proportions.

Recipe for candy

Here is the recipe for home-made candy which again is cheaper than commercially prepared fondant.

Ingredients

- White granulated sugar — 5 measures by volume.
- Water — 1 measure by volume.

or

To each 1 kg of sugar use 180 ml of water,

or

To each 1 lb of sugar use 3 fluid ounces of water.

Equipment

- Cooking stove.

- Thick bottomed saucepan of adequate capacity.
- Wooden spoon.
- Disposable moulds to receive candy.

Method

- Prepare the moulds for the candy. Small ice cream tubs, or halves of discarded small cardboard soft drink cartons, or sheets of A4 paper with the edges folded up by about half an inch and stapled to make shallow trays are all satisfactory. These will be used to give the candy to the bees and are usually discarded afterwards. The plaastic dishes in which Chinese restaurants suppy take-away dishes make excellent moulds which can be re-used.
- Place the sugar and water in the saucepan, bring to the boil slowly while stirring with the wooden spoon to prevent the mixture from "catching".
- Boil vigorously for *three minutes exactly* stirring occasionally.
- Remove the saucepan from the heat, and if possible cool it rapidly, say in a sink partly filled with cold water, while *beating the mixture vigorously with the wooden spoon.*
- As soon as the mixture starts to thicken, turn it out into the moulds and let it set.

Archie Ferguson's method with sugar bags

Here is another method to use in place of fondant.

Buy a few bags of sugar. Without opening the bags, dip them briefly in cold water and let them dry and harden. The timing of the dipping in cold water is critical. Too short a time and the sugar fails to harden, too long and the sugar melts into a syrupy liquid. The time needed depends on the quality of the bag.

Remove the crown board and place an empty super over the hive. Tear away the paper from one side of the hardened bags, and lay them gently over the cluster of bees. Cover them with an old blanket and over all place the crown board and roof. The bees will eat their way up through the crystallised sugar as though it were candy.

Chapter 6

Diseases and pests

6.1 Introduction

In this chapter all those diseases and pests which need to be of practical concern to the beekeeper are systematically dealt with. The chapter is arranged by the types of causative agents of the problems that arise, from the smallest — the viruses, to the largest — human beings.

However before dealing systematically with this, you must first of all note the following. There are **four** diseases of bees which are at present (2018) **notifiable by law**. They are **American Foul Brood (AFB)**, **European Foul Brood (EFB)**, infestation with the **Tropilaelaps mite** and infestation with the **Small Hive Beetle (Aethina tumida)**. If you discover or suspect that your bees have any of these then you are obliged by law to report the matter to the local Bees Officer of the Scottish Government Rural Payments and Inspections Directorate (SGRPID) — see 6.11.2 for contact details. **Varroa** infestation had become so widespread in Scotland by 2007 that in that year this was removed from the list of notifiable diseases.

Infestation with the *Varroa* mite is a serious problem, but as it is is now endemic throughout most of Scotland and certainly is universal in the Stirling area, it must be dealt with annually in our area.

The other serious diseases were until recent years uncommon in Scotland, but the picture unfortunately changed in 2009.

Serious outbreaks of both AFB and EFB were discovered in that year in central Perthshire and Angus and also in the Inverness area. One outbreak of AFB was found in West Lothian in 2010, but although it appeared at first that measures taken in 2009 to bring these diseases again under control had been largely successful, further outbreaks of both have occurred in every year since then of both EFB and AFB. So continuing vigilance, practice of apiary hygiene and caution about moving bees are still advisable. Details of what this involves are given later.

The Small Hive Beetle is a native of sub-Saharan Africa. There it causes little difficulty, but it was unfortunately discovered in 1996 to have been inadvertently imported into the United States where the different conditions provided by large scale commercial beekeeping made it a serious pest. Sadly in 2014 an outbreak was found in southern Italy. Many imports of bees commonly occur from Italy to the UK, so this now means there is a real risk of the import of Small Hive Beetle here. So far it has not been found in the UK (except in specially monitored laboratories for scientific work), but there is a need for vigilance. It is a notifiable pest, so must be reported by law if you find it.

6.2 Viruses

The systematic study of viruses is fairly recent, as it is only since the development of the electron microscope that it has been possible to see these tiny entities, which are in fact not independent living creatures. Each one consists of just a small amount of either DNA or RNA — the stuff of the genetic code — surrounded by a protein coat and little more. They can only reproduce by gaining entry to a living cell, usually a specific cell type of a much more complex organism, and inside the cell taking over and turning most of the cell contents into further copies of the virus particle. The dead cell then bursts open releasing the new virus particles to infect further cells of the host organism, or to be released into the outside world to seek a new host. The most successful viruses are ones which can readily pass by infection from one host organism to another, but which do not seriously disrupt the life of the host, and certainly do not kill it. Most human beings who have suffered from chickenpox continue to carry the virus for the rest of their lives, and it is only rarely that the virus is *activated* or undergoes *induction* in the human's later life producing the much more serious affliction known as shingles. It is significant that shingles normally appears when a person is under severe stress, either from the pressures of life, or from some other disease, and this pattern is one which is of great importance when honey bee viruses are considered.

The work of L. Bailey and Colin Denholm at Rothamsted Institute of Arable Crops Research (IACR) in England have greatly extended our knowledge of the great range of viruses which are present among honey bees. Among those which have been identified are Sac-brood virus (SBV), Acute Paralysis virus (APV), Slow Paralysis virus (SPV), Cloudy Wing virus (CWV), Deformed Wing virus (DWV) and Black Queen Cell virus (BQCV). Almost all these viruses can be shown to be present at low levels in a high proportion of bee colonies. When this is the case the colonies remain perfectly healthy, but as for shingles among human beings, when the colony comes under stress, or the levels of virus present are raised above a certain level, the colony begins to suffer as a result.

Sac-brood virus causes a failure of affected larvae to moult properly. The moulted skin fails to detach itself from the larval head, and the larva dies becoming initially a fluid-filled sac enclosed within the skin which has not been moulted. Ultimately this dries up within the brood cell and forms a distinctive "Chinese slipper" appearance.

Acute Paralysis virus and Slow Paralysis virus both cause affected adult bees to develop paralysis of their flight muscles, and to become black and shiny. Sometimes other workers attempt to eject the paralysed workers, and a severe attack of paralysis can look like robbing by another hive. Acute Paralysis virus kills its victims more quickly than Slow Paralysis virus.

The other viruses cause problems in the affected brood or bees of a kind reflected by the name of each particular virus.

For none of these viral infections is there any direct treatment available, and the only action the beekeeper can take is to try to reduce the level of stress on the colony so that the activated virus returns again to its quiescent state. Very often the stress is caused by a disease or infestation of another type, and the beekeeper must endeavour to control that.

6.3 Bacterial infections

Two of the most serious diseases of honey bees are caused by bacteria, which are the organisms most of us mean when we talk of "germs". These can be seen under a high-power optical microscope, and were the first kind of pathogens to be widely studied following the work of Pasteur and Koch in the nineteenth century. Many of them are susceptible to antibiotics, which viruses are not, and the widespread use of antibiotics in both human and veterinary medicine shows their importance as a group of disease-causing entities.

6.3.1 American Foul Brood

American Foul Brood (AFB) is a disease of the sealed brood caused by a spore-forming rod-shaped bacterium called *Paenebacillus larvae*. It is by no means restricted to America, but got its name because it was first described there. Because the bacterium forms spores when it is not actively infecting a honey bee larva, and because these spores are resistant to drying out, to cold, and to a rather high level also of heat, it is extremely difficult to eradicate this infection. The spores can live for many years in old comb or stored honey, or even in honey in jars for human consumption (where they do no harm at all to humans). For this reason it is very bad policy ever to feed bees on honey from an unknown source — imported honey poses a very real danger of causing an outbreak of AFB if it is used as feed for bees. The sharing of honey processing equipment can also be hazardous, and should not be allowed in areas where AFB is present. For this reason also it is good policy never to encourage robbing by leaving traces of honey around the apiary after inspections of hives.

Larvae become infected by being fed with honey containing spores of *P. larvae* by the workers. It is only after the larvae have pupated that the infection spreads through the larval tissue and the larva dies inside the sealed cell. The capping of the cell then takes on a wet and sunken appearance, and the worker bees may make some attempt — usually unsuccessful — to clean out the cell, so that the capping may be perforated. At this stage a matchstick inserted into the cell, twisted and withdrawn can draw out the rotting larval remains into a sticky thread 2 to 4 cm in length. This appearance is almost diagnostic of AFB, but diagnosis should be confirmed by microscopic examination of the larval remains by an expert in the subject.

Later the larval remains dry out into a scale which is so securely attached to the cell floor that the bees cannot detach it to clean out the cell, and the brood combs of a severely infected colony contain many unused cells and so take on a suspicious "pepper-box" appearance. The scales contain many thousands of spores of *P. larvae* and form a long-term reservoir for repeated re-infection of successive generations of larvae.

Colonies infected with AFB usually die out within at most two years of becoming infected. In the last stages of the disease they become a serious hazard for all beekeepers in the area, since the weakened stock becomes a target for robber bees from any colony within a mile of the infected one. The robbers inevitably pick up spores of *P. larvae* and take them home to start an infection within their own colony.

Some races of honey bees have been found to have an innate hygienic behaviour, so that they make determined and successful efforts to clean out the remains of infected larvae. Some of these races can tolerate infection with AFB, and in parts of the world where AFB is endemic, efforts are being made to breed such strains up so that no other treatment is necessary.

P. larvae in its *active* phase (not its spore phase) is susceptible to sulphathiazole and some other antibiotics, and in some countries over-seas, treatment for AFB with antibiotics is routine. This carries two hazards with it. The first is that it is all too easy to suppress but not eradicate an infection by this means. In this way outbreaks of the disease can be allowed to continue for many years as a threat to other beekeepers. The other difficulty is that treatment with antibiotics (some of which are used in human medicine) carries with it the risk that honey will become contaminated with significant residues of antibiotic, which may interfere with the medical treatment of people who have eaten such contaminated honey.

Within the UK AFB is a notifiable disease, and so must by law in Scotland be reported to the local SGRPID officer when it is detected. Local Bees Officers are also obliged by law to seal up any colony known to be infected with AFB, to kill the bees, usually by introducing petrol through the feed hole, and to destroy all the bees and combs by fire at night when no robbers will be flying. The remains must then be buried in a pit. The hive boxes themselves may be kept for re-use if desired, but they must be disinfected by scorching with a blowlamp.

Note also that spores of AFB may be carried on apiary equipment such as hive tools, gloves and smokers. Any metal items can of course be disinfected either by prolonged boiling, or by scorching, but clothing is more difficult, and gloves and cover cloths in particular might be best burned after they have been in contact with AFB.

Because of the rigorous destruction policy, outbreaks of AFB in this country have until recently been rare, but serious outbreaks were found in 2009 in Perthshire and near Inverness. Further outbreaks in Scotland have been found in every year since then. It is therefore essential to be vigilant, and to report any suspicious findings promptly to SGRPID who will then send an inspector to your apiary to check your hives. There is no charge for this service, and the inspectors are always on the beekeeper's side.

6.3.2 European Foul Brood

Just as AFB is by no means confined to America, so European Foul Brood (EFB) is not confined to Europe. It is unfortunately fairly common in the UK, but appears usually to be confined to particular areas. It is commoner in southern England than it is in Scotland, but a serious outbreak was discovered in 2009 in Perthshire and Angus, and further outbreaks have been cofirmed in every year since then.

It is again a brood disease caused by infection with another bacterium *Melissococcus plutonius*. As for AFB the infection is introduced to the larvae by the workers with the brood food. Infected larvae usually succumb within the last day or so before the cell is sealed, so that this is a disease of the *open* brood, the dead larvae lying in twisted and uncomfortable looking postures in their cells. However some larvae can survive until shortly after the cell has been sealed. It takes an experienced eye then to find and open up the darker or sunken capping covering an often yellowish dead larva sometimes with a sourish smell. Later the remains "melt down" and then dry out, but can be cleaned out by the bees. As for AFB, colonies severely affected with EFB will normally die out, and the infective agent can be spread from colony to colony by both drifting and robbing.

Because this bacterium does not form spores, it is rather easier to eliminate, and it is susceptible to the antibiotic Terramycin.

Like AFB, EFB is a notifiable disease, and so must by law in Scotland be reported to the local SGRPID office as described for AFB. However Bees Officers have some discretion about how they will treat an outbreak of EFB. The default treatment is to destroy the colony as for AFB, but it is permitted for Bees Officers at their discretion to treat a mild outbreak by the "shook swarm" technique. This must not be attempted by the beekeeper acting alone when EFB has been diagnosed, but only with the consent and assistance of a SGRPID Bees Officer who will explain and advise on how it is to be done then.

Because the bacterium is not spore-forming, there is less danger of long-term infection being carried in old combs or on apiary equipment, but sensible disinfection procedures should be carried out nevertheless. A strong solution of washing soda (1 kg to 5 litres of water) is an effective disinfectant for EFB.

6.3.3 Apiary hygiene and movement control to prevent the spread of Foul Brood

In or near an area where Foul Brood infection has been confirmed, rigorous apiary hygiene is prudent, involving the use of disposable gloves and washable veils.

Systematic disinfection of hive tools, smokers etc. with washing soda solution should become routine in apiaries near where EFB has been found. The use of cover cloths which are hard to disinfect should be discontinued in apiaries where either of the Foul Broods is a risk.

Movement of stocks of bees from an infected area to another location is then imprudent, and in fact will be forbidden by law within 5 km of any apiary where Foul Brood of either kind has been diagnosed until the eradication of the infection is confirmed by a SGRPID Bees Officer.

Using the technique of the "shook swarm" in April on stocks which have been exposed to infection by EFB is being actively encouraged in England as a way of eradicating the disease from an apiary. All the bees from the hive are shaken off their combs into a clean cardboard box where they are confined with a ventilated cloth cover such as an old net curtain for 24 hours. They are then hived in a completely clean brood box fitted with new frames and clean foundation and generous feeding of the colony with syrup begins and continues until combs are well drawn and a good reserve of food is stored. The old combs with the old brood nest are burned, along with the cardboard box and cloth cover, the brood being sacrificed. The queen excluder is initially put below the new brood box to stop the bees from absconding with the queen. After a week or so the queen excluder is put in its usual place. The initial confinement and starvation in a cardboard box are carried out to ensure that no possibly infected food reserves carried by the bees are fed to larvae in the new brood nest.

This will give a colony a severe set-back in spring, but it should ensure a clean start, and may well suppress the swarming urge for the season. Note however that it is illegal to treat any stock actually infected with EFB in this way, without the consent, approval and assistance of a qualified Bee Inspector, who will determine how such a stock is to be treated.

6.4 Fungus infections

Several diseases are caused by fungus infections, of which I shall only describe two, one affecting brood, and the other the adult bees.

6.4.1 Chalk Brood

The fungus *Ascosphaera apis* (Maasen) develops inside the rear end of larvae being reared in cold and damp combs where spores of this fungus are present. The mycelium of the fungus spreads throughout the larva as it matures, and converts the whole larva before it pupates into a chalk-like mummy which lies quite loose in the cell amongst the sealed brood of its unaffected sisters. The mummies are later thrown out of the hive by worker bees doing cleaning duties.

Avoidance of weak colonies and damp conditions reduces the effect of this fungus, but almost every colony in Scotland with our damp mild winters suffers to some extent from this problem. The regular replacement of old brood combs and the disinfection of brood boxes by scorching will also reduce the level of fungal spores in the hive.

A severe outbreak of Chalk Brood can seriously check a colony's development however, and clearing away and burning as many discarded mummies as possible is helpful, as they continue to shed fungal spores into the air for many months.

6.4.2 Nosema disease

Nosema apis (Zander) is a unicellular parasite of the class Microsporidia, which in 2010 were re-classified as fungi or fungus-related. It infects the mid-gut of the adult bee. If severe enough, the infection causes dysentery in the bee and shortens its life. Those bees suffering from dysentery, which either through weakness or through adverse weather are unable to fly to empty their bowels, will foul the combs, and other bees in cleaning up the mess will pick up the spores of *Nosema* so spreading the infection.

In warm summer weather any infection with *Nosema* tends to die out as infected bees die, usually away from the hive, and the number of infective spores in the hive falls. Weak colonies in a damp cold spring if infected may suffer severely enough to perish.

In addition the stress of a severe *Nosema* infection may be enough to trigger into action some of the latent virus infections within a colony, as mentioned in the first section of this chapter. The combination of *Nosema* and APV or SPV can be deadly and wipe out a colony quite quickly.

If *Nosema* infection is suspected, then a sample of adult bees showing signs of weakness should be sent off with an appropriate covering note for analysis to the Bee Diseases section of Science and Advice for Scottish Agriculture (SASA) whose address is given at the end of this chapter. Some members of Dunblane and Stirling Beekeepers have now received training form SASA in the detection of *Nosema* infection, so it may be possible to get samples of your bees examined for this condition locally using our own Association's high-power microscope.

Good hygiene measures by the beekeeper can greatly reduce the severity of any *Nosema* infection. The regular replacement of combs prevents the build-up of undue numbers of spores of *Nosema*. The thorough cleaning of floors and exposed frame surfaces at spring inspections also helps.

Because *Nosema* spores are triggered into development by the acid environment of the bee's stomach, combs can also be effectively disinfected from *Nosema* by fumigation with 80% acetic acid, which fools the spores into starting development before they are inside a bee. Up to five boxes of *unoccupied* combs should be stacked over a solid floor with the entrance tightly blocked to provide an air-tight seal. Above them should be placed an empty box with another board at hand to provide an air-tight seal at the top of the stack. On top of the combs should be placed a saucer with a piece of wadding on which should be poured 120 ml of 80% acetic acid per box. The stack should then be sealed with the top board and all joints carefully sealed with wide parcel tape to prevent the fumes which are heavier than air from escaping. The stack should be left for about a week. Before re-use the boxes must be ventilated thoroughly for at least two days to allow the acid fumes to disperse.

This treatment is also effective in destroying all stages of wax moth, and in killing the spores of chalk brood and of the organism causing Amoeba disease, though it is not known to have any effect on either EFB or AFB.

This treatment has several disadvantages. Concentrated acetic acid is a highly corrosive chemical, and must be handled with extreme care using protective clothing including thick rubber gauntlets and eye goggles. Avoid breathing the fumes which can cause breathing problems. If any is spilled on the skin, wash immediately with plenty of cold water, and seek medical advice. The acid also corrodes the frame nails and the reinforcement wires in the comb foundation, although greasing of all exposed metal parts before treatment alleviates this to some extent.

Since about 2006 there have been reports from several parts of the world of infections of colonies of the Western honey bee (*Apis mellifera*) — our bee — with a closely related organism *Nosema ceranae* which usually infects the Eastern honey bee *A. cerana*. This in combination with certain virus infections appears to be particularly deadly and may be responsible for some of the large-scale losses of bees being reported recently from America.

Recent work by SASA confirms that *N. ceranae* is also quite widespread in Scotland. Acetic acid is effective in killing spores of this disease also.

6.5 Protozoal infections

The protozoa are single-celled organisms, some of which are quite large. All can be seen under a microscope. One of them is responsible for infections of honey bee colonies which are of fairly frequent occurrence.

6.5.1 Amoeba disease

The protozoan *Malpighamoeba mellificae* (Prell) causes digestive problems to the adult bee. It infects the Malpighian tubules in the bee's lower digestive tract which act as the bee's kidneys. The result is again dysentery. It is not at all easy without microscopic examination to distinguish between Amoeba disease and Nosema disease, so here the help of the diagnostic unit at SASA is essential if it is necessary to be sure what the problem is.

Once more the principal problem with this disease is probably that it is a stress inducer which may trigger viruses into activity.

6.6 Arachnid infestations

The spiders, ticks and mites all have eight legs and form the family of the arachnids. They cause many problems of troublesome infestations in agriculture, and two of them are important problems for the beekeeper.

6.6.1 Acarine disease

In the 1920s in the UK the so-called "Isle of Wight disease" caused enormous losses to beekeepers in this country, and a large proportion of the stocks of the old British black bee were wiped out. At the time the trouble was eventually attributed to a mite *Acarapis woodi* (Rennie), which parasitises the thoracic tracheae (breathing tubes) of the bee. For this reason these mites are sometimes called thoracic mites, particularly in America.

Bees lightly infested with this mite can survive, but have a shortened life-span, and weakened flying capability, and those severely infested die of the infestation.

The infestation can be diagnosed by dissecting out the main thoracic tracheae of infested bees and examining them under a low-power microscope, when the mites can be clearly seen. A more modern but lab-based method of detecting it is the use of the Polymerase Chain Reaction (PCR) to detect the DNA of the acarine mite in a sample of bee tissue.

The modern acaricides developed in the 1980s for treating *Varroa* can also be used to treat acarine if the need arises.

Although acarine continues to occur among honey bee colonies in Britain, it is seldom now reported as a serious problem. However within the early 2000s a few cases of sudden colony collapse were attributed by SASA to high levels of acarine infestation.

A new view of "Isle of Wight" disease was proposed in the 1980s. It may well be that the acarine mite entered Britain through the South of England at the start of the twentieth century, probably because of the increased amount of travel and trade developing then. The bees then being kept in this country were meeting a new parasite for the first time, and were extremely stressed by it, so that latent viral infections were triggered into activity, and caused viral reactions of sufficient severity to kill colonies. Certainly many of the symptoms attributed to "Isle of Wight" disease are very like those observed in colonies suffering from severe outbreaks of APV or SPV.

6.6.2 Varroosis

The origin and spread of the condition

The parasitic mite *Varroa jacobsoni* (Oudemans 1904) is a natural parasite of the Eastern honey bee *Apis cerana*, discovered in 1904 on the Eastern honey bee in Java by Edward Jacobson, and sent to Holland for classification and description by the famous scientist Dr A. C. Oudemans. Attempts to keep the Western honey bee (our bee) *Apis mellifera* in Asia at the beginning of this century always failed — perhaps because of *Varroa*. Some time in the 1950s attempts to keep our bees in Japan succeeded, but the bees tended to die out, and the problem was attributed to infestation with *V. jacobsoni*. More recent work however by Dr D. L. Anderson in Indonesia, as explained in *The Scottish Beekeeper* of 2001 January has established that the mites present on the western honey bee belong to a larger but closely related species, now to be called *Varroa destructor* (Anderson, Trueman 2000), which may perhaps be related to a parasite of the eastern honey bee. Throughout Europe and Africa the race of *Varroa destructor* present is the Korean one, but in America it is the race from Japan and Thailand.

Although *A. cerana* can live with *Varroa*, because of a slightly shorter sealed brood time, and an aggressive behaviour by the adult bees towards the mites, European races of *A. mellifera* which lack these traits usually succumb to *Varroa* infestation, colonies dying out in the second or third year.

Somehow infested colonies of *A. mellifera* were transported across the Ural Mountains into the East of the Soviet Union, and since then the infestation has spread steadily through the world's population of western honey bee colonies in all continents, largely through the uncontrolled importation of colonies from infested areas.

In summer 1992 the first known cases in the UK were reported from Hampshire in the south of England. In 1996 the infestation had spread throughout England and most of Wales and reached as far as the Scottish border. Until 1997 only sporadic cases had been reported in Scotland, but in the summer of 1998 major outbreaks were identified in the Dumfries area, around Peebles and in St Andrews. In August 2002 it was first found in the Stirling area, and is now widespread in our area. In the summer of 2003 it was also found in Islay and in some other small islands, and in the light of this SEERAD (at that time the authorised Government Department) decided to declare the whole of Scotland a Statutory Infested Area (SIA), so there is now no LEGAL restriction on where you may move bees within Scotland. Nevertheless it is decidedly wrong to take bees you know or suspect may be infested with *Varroa* to areas where it has not yet been found, particularly to the more remote island groups such as the Outer Hebrides, Orkney or Shetland.

One universal experience in the spread of the infestation is that beekeepers are almost always unaware of its arrival for some time after *Varroa* is present in an area. After one beekeeper's stocks are found to be infested, further investigation almost always reveals that the infestation has spread widely. This was indeed what happened to us locally here around Dunblane and Stirling.

The effects of Varroa

Adult female *Varroa* mites can live on adult bees. They tend to adhere to the under-side of the abdomen, between the segments, where they bite through the cuticle and suck the bee's blood (haemolymph). These female mites however always seek when possible to enter *brood cells* just before they are capped, preferring drone brood when it is available, presumably because of its longer time as sealed brood. Within the brood cell the mite is stimulated by the hormones it receives when it sucks the larva's blood to begin egg-laying. Like the bees themselves the mites reproduce parthenogenetically, unfertilised eggs developing into males, and fertilised ones into females. The first egg laid is always an unfertilised (male) one, and the remainder are females. The adult female mite continues to lay individual eggs at 30 hour intervals. Once they have matured sufficiently, the single male mates with all the young females. Because of the mites' developmental time, only one or occasionally two young females (together with their mother) can emerge with the bee when a worker bee has finished development. From a drone cell on average about four can emerge. The male mite always dies when the bee emerges. The mother mite can enter a second and even a third brood cell before she dies. Bee brood which has been parasitised develops into stunted and short-lived bees which are not much use to the colony, particularly if more than one adult female mite has been breeding in that cell, which occurs when the mite population builds up sufficiently. Because of the relatively slow build-up of the *Varroa* population in a bee colony, it can take two or even three years before the bee colony collapses, but in the meantime the infestation has been passed on to other colonies by adult mites adhering to bees entering other colonies, especially drones which are not colony-loyal. Drones are powerful fliers and can easily fly 10 km (5 miles) or more.

A secondary effect of *Varroa* infestation, which some of the most recent research suggests may even be one of the principal ones causing colony collapse, is, as for so many of the other diseases described before this one, that the transmission of blood-borne infections between adult bees, and the stress of the infestation by the mites can cause epidemics within a colony of various viral infections, which are almost always present at low levels, but which do not usually cause a problem. Most of the viruses mentioned at the start of this chapter have a role to play here. Many recent colony losses have been reported in spring, perhaps caused by the shortened life-span of the wintering workers or by the activation by *Varroa* of the Deformed Wing Virus within the colony.

Dealing with Varroa

As this pest must now be considered endemic, we have to learn to live with it. This section contains a brief guide to the essentials, but a much fuller guide (including all the principles in detail, as well as a fuller list of available control substances) is contained in the DEFRA booklet "Managing *Varroa*" which is available as a download from:–

`http://www.nationalbeeunit.com/index.cfm?pageid=167`

Integrated Pest Management

For the first time beekeepers are having to learn about Integrated Pest Management (IPM). The principles of this are:–

- monitor colonies for levels of infestation;
- be aware of appropriate trigger levels for
  - light infestation: no action needed;
  - moderate infestation: light action needed;
  - heavy infestation: severe risk, urgent need of treatment.
- treat only when necessary;
- choose a treatment appropriate to the season, the level of infestation and the strength of the colony.

Monitoring *Varroa* infestation levels

Two simple methods are available:–

- use of an open mesh floor and monitoring Daily Natural Mite Drop;
- in the *summer only*, the search of sealed drone brood for level of infestation.

For more accurate assessment of infestation levels, two newer methods are also now recommended — "Powdered sugar sampling" and "Alcohol washing". These demand considerable confidence in handling quite large samples of live bees and also some special equipment, so are not included in these beginners' notes. For those interested in more detail see

`http://honey beehealthcoalition.org/wp-content/uploads/2016/03/HBHC-Guide_Varroa_Interactive_18FEB2016.pdf`

It is hoped to demonstrate these methods as part of the "Hands on beekeeping" programme later in the year.

Daily Natural Mite Drop

It is now widely accepted that colonies do well if kept permanently on an open mesh floor instead of a solid wooden one. These are usually constructed so that a yellow plastic board can be inserted below the mesh. It is recommended that this is presented with a sticky upper surface. Simply grease it with petroleum jelly or spray it with cooking oil spray. The tray is left in for no more than a week, and then the adhering mites are counted and the total divided by the number of days the tray was in place, to get the average daily natural mite drop. To help in accurate counting it is helpful to rule off the board into squares about 25 mm square with indelible pen before using it. NOTE THAT NO TREATMENT MUST BE GOING ON WHILE THE COUNT IS TAKING PLACE. The table below gives a rough guide as to when action is needed:–

	Average Daily Natural Mite Drop		
Jan to Mar	Less than 2 No action	2 to 7 Plan control	More than 7 Consider immediate control
Apr to Jun	Less than 1 No action	1 to 7 Light control	More than 7 Severe risk
Jul to Aug	Less than 2 No action	2 to 7 Light control	More than 7 Severe risk
Sep to Dec	Less than 6 No action	6 to 8 Light control	More than 8 Severe risk

Inspecting sealed drone brood

By inserting an uncapping fork into sealed drone brood and removing the pupae, *Varroa* on them can easily be seen and counted. This method can only be used in summer but then the following rough guide table is useful. At least 50 pupae should be inspected.

	Proportion of infested pupae		
Up to June	Less than 2% No action	2% to 4% Plan control	More than 4% Consider immediate control
Jun and Jul	Less than 3% No action	3% to 7% Light control	More than 7% Severe risk
Aug	Less than 5% No action	5% to 10% Light control	More than 10% Severe risk

Overview of treatment methods

There are three main approaches to treating varroosis. The first is an attempt to keep the infestation down to a tolerable level for as long as possible by means of various biomechanical treatments. It has the advantage that we do not need to introduce any poisonous chemicals into the hive, and that we can carry these measures out at any time whether or not honey supers are on the hive. They need to be carefully managed if they are not to disrupt the normal hive routine, put the bees under stress, and almost certainly reduce honey yields. They could well form the basis of the proposed "Light controls" above.

The second approach is the orthodox use of one or other of the acaricides licensed by the Veterinary Medicines Directorate.

The third approach is the use of some of the alternative substances which, while not licensed as treatments for the infestation, are of proven efficacy in reducing mite populations.

Some suggestions for manipulative treatments

One simple manipulative treatment which could be very effective is to use the brood nest from an artificial swarm set up at the end of May to found a new colony for the late heather flow. This may well become the standard practice for those wishing to work the heather, since autumn treatments after return from the heather are likely to be too late to produce an adequate healthy population of wintering workers. Try to prevent cross-infestation of such a stock however, since it relies on its broodless period while awaiting a new queen (possibly supplemented by some chemical treatment then), to bring its *Varroa* population down to a low level.

A less disruptive treatment, which will also be less effective, but which will reduce the *Varroa* population while supers are on, and most acaricides cannot be used, is the following fairly simple plan.

- Introduce into the brood chamber near the outside edges of the brood nest two *shallow* frames (of the size used in the supers), fitted with ordinary foundation.
- Let the bees (as they will) draw "wild" comb below the bottom bar of the shallow frame. Most of the cells in this position are likely to be drone cells.
- When the brood which is laid in this wild comb is mainly sealed, cut off these wild combs, put them in the deep freeze for 24 hours, to kill both the *Varroa* and the brood, and then dump them.
- After the wild comb has been cut off, the shallow frames can be given back to the bees and the operation repeated.

Many of the *Varroa* will have been attracted into the drone cells here. You will lose some (but not much) worker brood as well, but will make significant inroads into the mite population. The queen's laying has not been interrupted, and the colony can be expected to flourish as usual.

More elaborate variations on these themes are to be found in some of the literature, and this is clearly an area where your own experimentation is likely to pay well. None of us in Scotland has yet had enough experience to know how best to operate in our local conditions, but listen to those who are now gaining painful experience.

The generous sprinkling of icing sugar over the bees on the brood frames at swarm control inspections is also believed effective in helping to control *Varroa*. Perhaps this makes mites slip off the bodies of bees more readily, and it certainly stimulates the impulse for mutual grooming of the bees by one another, during which the bees frequently catch and kill *Varroa* mites. It is of course also cheap, simple and harmless to both bees and humans.

Using licensed products to control Varroa

The number of products licensed by the Veterinary Medicines Directorate for the control of *Varroa* infestation of honey bees continues to grow. Below is a complete list of such products which were licensed by November 2017. They are grouped by the principal active ingredient in each product. For a more up to date list at any time, look up on the internet:–

`https://vmd.defra.gov.uk/ProductInformationDatabase/Search.aspx`

and then in the "Species" box insert "Bees" and launch a search.

Active ingredient	Product Name	Form	Application	Length of time
Amitraz	Apitraz	Strips	Suspend between store combs	6 weeks
Formic Acid	MAQS	Impregnated pads	Above or between brood boxes	1 week
Oxalic acid	Apibioxal	Powder	1. In syrup to trickle on bees 2. By sublimation of powder	1 application per year 1 application per year
	Oxuvar	Concentrated solution	By trickling or spraying	1 application per year
Synthetic	Apistan (tau-fluvalinate)	Strips	Suspend between brood combs	6 weeks then remove
pyrethroid	Bayvarol (flumethrin)	Strips	Suspend between brood combs	6 weeks then remove
	Apiguard	Gel	On flat surface above brood combs	2 + 2 weeks
Thymol	Apilife Var	Green foam strips	Away from brood and stores	4 x 1 strip per week
	Thymovar	Yellow sponge strips	Away from brood and stores	3 + 3 weeks

Some of these products require special care in their handling. Full information on this is provided by the manufacturer with the packaging, and it is important to read all of this carefully before using any of them, and to take the appropriate precautions. Some of the more extreme hazards are noted below.

Skin contact should always be avoided by the use of rubber gloves, and care taken in disposing of them after use or when they go out of date to avoid contaminating the environment.

Particularly hazardous is the sublimation of oxalic acid crystals or powder. This should only be undertaken when wearing a respirator which gives full protection against organic acids as the aerosol produced can be fatal if it is breathed in.

The formic acid in Mite Away Quick Strips (MAQS) is extremely corrosive and must be handled when wearing thick rubber gloves giving protection against chemicals, as well as ensuring adequate respiratory protection, as the fumes given off are dangerous. There are other obvious things to avoid such as brushing your face with gloves smeared with the MAQS liquid! Some beekeepers have also found that MAQS can induce bees to supersede their queen which may be a good thing or a bad thing, depending on when it happens.

Spraying of Oxuvar which is one recommended method of application should only be done when adequate eye protection with goggles is in place.

Other things to note are that both the synthetic pyrethroid medicaments are now of limited efficacy since most strains of *Varroa* have now become resistant to them.

Also all the thymol-based products can only be used effectively when the temperature is above 15^0 C and that they become dangerous to bees when the temperature is above 30^0 C. The latter consideration is not often of concern in Scotland, but the former makes them useless in the winter months here. Thymol must also not be used when honey for harvest is being collected as the result is honey which tastes absolutely foul (personal experience!) and is unfit for human consumption. Bees do not like the flavour either, and may refuse to enter feeders if they stink of thymol. Do autumn feeding before or after any thymol treatment, not during.

In choosing a product to use, one should always be guided by the principles of Integrated Pest Management which were presented above. One is always to monitor levels of infestation and only to treat if it is necessary. A second is to choose a treatment which is effective at the current season and in the current situation. These must always be borne in mind.

Finally, having decided to use a particular substance to treat, it is vital to adhere exactly to the instructions for handling and using the substance, since many of these substances can be dangerous if improperly used.

Legal requirements for handling veterinary medicines

The law requires those handling any licensed veterinary medicines to keep written records of purchases and other acquisitions, of uses and of disposals of them, with dates, and to store them safely away from foodstuffs and away from access by those not authorised to use them, so do take care to comply with the law. Note that they must not be used after the expiry date shown on the packaging, so do not over-purchase. Sharing bulk purchases with fellow beekeepers can be helpful, but needs coordination.

The use of alternative substances

Other substances which have been found to be reasonably effective in controlling *Varroa* are the three organic acids, lactic acid, formic acid and oxalic acid. Thymol itself can also be independently purchased as a simple product to use in controlling *Varroa.* I shall not go into the use of these as simple substances here, as it is a rather specialised area, and some of them (particularly formic acid) are very dangerous to handle, all requiring the systematic use of protective clothing and good precautions to avoid contact with the skin, or inhalation of vapour.

Long-term prospects

There is much active research work going on just now on breeding a strain of the Western honey bee which shows the same degree of resistance to *Varroa* as the Eastern honey bee. In my view that will be the long-term solution. However, we have not reached that point yet, and experience elsewhere suggests that those who do not treat their bees against *Varroa* when it arrives, after two to three years will have no bees.

There is also active research into finding possible diseases which will knock out the *Varroa* mite itself.

One factor which may have more influence on the outcome of this problem than the scientists acknowledge is the continued existence in our countryside of feral colonies of honey bees. These will of course initially be largely destroyed by *Varroa*, as the rabbits were by myxomatosis. However the sites where they lived will still contain combs full of honey, and will be very attractive to escaping swarms. These stocks of course will repeatedly become infested, and will be a continuing source of reinfestation for our bees. However they will also be *untreated* and, as happened with the rabbits, among them natural selection for resistance to *Varroa* will continue to operate except in so far as they cross-breed with our bees which are being treated. It took the rabbits about twenty years to solve the myxomatosis problem for themselves completely without assistance. Will the honey bees do the same, and if so how quickly?

6.6.3 Tropilaelaps clareae

This mite, which is a parasite of the two giant honey bee species *Apis dorsata* and *Apis laboriosa* has now been found also in some parts of Asia as a serious parasite of the western honey bee. Its life-cycle is very similar to that of *Varroa* but it has so far not been detected anywhere in Europe. However SGRPID have also made it a notifiable disease. Let us hope we never need to worry about it.

6.7 Insect infestations

6.7.1 Braula

The so-called Bee Louse *Braula coeca* is actually a wingless fly. It used to occur very commonly in bee-hives, and the queen and her retinue were most frequently parasitised. The adult fly, which is about the same size as *Varroa* but longer from front to back than from side to side, and with only six legs rather than eight, typically perches on the back of the thorax of a bee on the comb, from where it occasionally runs down to steal a drop of food as bees exchange food between one another. The adults appear to do no significant damage in a bee colony, and most beekeepers ignore them. If however you are wishing to have comb honey for show or for sale, you may wish to try to reduce the *Braula* population, since their larvae live on the wax of the honey cappings in the combs, and make unsightly tunnels there.

The chemicals which kill *Varroa* are also effective against *Braula* so *Braula* is now becoming a rarity.

6.7.2 Wax moths

Two species of moths, the Lesser Wax Moth *Achroia grisella* and the Greater Wax Moth *Galleria melonella* have evolved to live in their larval phase by feeding on beeswax and the debris of pupal skins etc in the brood combs of honey bees. The Greater Wax Moth does not usually cause much problem in Scotland because the climate is too severe for it, although it can be a serious menace further south, as the damage it does is much worse than that caused by the Lesser Wax Moth. In particular the pupae of the Greater Wax Moth usually are set into hollows which the larvae dig out in the woodwork of the hive, causing quite severe damage to the wood in the process.

The Lesser Wax Moth looks very like the common clothes moth, and has very similar habits, except that its larvae feed on wax combs not woollen fabric. Any strong stock will hardly allow any wax moths to survive within a hive, unless there are crevices where the moths and their larvae can hide and the bees cannot reach them. The larvae of both kinds of moths however can quickly wreck any stored brood combs when they are kept away from bees, turning them into a crumbly brown frass interwoven with silk tunnels where the larvae have burrowed. The times of greatest danger are in spring and autumn, since in the cold winter months the weather is too cold to allow the eggs to hatch out. In summer most combs are in use and not stored, but any that are stored are certainly in danger.

Combs of honey supers which have *never* had brood reared in them are comparatively safe, since the moth larvae require larval debris as well as wax in order to grow satisfactorily.

The best remedy is to keep a watchful eye out, and to burn any combs that become infested. Moths and larvae in combs can be effectively killed by a twenty-four hour spell in a deep freeze, or by the fumigation with acetic acid used against *Nosema*, but the danger is reinfestation from outside, so a box of combs treated in either of these ways should, before storage, be wrapped in an individual plastic bag, carefully sealed with parcel tape. If a box has been infested by this pest, it is a good idea to scorch the box with a blowlamp to kill any remaining eggs or pupae. Combs in it are usually beyond redemption and have to be burned.

Note that wax-moth is a very common problem to meet if you buy second-hand equipment that has lain neglected for some time, and it is wise to ensure that you don't in this way introduce this pest into your apiary. Also do not keep *Varroa* monitoring trays for long periods under open-mesh floors, as the space above them is wax-moth heaven, since wax-moth larvae there are showered with a continual rain of nourishing wax debris, and the bees cannot get at them.

6.7.3 Ants, wasps and hornets

Ants can become a serious problem to a bee colony if they discover a way into a hive by which they can rob the honey store. In extreme cases it may be necessary to set the hive on a stand with its legs resting in tins of oil to keep ants out.

In the autumn when bees have acquired a large honey store, worker wasps can be very aggressive in trying to gain admission to the hive past the guard bees in order to rob honey. If there are very many, it may be worth looking for the wasp's nest and destroying it. I have also seen a queen wasp in spring sneak into a hive past the guard bees, and emerge a minute or so later with a bee larva in her jaws to take to feed to her own young. Avoiding spills of honey or sugar syrup, and reducing the size of hive entrances, especially those with weaker stocks, are wise precautions against both wasps and robber bees in August and September.

Hornets have a life-cycle almost identical to that of the common wasp, with an annual nest founded by a mated queen which has successfully hibernated, and which dies out in the autumn after the production of queens and males to found next year's nests.

The European hornet *Vespa crabro* looks like a very large wasp. It is a predator of large insects, including bees, but does not deliberately target honey bee colonies, and has never been regarded as a serious pest by beekeepers. It does occur in Scotland, but only rarely, and is commoner in the south of England.

However in 2009 the yellow-legged Asian hornet *Vespa velutina* was unintentionally imported into France with some imported goods, probably from south-east Asia which is its native home.

It is largely black in colour but with yellow tips to its legs and one orange band near the rear of its abdomen. It is about 30 mm (a little over an inch) in length.

Since 2009 it has become widely established in France and has spread to other European countries including Spain, Portugal and Italy. In August 2016 it was for the first time recorded in the UK, two nests being discovered, one in Gloucestershire and the other in Somerset. Both nests were destroyed, but probably too late to prevent the new season's queens from leaving the parent nest to prepare to hibernate independently. At least one further nest in south-west England was found in summer 2017, so it does look as though it is going to become established in Britain also.

It deliberately seeks out honey bee colonies, and gangs of hornets can then be seen hovering in front of the hive entrance in wait for returning forager bees, which they catch, decapitate, and take back to the hornet nest to feed to the hornet larvae. They can, if they make a concerted attack, quite quickly destroy a honey bee colony, since in the last stages they invade the hive, and kill all the bees and brood, and also consume the honey.

They build very large nests, typically high up in a tall tree, and are very aggressive to passing humans who get too near. People on horse-back are particularly vulnerable as both the horse and the rider get stung.

Perhaps the Scottish winters may prove too cold for it, but if it does become established here, we shall need to cope with it.

6.7.4 The Small Hive Beetle

The Small Hive Beetle *Aethina tumida*, is a pest of honey bee colonies native to sub-Saharan Africa. The damage it does is very similar to the damage caused by wax-moths, the larvae destroying combs. It is much more serious however, and an infestation with SHB can often kill a stock of bees.

In its native region it has never caused much concern, but in 1996 it was found in Florida where it is now regarded as a serious problem, particularly of stored comb. So far it has not been found in this country, but the fact that pupae can be imported with fruit and vegetables have caused SGRPID to be worried in case it appears, and it too has been made a notifiable disease of honey bees.

Most recently a serious outbreak of Small Hive Beetle infestation was found in southern Calabria in the "toe" of Italy in 2014. Despite a determined effort to eradicate it, further infestations were found in Taurionova in Calabria in 2015.

Many commercial beekeepers in the UK have made a regular practice of importing bees from Italy, particularly after hard winters with heavy winter losses, so this route poses a real threat of the import of SHB into Scotland. There is a leaflet published by the Department of Food and Rural Affairs (DEFRA) giving full information about it, and all beekeepers are advised to study this so they know what to look for. A serious infestation really cannot be missed as the combs in the hive become a wriggling mass of thousands of beetle larvae.

Some protective measures (such as beetle traps) are being developed. Strong colonies can resist infestation, but of course it must be reported if found.

6.8 Amphibians, birds and mammals

Toads and frogs are said sometimes to lie in ambush in front of beehives and to capture worker bees as they fly out to forage. I can hardly believe that a hive placed in a reasonably dry site will suffer seriously from this particular threat.

Small birds such as tits and flycatchers do however sometimes find it worth their while to ambush bees in this way as they fly in and out, and if they can be discouraged it would make sense.

The most serious bird problem however is undoubtedly that posed by the Great Green Woodpecker, which can in short order drill a hole through the side of a brood box, and then have a very profitable time feasting on the bees and larvae within. Not only does this damage the colony, but also it does very significant damage to the beehive itself. In areas where this bird is common, it is sometimes necessary to protect hives from it by some sort of cage made of wire netting. As yet it has not been found north of the border.

Both mice and shrews can be a pest to colonies of bees. Field mice in winter will readily take up occupation in a hive, nest there, foul the combs so that bees will not use them again, and eat the bees' stores, the bees themselves, and a large part of the brood nest. They must be kept out at all costs, and mouse guards are the solution. In summer the bees can protect themselves against mice. Shrews do not usually permanently occupy a hive, but they will sneak in and out if they can to have a feast of bees. This can destroy a hive in winter if it goes unchecked.

6.9 Human pests

The most obvious way in which people damage bee colonies is by deliberate vandalism. Teenage boys (and younger) particularly delight in kicking over or throwing stones at beehives in winter, with damage which can be very serious to the bees at that time of year. Such activity does not usually take place in summer! Having hives in a place where access is not easy and/or they are under a vigilant eye are the best remedies, but are not always easy to ensure.

Neighbours of a beekeeper who are, reasonably or unreasonably, afraid of bees are nowadays making it ever more difficult to keep bees in our increasingly urban environment. There is no doubt that trying to make allies rather than enemies is the best approach. Timely gifts of honey, and meticulous attention to swarm control so that bees are not a nuisance are the two best actions here.

The theft of beehives (with the bees) is also becoming more common nowadays. Not having apiaries which are easily accessible by road reduces the risk, as does having beehives in full view by their owners. It is not advisable to publicise apiary locations too widely for this reason.

The main threat to bees from people however is undoubtedly the risk of having bees poisoned by the spraying of agricultural or garden chemicals. Very often these chemicals are insecticides aimed at controlling insect pests. If they are applied at a time and place where our bees are foraging however, they will kill the bees very effectively. Most beekeeping associations have some form of compensation scheme to help in such cases, and the beekeeper may have a case at law if his stocks have been damaged by reckless and negligent application of sprays.

In order to establish a claim for such damage however it is necessary to be able to prove that the bees have been poisoned by the spray that was applied. Usually there is no shortage of dead bees around the hive for the beekeeper to collect if this has happened. In this case a large sample should be collected and sent off for analysis to the Science and Advice for Scottish Agriculture (SASA) whose contact details are given below. Several hundred bees should be sent in this case, since quite elaborate chemical analysis will be needed to try to determine exactly what chemical is involved.

The covering letter should contain as much information as the beekeeper can obtain about the time and place of the spray, who was applying it, and if possible exactly what chemical was being sprayed.

6.10 A disease inspection

Now that the two Foulbrood diseases are continuing to be found every year in Scotland, the Bee Inspectors are encouraging all beekeepers to make *one* disease inspection of every stock every season. This is best done before mid-May while hives are not too populous. The point about this inspection is that it concentrates on just ONE objective, namely to seek out any serious disease problem and to be prepared to take the appropriate action if a problem is found.

All brood combs are inspected and the routine for each brood box is as follows:–

- Ensure you have a supply of match-sticks or something like that for examining suspect sealed brood cells;
- Remove an end frame or dummy as usual to make working space. Leave the inspection of that frame till the end if it is not a dummy, but as usual ensure the queen is not on it when you prop it up outside the hive. If you find her, run her back into the hive.
- Then for each frame in turn, lift it and
  1. examine the adult bees on the frame for any signs of disease (paralysis or deformed wings);
  2. check the queen is not on the frame — if you find her run her back into the hive, preferably on to a frame already inspected;
  3. lower the frame into the centre of the working space in the box, and by bumping your hands down on to the edges of the box, bump most of the bees off the frame on to the floor of the hive;
  4. withdraw the frame again and make a very careful inspection of the brood cells, checking for a regular pattern of egg-laying, healthy worker brood in all stages, and not too much drone brood;
  5. look for signs of the two Foulbrood diseases (see above), using a matchstick to investigate any suspect sealed brood cells, the used match-stick being then dropped into the smoker to burn;
  6. look for fouling of the comb by dysentery which might indicate *Nosema* disease.
- Write up all you have found, and decide what action is appropriate. If the hive has a clean bill of health note that fact along with the date in your hive record.

Beginners are strongly advised to have an experienced mentor to guide them as to what they find, and what is the appropriate action. Details of what to look for have already been given. That and other relevant literature on bee diseases should be carefully read before carrying out this inspection.

6.11 Useful contact addresses for help in dealing with bee diseases

6.11.1 Science and Advice for Scottish Agriculture (SASA)

This government agency provides a *free* diagnostic and advisory service for all bee diseases, supported at present by European Union money, so use it wisely and well. Always send specimens in *paper* or *cardboard* packing, not plastic, which causes them to rot. Remember to enclose a covering letter giving your own contact details, and saying what you believe the problem is. It is also helpful if you indicate where the bees are kept from which the specimen came.

Bee Diseases Section, Science and Advice for Scottish Agriculture
1 Roddinglaw Road, Edinburgh
EH12 9JF
Telephone:– 0131–244–8890
email: info@sasa.gsi.gov.uk

6.11.2 SGRPID contacts

If you suspect or have the misfortune to find one of the four notifiable diseases listed at the beginning of this chapter then you have a legal obligation to report the matter to the Scottish Government Rural Payments and Inspections Directorate (SGRPID). The local Stirling SGRPID Bees Officer in 2018 can be contacted at

Local Bees Officer, SGRPID Local Office
Strathearn House, Broxden Business Park, Lamberkine Drive
Perth PH1 1RX
Tel:– 01738–602000
email:– SGRPID.Perth@gov.scot

and for other areas of Scotland the appropriate contact can be found by looking on the Internet at
`https://www.ruralpayments.org/publicsite/futures/topics/contact-us/`

Alternatively you may approach the Lead Bee Inspector's office in Edinburgh directly by email to:–
`BeesMailbox@scotland.gsi.gov.uk`

The inspectors are invariably helpful and will always give expert advice free. Do not be afraid to contact them. They would much prefer to deal with several false alarms rather than miss one real problem.

6.11.3 The Scottish Beekeepers' Association's Science and Bee Health Officer

The Scottish Beekeepers' Association keeps a vigilant watch for the occurrence of any of the serious diseases throughout Scotland, and their Science & Bee Health Officer should always be advised of the occurrence of any serious problem. This Officer is also always willing to give help and advice free of charge if it does not demand too much time. The contact details are published monthly in the SBA's magazine *"The Scottish Beekeeper"*. In January 2018 this Officer is Gavin Ramsay, 14 Redcliffs, Kingoodie, Dundee DD2 5DL, Tel: 07751–142155, email:– `gavinramsay@btinternet.com` .

Much more information is available on the web-site of the Scottish Beekeepers' Association
`http://www.scottishbeekeepers.org.uk/`

Chapter 7

The Annual cycle of Beekeeping: Setting up as a beekeeper

7.1 The year's work in outline

Summarising how the various techniques described earlier fit into an annual cycle which in turn fits into the natural cycle of the honey bee colony described at the beginning gives us the following calendar for local conditions here.

- **August:–** Start of the beekeeper's busiest period. Honey removed after the main summer flows must be dealt with and beeswax processed. If heather honey is sought, then at the beginning of the month strong colonies headed by young queens must be prepared with some reserve stores but also ample empty combs for the moors, and transported to a site which must have been previously arranged and prepared. Ensure the hives will not be knocked over by grazing sheep or cattle.

  Some swarm control inspection may still be needed, but the swarming season ends by the middle of this month at latest. Many hives now cast their drones, so try to ensure that all young queens are mated and laying by then, or mating may be unsuccessful. Queen rearing must now stop for that reason.

  As the queen's laying starts to be reduced, now is the moment to check for heavy late-summer *Varroa* infestation by checking natural mite drop. Measures taken under Integrated Pest Management should have prevented a large build-up, but once this check is complete, this is the ideal month for starting treatment against *Varroa* where it is needed, applying any treatment exactly as recommended. Some methods can be continued until October.

- **September:–** the busiest month. Assess all stocks and unite weak ones in preparation for winter. Feed with liquid feed those low in stores. Continue processing honey and wax. In the middle of this month, hives at the heather must be brought back, the honey removed and processed, and these stocks fed. ALL AUTUMN LIQUID FEEDING SHOULD BE OVER BY THE END OF SEPTEMBER to allow the bees to ripen the feed and seal it before the cold weather begins, or else the stored syrup may ferment leading to dysentery among the bees. Remember to check heather stocks for *Varroa* on their return from the heather, and hope that no late-starting treatment against the mite is needed as it will be less effective now, but must be done if infestation is heavy. Hefting of hives to check for adequate weight of stores should continue periodically till the end of October, as sometimes in mild autumns bees can consume much of their winter stores during this time.

- **October:–** Put mouse guards on all hives at the beginning of the month and make a final check of winter security. Finish processing late honey and wax.

- **November:**– A quiet month. Periodically check hives have not been disturbed by weather or vandals. Do not disturb the bees.
- **December:**– As November. If treatment for *Varroa* with oxalic acid is to be done, this is the month for it. If correctly done it involves minimum disturbance. Hefting of hives to check for stores is needed for all stocks or quick visual checks under the crown board every two to three weeks. Feed candy or fondant to any stocks short of stores.
- **January:**– As December. Do NOT remove snow from hive entrances, but clear it off roofs. Bees are best left lightly imprisoned in bright snowy weather, or many may come out and be chilled on clear frosty days. Continue checking for food reserves by hefting or quick inspection under crown boards.
- **February:**– Brood rearing will usually re-start this month. Again check quickly for honey reserves and feed solid sugar as candy, fondant or dampened sugar bags as necessary. A good month to check natural mite drop of *Varroa* in case some spring treatment is needed for heavily infested colonies.
- **March:**– Some time this month check food reserves in ALL hives. Liquid may now be fed if the weather is mild, but fondant or candy will still be safer if it is cold. Where reserves are adequate, do nothing. When weather warms up remove mouse guards to allow unrestricted gathering of pollen.
- **April:**– If foul weather persists, feed fondant or syrup to all stocks. This is the month of greatest danger of starvation. When fair weather occurs, make spring inspections. Willow should be yielding early nectar which will be seen in combs, as well as plentiful pollen which will also be seen on the hind legs of returning foragers. If so, feeding is unnecessary.
- **May:**– Spring inspections should be complete by mid-month and regular swarm-control inspections begin now. Also any spring treatment against *Varroa* involving chemicals should be brought to an end. If such a treatment is used, then spring honey should not be harvested for human consumption. Biotechnical methods can be used continuously if necessary.

  A disease inspection of each stock some time this month is advisable.

  As soon as the major honey flows from sycamore and oil seed rape begin, put honey supers over queen excluders on well-developed stocks. Do this too soon rather than too late. Be prepared to start taking swarm control measures towards the end of this month, and if possible take the opportunity to rear early young queens if the weather allows. Keep adding supers, when the top one is about half full. You may remove full supers for extraction, but it is a good policy to leave at least one half full super on each hive throughout the summer to tide the stock over a spell of bad weather.
- **June:**– The main swarming month: ideal for queen rearing. Sometimes there is a gap in the honey flow this month with adverse weather. If young *mated and laying* queens become available, some stocks preparing to swarm may be re-queened to dissuade them from it. A good month to check drone brood for any unexpected build-up of *Varroa* requiring urgent action. Wild drone comb on *Varroa* check combs must be cut out when sealed, or the drones will emerge and the new young *Varroa* mites will all emerge with them to give your hive a really heavy infestation!
- **July:**– Swarm control continues but the risk is less now. Late swarms this month will do little good this year. The main honey flow should occur now, weather permitting. Keep adding supers as necessary, but if weather is bad you may even have to feed! More re-queening may become possible.
- **August:**– completes the cycle again.

7.2 Setting up as a beekeeper

- **A Choosing an apiary site**

  The site should be open and sunny but sheltered from strong winds. Fresh water from a source nearby where bees can safely drink is an advantage. Avoid frost pockets and damp areas. Hives must not be subject to vandalism and should be screened by trees or fencing from human passers-by to keep both bees and passers-by happy. If the apiary is away from home, convenient vehicular access is important to avoid the necessity of carrying heavy honey-filled supers over long distances. Most important of all as regards an apiary site, the surrounding area should contain an ample supply of seasonal nectar bearing plants, to enable the colonies to survive, and to ensure that a honey crop may be obtained.

- **B Setting up hive stands**

  Hives must not be set unprotected on the ground, or the damp will quickly rot the floor away, and vegetation will grow up and block the hive entrances.

  Wooden stands are often used, but they must be stoutly built as hives when full weigh 50 to 100 kg (100 to 200 lb). Another good and simple solution is to set each one on a concrete slab — or better a stack two high of two concrete slabs. Using part slabs for the upper layer leaving a central ventilation channel under the hive floor from side to side is a useful refinement. Even WBC hives last longer if their legs are placed on stone, not earth. Bees' natural inclination is to choose a site quite high off the ground, so lifting them up about a couple of feet is good for them, and good for your back too when you are working the hives.

  The ground in front of the hives must either have the vegetation regularly cut down to leave a clear flight path for the bees, or be treated so that nothing grows there — tarmac, weedkiller, or corrugated sheets are three possibilities. You will be able to think of others.

  As the beekeeper should work the hives from behind, a space should be left behind the hives which gives the beekeeper convenient access. If the space there is level and wide enough to accommodate roofs and stacks of supers etc., lifted off during inspections, working the hives is much easier.

  It is generally believed the hives work best if the entrances face south or south-east. However this is not a matter of first importance.

  Check that each stand you construct is

  - solid and firm and not rocking;
  - level from side to side;
  - sloping slightly from back to front with the front lower than the back.

  Time spent on these details *before* the bees are on your hands will save much labour and heartache later.

  C Obtaining equipment

  This has already been dealt with in detail in Chapter 2 so will only be briefly dealt with here.

  First decide on a hive type, then do your best to stick to this one type and acquire no other. The simplest in Britain are probably National or Smith, as Langstroth extracting equipment is not so readily available as equipment to handle British Standard frames. National and Smith are certainly the most widely used locally. At the end of this chapter is an Appendix, giving details about assembling and preparing hives for use.

  Some of you may have inherited or be going to acquire bees already in hives. In this case, provided the hives are sound and of a single orthodox kind, I would advise sticking to that kind, at least to begin with.

The next decision to make is how many hives to stock. I would always advise starting in a small way, with one or at most two hives. In the second or third season it would be sensible to expand a little. I personally feel that 3 hives is the minimum to keep in the long run, as the loss of a queen, perhaps during the winter, can then be made good by splitting another stock, or perhaps by robbing one of the other hives of a frame containing worker eggs from which the queenless stock can rear a new queen. Even with two hives, it is all too easy to end up with both hives hopelessly queenless, and then the only remedy is to appeal for help to another beekeeper, or else to hope that you may find a swarm to take during the summer.

Later when you have learned by experience exactly what is involved, it will be time enough to consider any further expansion. Note that it is important to be ruthless about uniting stocks in the autumn, or your successful experiments in queen rearing can quickly lead to uncontrolled creeping expansion, which soon gets as out of hand as rabbit breeding.

- **D Acquiring the bees**

  Bees can be bought from many different sources, but at the present time, demand outstrips supply so they are quite expensive to buy. Acquiring bees from outwith your own local area has attendant risks attached of possibly bringing in diseases from elsewhere, which could be a disaster for you. Also local bees are almost certainly better adapted to your own local conditions, so if it is possible I would advise acquiring bees locally.

  There are four different ways to acquire bees, and I will enumerate them from dearest to cheapest, explaining how to start in each case.

  1. Buying a nucleus stock or package from a commercial dealer.
  2. Buying a full stock in a hive locally.
  3. Buying a nucleus stock locally.
  4. Acquiring a swarm — either from a local beekeeper who will probably want something for it, or by your own catching of a stray when it is FREE — but of unknown origin and disposition and a lucky break if you get one that is of a mild-tempered and hard-working strain.

  1. A nucleus bought from a supplier is just like one bought locally and both are to be treated alike. A package is in essence an artificial swarm — though the queen may be caged when you get it. Treat it like a swarm, following the seller's instructions about the queen. Note however that in these days when varroosis is present throughout most of Britain and all of continental Europe, the availability of stocks of bees for commercial sale is very limited, and *you should definitely not bring into a Varroa-free area a stock from an area that is not guaranteed free from Varroa*. Save your money and get your bees locally.
  2. If a full stock is bought, or inherited, then you save yourself the cost of buying a hive separately. Simply start the annual cycle according to the month. Spring is the best time to start as the stock has safely wintered and can be checked at a spring inspection before you buy. *"Caveat emptor"* — "Let the buyer beware" — applies.
  3. If you acquire a nucleus reasonably early in the summer (and such a thing is unlikely to be available earlier as they do not winter well), it should build up into a strong stock by autumn, but will probably not yield much surplus honey in its first season. It will consist of 4 to 8 British Standard combs with honey, pollen, brood, bees and a *mated laying queen*. See her before you buy.

     The demand for nucleus stocks in recent years has far outstripped the supply. Our Dunblane and Stirling Beekeepers' Association, like many other local beekeeping Associations is strongly encouraging its members to rear nuclei for sale, and in good years you should be able to purchase a nucleus locally. Their value has greatly increased, and you must be prepared to pay a reasonable price for one.

Acquiring bees locally is in my view always a sound policy, since it avoids the risk of bringing in disease or bees not well adapted to local conditions from elsewhere.

A nucleus will come to you in a closed travelling box. The box still belongs to the seller and should be returned promptly. The contents are all yours once paid for.

When the nucleus arrives, place the box on your hive stand, loosen whatever is holding the roof on, put your veil on and open the doorway of the travelling box to let the bees fly. Then leave them to settle for an hour or so, or even for several days if the weather is bad.

Then, when the weather is good, put on your protective clothing, light your smoker and go to them again.

Lift the travelling box gently over to one side of the hive stand, and put the floor and empty brood box of your own hive on the stand.

Now smoke the nucleus lightly and remove the lid of the box. Carefully lift the combs from the travelling box one at a time, and place them in the same order in the brood chamber of your hive. Give them one or two extra frames of foundation and then a dummy board. Fill the space beyond the dummy with crumpled rags or newspaper so the bees don't start to build wild comb there. Bump any bees remaining in the travelling box down on to the tops of the frames in the hive. Put on a feeder. Give them liquid feed and cover the hive appropriately ending with the roof. Close the entrance of the hive to about 2 cm (1 inch) using a strip of foam rubber or the entrance block, and leave them alone for a week.

Check their development weekly, and as they expand to cover the new frames, give them more frames one or two at a time till the brood box is full. Feed as necessary but do not over-feed or the combs they build will get clogged up with stored sugar syrup and the queen will have no room to lay. At the same time gradually widen the entrance as the strength of the guard bees gradually builds up.

Ultimately you may be able to give them a super or at least a "cap" for a limited honey harvest.

4. If you acquire a swarm or a package, follow the instructions on hiving a swarm given earlier, or if you prefer simply bump the bees down through an *empty* super on to the tops of the brood frames in your prepared hive, let them settle directly into the brood box and remove the super. Then feed them generously until they have good drawn combs, and check their development as for a nucleus. Note that even in mid-summer it is probably a good idea these days to treat any newly-hived swarm against *Varroa*, since there will be no brood being capped for a full eight days, and no supers on the hive, and in this way you can ensure that they do not build up a heavy infestation in their first season.

Once you have acquired bees, you have taken a major step in becoming a beekeeper, and the bees themselves will be your best instructors if you watch and interpret what you see in the light of what you know. All the methods and ideas presented here are workable ones and will give you a good practical start, but be prepared to read books, to listen to and watch other beekeepers, and then to try different methods for yourself. In this way you will gradually find the regime that suits you.

7.3 Mutual support of beekeepers

In some countries where beekeeping is an important part of agriculture, government support is available for beekeepers. Such support in Scotland is very limited. However the Scottish Beekeepers' Association (SBA) and a network of local beekeeping associations provide a valuable resource of assistance for small-scale beekeepers. Indeed these notes have been prepared for the Dunblane and Stirling Beekeepers' Association, but they are also made freely available to all beekeepers in Scotland through the Scottish Beekeepers' Association. The Scottish Beekeepers' Association also provides many other services for beekeepers including a monthly magazine, an education programme, insurance for members relating to their beekeeping, an excellent library and a disease monitoring service.

Within the last two years also the SBA has been encouraging beekeepers in Scotland to register (free!) with BeeBase, through the Food and Rural Affairs (FERA) National Bee Unit web-site, which was originally organised in co-operation with the British Beekeepers Association (BBKA) for beekeepers in England and Wales.

If you become a beekeeper in Scotland, it is wise to avail yourself of the services these organisations provide at a cost which is very modest in comparison with the other costs involved in beekeeping. When you join your local association and the SBA you will also make good friends, and have the opportunity to contribute yourself to your local and national support network for beekeeping.

For details of how to join either the SBA or BeeBase, ask your beekeeping teacher, or look on the SBA's web-site at

`http://www.scottishbeekeepers.org.uk`

or the BEEBASE web-site at

`http://www.nationalbeeunit.com` .

7.4 Appendix — Details of hive assembly

7.4.1 Introduction

This short section goes into the detail of assembling a hive and its components for use, explaining some of the snags to be avoided.

7.4.2 Top and bottom bee-space

Bee space is the space that bees require as a corridor to move around the internal surfaces between, above and below the frames of the hive. It is defined as being from 6 to 10mm but is generally taken as 8mm. If the space betweeen two parts of the hive is less than 6mm the bees will fill tht gap with propolis. Propolis is a resinous substance, orangy brown to red in colour and is obtained from woody plants and is extremely sticky. If the gap is greater than 10mm then the bees will draw out brace comb. Propolis and brace comb make the task of maintenance and inspection in the hive much more difficult, so it is best for the beekeeper to try and maintain the 8mm gap. The National hive has bottom bee space and the Smith hive has top bee space. Do not mix top and bottom beespace equipment in the one hive. This will lead to problems and drive you nuts!!!

The original Langstroth design, the WBC hive, the Wormit Commercial and the original and modified National designs used the first arrangement. Most others use the second, which is thought by many beekeepers to be slightly more convenient for the beekeeper. All modern Langstroth hives and some modern National hives have gone over to this second arrangement of top bee-space. Before buying additional equipment, make sure it matches yours in this regard.

The usual National hive design uses bottom bee space and the Smith hive uses top bee space.

7.4.3 Assembling hive boxes and roofs

If hive boxes and roofs are being bought new, some money can be saved, and transport made easier, if they are bought "in the flat". They then have to be assembled, which is a reasonably straightforward job with hammer and nails, though for knocking together the joints on Smith or Langstroth type hives, hammering the parts through a piece of scrap wood avoids the bruising of the hive wood that direct hammering will cause. Glueing the joints with PVA wookdworking adhesive as well as nailing them is recommended. The instructions that come with the boxes are fairly clear, but more detailed instruction will be given in a practical evening which follows the week when this chapter is presented.

The top quality traditional hives are of western red cedar and are best left unpainted. If any wood treatment is applied, then

- only apply it to the *outside* of the boxes where the bees don't walk much;

- make sure it is a type which does *not* contain an insecticide as protection against woodworm. That would kill your bees in short order! The manufacturers of beekeeping equipment sell a recommended type, though many beekeepers successfully leave western red cedar boxes totally untreated, and they last for many years.

As stated earlier, the outsides of polystyrene hive parts must be painted with standard exterior masonry paint *after assembly* before they are used out of doors. Some polystyrene hives however are now supplied already pre-painted.

7.4.4 Assembling frames and foundation in which the bees will build combs

The frames for the bees to build their combs in, of whatever design, are best bought in pieces for assembly at home. When frames are assembled the parts fit snugly together and many beginners think that friction with added propolis is all that is needed to keep them together. Don't make that mistake, or you will one day lift a comb by its top bar to inspect it, only to have the whole thing suddenly detach itself to fall in a hopeless mess at your feet of squashed bees (maybe including the queen!), spilled honey, broken comb, and destroyed brood. Even worse, you may find that when you prise out the top bar with your hive tool, the top bar is all you get, and the comb and the rest of the frame is still in the hive, and totally impossible to get out. Frames MUST be securely nailed, and frame nails are readily available.

Before fully assembling the frame however, remember that *wax foundation* must be secured inside it.

Foundation is the name given to the sheets of beeswax embossed with the pattern of honeycomb cell bases which appliance dealers sell, and which is fitted inside each new frame before it is placed in the hive. It can be purchased with wire reinforcement inserted for additional strength in the brood nest, or for combs that will be spun in a centrifugal honey extractor. Alternatively thin unreinforced sheets can be bought if you decide to harvest your honey in the comb. Foundation is what guides the bees to build their comb where WE plan and not where THEY fancy, which might well be spanning three or four of the wooden frames, making it impossible to lift out individual combs for inspection, thus defeating the whole Langstroth philosophy. In assembling a new frame therefore, the order of operations is as follows.

First remove the wooden wedge from the top bar, which is held there by a sliver of wood, and clean away that sliver with a sharp knife or your hive tool. Then assemble the top bar and the side bars, by fitting the side bars to the top bar, knocking them right home after making sure that the slots in the side bars are facing *inwards*, and then securing each with two frame nails hammered in *across* the frame, *not* downwards from the top. Make sure the frame remains square.

Next fit the bottom bar on the side of the frame away from the wedge and nail it in place. Before nailing ensure that each end of the bottom bar lies flush with the outside edge of the side bar so that the side bars will hang truly parallel and at right angles to the top bar. If the frame is not to be given to the bees immediately, next fasten the wedge and the other bottom bar to the frame with sellotape and leave it like that until the day it is to be given to the bees. Foundation put into a frame quickly loses its attractive aroma of beeswax and goes stale, and then bees will not build satisfactory comb from it. Foundation kept in its air-tight plastic wrapper will keep in good condition for several years, provided you don't let mice get at it. This is another good reason for assembling frames yourself, and not having it done when you buy the hive.

When inserting foundation into the frames, choose a warm day or a warm room to work in so that the wax is not too brittle. Carefully slide the foundation along the slots in the side bars, orienting the sheet if it is wired so that the loops on the zig-zag wires (bent by you at right angles away from the sheet of wax) fit into the gap where the wedge came out. Then lay the wedge back into the place it came from and use it to nip the top of the sheet of foundation and to trap the ends of the wires, securing it with three nails. Finally insert the remaining bottom bar in the frame, ensuring that the bottom edge of the foundation can slide freely between the two bottom bars to allow for expansion when the bees warm up the wax, and finally nail that second bottom bar in place.

It is worth making sure you get all this right. Frames which have not been correctly assembled will put both you and the bees thoroughly out of temper, probably on a day when you are both already fed up because the weather is bad.

7.4.5 Spacing frames in the hive

The standard frames with straight side-bars (Thornes DN1 or SN1 frames) must be spaced apart in the hive by some sort of spacer. The traditional modern British spacer is the "plastic end", which is fiddly but works well enough on a National standard frame but can slide off the short lugs of Smith frames at embarrassing moments. Most users of the Smith hive prefer the alternative of self-spacing Hoffman frames (Thornes DN4 or SN4), whose side-bars are thickened at the top so that they are in contact over a short distance when the frames are correctly spaced. If like me you dislike fiddling with plastic ends, then Hoffman frames can also be used in a National hive. The bees do propolise the contact area, but it is small enough to be tolerable. Alternatively Hoffman converter clips in plastic can be nailed to the side bars of conventional frames to do the same job. In the honey supers, straight-sided Manley frames in contact throughout their depth are excellent, since they hardly ever have to be inspected, and so the fact that they get propolised hard together does not matter, since they only need to be dealt with away from the bees at harvest time. These Manley frames are a little more expensive, as they use more timber, but they are very strong, hang beautifully straight in the honey extractor, and last for many years.

Another spacing alternative in honey supers is to use ordinary straight-sided frames without any attached spacer, but to fit *castellated spacers* inside the super, which are metal strips looking like the battlements on a castle, and into the gaps of which the frames fit neatly. Modern National supers are made with a slot to receive these castellated strips. They must *never* be used in the brood box however, since they prevent the frames from sliding along and make inspecting the brood box very difficult.

The National and Smith hives are designed to take 11 frames in a box at plastic-end spacing. Some modern Hoffman frames give a slightly closer spacing — 35 mm ($1\frac{3}{8}$ inches) instead of 38 mm ($1\frac{1}{2}$ inches) — and it is then possible to squeeze a twelfth frame in. This is inadvisable as the frames jam hopelessly after a little propolis has been added by the bees. It makes for much easier working if the end space is filled with a *dummy* — a simple wooden board cut into the shape of a frame, and easily made at home from an off-cut of shelving. (In the WBC hive the same argument arises between using 10 frames and a dummy rather than a squeezed in 11th frame).

Chapter 8

Dealing with the crop of honey and beeswax

8.1 Honey in shallow frames

The commonest way of obtaining honey locally is in shallow extracting frames fitted like the brood frames with wired wax foundation.

Once the honey is sealed it is ready for harvest, and it is removed from the combs in a centrifugal honey extractor, so that the combs can be returned to the bees for re-use which means a much quicker second fill of the same super as the bees do not have to use time and honey in secreting wax to re-build the comb. It has been estimated — probably by comparing the chemical make-up of carbohydrates (honey) with that of hydrocarbons (wax) — that bees use as much as 6 kg of honey to produce 1 kg of beeswax.

When extracting honey you should work in a warm room and with freshly removed supers. Combs kept for more than a day or two away from the hive are much more difficult to extract, particularly if they have been allowed to cool down.

Before extracting, the cappings must first be removed from the combs by cutting them away with a knife. I sometimes use an uncapping fork, holding the comb on edge above a large bowl to receive the cappings, and working upwards. Special uncapping knives can be bought, and a pail with a batten over it having a nail sticking up from it on which the end of the top bar of the frame can be impaled is better than a bowl. The cappings in the pail or bowl are left for processing at the end. Remember to uncap *both* sides of each comb.

Make sure the extractor has a fairly evenly balanced load before starting to spin it (and of course make sure that it is clean and honey-tight before you begin).

With the small tangential extractors, spin gently to extract the bulk of the honey from the outer comb faces, but not enough to force the honey on the inner faces to burst the mid-ribs. Then turn the combs and spin fairly hard, turn again and finish the first face.

When the level of extracted honey in the extractor rises to near the bottom of the extractor cage, it is time to run it off from the tap through a coarse strainer into a settling tank or ripener.

Finally after finishing off the extracting, the mush of cappings and honey can be dumped into the strainer to let as much honey as possible drain from them. The washing water from the cappings when they are turned out from the straining mesh or cloth forms a good basis for a brew of mead if you like that kind of thing. When you are finished, wash all the equipment starting with *cold* water so that scraps of wax float away and do not melt and adhere to everything.

Next day the honey can be run off (ideally through a finer strainer) into jars or storage tins or pails from the settling tank. Honey jars in 2017 cost about 36p each or more. If you are going to sell honey in jars, then be sure not to under-fill them, not to spill honey on the outsides, and also to use commercially produced labels which state in the legally required type size the legally required particulars about weight etc. which now includes the name and address of the producer, and some form of batch number which will allow the producer to identify when and where the jar originated if there is any come-back from a customer. The country of origin (either UK or Scotland) must also be shown, and a "best before" date (which for the small producer can be printed as "Best before end. . . " allowing the producer to fill in a year two years after the bottling date (which is probably about right). The appliance dealers will produce labels for you at reasonable cost with the appropriate name and address particulars, but of course you must add your own batch number when you jar the honey.

Honey which has not yet been sealed by the bees is usually unripe with too high a water content to keep satisfactorily. It tends to ferment. Combs with more than a small area of unsealed cells should not be extracted, but should be returned to the hive for the bees to finish.

8.2 Section honey

The simplest form of honey crop to deal with is that in which the bees have stored the honey in small wooden *sections* a little over 10 cm (4 inches) square, holding about 400 grammes ($\frac{3}{4}$ lb) of honey each. To use these, a section crate must be bought to sit inside or take the place of a super, and the sections must then be fitted inside it with each row of three separated from its neighbour by a tinplate (or plastic) divider. Before the sections, which are purchased flat, can be used, they must be folded up and fitted with starters of thin wax foundation. To prevent the wood breaking when you fold it, damp the outsides of the folding joints. Be sure you insert the foundation the right way with pairs of opposite parallel sides of the hexagonal cell bases lying *vertically* and not *horizontally*, and points of the hexagons at the top and bottom, not at the sides. As the sections are square, it is merely a matter of inserting them the right way in the crate if they are fitted with full sheets of foundation. However if you use starters of part sheets, make sure you cut the wax the right way so that the cell bases have the proper orientation when the starter is hanging from the top of the section.

At harvest, the sections are simply removed from the box, have any propolis carefully cleaned off, and are ready for sale or use. They are probably more saleable than any other form of honey. Tidily wrapping them in clingfilm keeps them clean and enhances their appearance.

There are three reasons why they are not universally used. The first and least important is that all the beeswax from the crop is lost, or at least is eaten with the honey. However beeswax is a rather specialised item with a limited market, and limited uses by the beekeeper and in the home, so this loss might be tolerated.

The second is that they involve purchasing extra equipment — crates and dividers — and are themselves expensive and wasteful as they cannot be re-used. The premium price obtainable however would compensate for this.

The third reason is the deciding factor. Bees HATE them. They dislike the confinement in small separate units apart from the queen and their sisters. They are often very reluctant to enter them and start storing honey there. If the season is poor, they sometimes refuse point blank. Sometimes an old section in the crate with some honey in it will entice them up to start, sometimes not.

The overcrowding in the brood nest when bees stay down in this way is only too likely to trigger off swarming, and many beekeepers therefore feel the game is not worth the candle, particularly if all you have at the season's end is a collection of unsaleable and unusable partly filled sections.

Some more modern forms of plastic section are said to be easier to manage, and more acceptable to the bees. After some experience you may choose to experiment with some form of section honey, but it is advisable to gain some experience with shallow frames first.

8.3 Dealing with Oil Seed Rape honey

Oil Seed Rape is now again becoming quite a popular crop with farmers locally, and this can improve honey yields greatly. It is a crop that bees love, and is of great benefit to beekeepers provided the farmers do not mis-time their insecticidal spraying, although recently the use of neonicotinoid seed dressings on this crop is sometimes being implicated in losses of bees.

Apart from the problems of pesticides on the crop its main drawback for the beekeeper is that it yields a honey high in the sugar called dextrose, which therefore granulates quickly into a very hard set honey when it cools down. If you try to spoon it out of a jar in this state without warming it up first, you will bend the spoon and crack the jar.

It granulates while still in the comb and even a small admixture of it will solidify a large amount of other honey. Honey set solid will of course not spin out in the extractor. There are three possible approaches.

First one can take supers very promptly off hives as soon as a reasonable proportion of the honey is sealed, and certainly before the super is completely filled. If it is quickly extracted at this stage, then the combs can be preserved, but any delay means that the battle is lost. If one succeeds, the extracted honey will again granulate before it is passed through a fine filter, so the best procedure is then probably to be content with only one coarse filtering, and then to stir the honey vigorously as it is setting. This breaks up the crystals and produces a fine soft granulation which is much easier to deal with. If it does set too hard, gentle heat will soften it again. See the table at the end of this chapter for the appropriate temperature which must be carefully controlled.

Second one can sell or use the honey as set honey in the comb, eating comb and all. This is a simple and straightforward solution, but not everyone likes eating beeswax.

A third approach is to re-heat granulated combs in a controlled way, observing limits on both time and temperature very carefully. The combs while warm can then be pressed through a straining cloth and the honey again allowed to granulate with frequent stirring to keep the set soft and fine. If this is the route chosen, then it is best to use *unwired* foundation in the supers. It is wasteful of foundation, but in compensation one gets a plentiful yield of beeswax every year. This involves a lot of hard work, but can produce very good honey harvests.

8.4 Heather Honey

Heather honey is a different story. It too will not spin out in an extractor because it is *thixotropic*, i.e., it is like a non-drip gloss paint. It forms a semi-solid gel until it is stirred, and then becomes liquid for a time, but re-sets again into a gel if it is left to stand.

If you fit *unwired thin super* foundation in your supers for heather honey, then the simplest way to harvest it is as cut comb honey where the comb as well as the honey is eaten.

Another good way of dealing with it is to scrape the combs down to the mid-rib with a spoon or a special Smith scraper, wrap the resulting mush in a straining cloth — a pair of lady's tights is very effective — and press the honey out. A proper heather honey press is expensive but it is possible to improvise for this job if you are operating on a small scale. The residue after pressing can again be rendered down for wax. Dunblane and Stirling Beekeepers have two small heather honey presses for use by members, so many of our members get their heather honey pressed that way.

Of course heather honey *sections*, if you can persuade your bees to fill them, are almost worth their weight in gold!

Note: The heather honey described above is that from the common ling heather which yields nectar in August-September in Scotland. Bell heather and cross-leaved heath yield a very dark honey looking almost like treacle, but of a purplish colour. It is gathered a month earlier than ling heather honey. Unlike ling heather honey it can be easily extracted. These kinds of heather are not nearly so common as the ling heather, so if you want to try for them, you will have to enquire about a good site where these plants grow.

8.5 Beeswax

The wax cappings (and any other comb scraps but *not old brood comb*) should be washed in several changes of water, and can then be melted down satisfactorily in a double saucepan over boiling water.
N.B. DO NOT RENDER WAX BY MELTING OVER DIRECT HEAT OR YOU WILL SCORCH IT BLACK AND MAY EASILY SET YOUR HOUSE ON FIRE. IT IS HIGHLY FLAMMABLE.

The molten wax should be allowed to set, and afterwards the surprisingly dirty cake of wax removed from the saucepan where there will be a residue of washing water under it. Some of the dross can be scraped away and the cake then be allowed to dry. The dirty wax must then be carefully re-melted and strained though a pre-heated fine filter — kitchen paper or nappy liners are good. A carefully timed sojourn in the *cool* oven of an Aga does the job well, but avoid prolonged heating which scorches and darkens the wax. The clean molten wax can then be poured into a mould and allowed to set. Small moulds can be purchased giving cakes of about 25 g (1 oz) in weight. For larger cakes a pyrex bowl makes a good mould, but it is hard to get a large cake to set without cracking.

Clean wax in bulk can be sold for not a very high price to the appliance dealers, or in part exchange for goods. It makes excellent *candles* and *polish*, and that can probably be sold for a better return. I now have a press for making foundation and have more wax for that purpose than I need. Making foundation is a rather slow process and needs a certain amount of dexterity if it is to be done successfully.

Appendix Some Useful Temperatures for honey and wax handling

Fahrenheit	What happens at this temperature	Celsius
400^0	Flash point of beeswax (where it catches fire) DANGEROUS!	204^0
250^0	Beeswax has no well-defined boiling point, but at this temperature starts to smokes	121^0
235^0	Boiling point of bee candy solution (5 lb sugar to 1 pint water) **Use candy thermometer only**	113^0
185^0	Beeswax starts to discolour when subjected to dry heat	85^0
150^0	Caramelisation of ling heather honey may occur depending on length of time	66^0
146^0	Average melting point of beeswax but can vary according to composition	63^0
145^0	Heating for 30 minutes destroys yeasts to prevent fermentation but can impair some honeys	63^0
140^0	Maximum for warm water to flush and dissolve honey in machines Microwave treatment to reliquifiy granulated honey in jars	60^0
130^0	Separating and melting granulated honey from cappings — 1–2 days	54^0
122^0	Honey viscosity suitable for pumping and filtering Small granules melt in 1–2 hours	50^0
120^0	Stirring for cooled bee candy solution	49^0
104^0	Maximum for spinning cappings in centrifuge	40^0
90^0	Pre-heating heather and oil-seed rape honey combs prior to extraction	32^0
80^0	Pre-heating blossom honey combs prior to extracting — 12 hours	27^0
75^0	Introducing seeding for granulating honey (5%–10% seed) Introducing yeast cultures to mead mixtures	24^0
57^0	Encourages rapid granulation	14^0
50^0	Storage of honey in bulk or jars	10^0

Most of the table above has values copied from a leaflet produced by the Scottish Agricultural College, but with some errors corrected. Fahrenheit temperatures in whole degrees were the originals. The Celsius temperatures have been rounded to the nearest whole degree.

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