The Food and Environment Research Agency

Managing *Varroa*


About this leaflet

Managing *Varroa*

Since its discovery in England in 1992 the parasitic mite, *Varroa destructor*, has spread to infest colonies of honey bees throughout the UK. Its management has now become a routine part of bee husbandry. The development of strains of mite resistant to treatments used against them poses new challenges to beekeepers. This leaflet describes the biology of the mite, how it can be recognised and monitored, the latest approaches beekeepers can use to control the infestation in their hives, and a look ahead to the future.

Varroa destructor was first reported in Western Europe in the late 1970s. The mite causes varroosis, a very serious and complex infestation of honey bees. It has caused massive economic losses and expense for beekeepers, and its destructive power is evident from the huge number of colonies lost since it first arrived in Europe. *Varroa* remains the number one management problem for beekeepers and scientists alike. The onset of resistance to the treatments available, and the potential impact of secondary infections, will make controlling the mite more difficult in the future. *Varroa* will continue to be a serious threat to the long-term sustainability and prosperity of European apiculture and to the environment through the disruption to pollination.

The Food and Environment Research Agency
Sand Hutton
York
YO41 1LZ
UK
Telephone +44 (0)1904 462 000
Fax +44 (0)1904 462 111
Email info@fera.gsi.gov.uk
Website www.defra.gov.uk/fera

This document is also available on BeeBase (National Bee Unit) website, www.nationalbeeunit.com

Published by The Food and Environment Research Agency. Printed in the UK, November 2010, on material containing 80% post-consumer waste and 20% Elemental Chlorine Free pulp.

Contents

This page gives a simple introduction to the *Varroa* mite, its presence in the UK, and its management by beekeepers. The concepts you will find below are explained in more detail later in the leaflet.

What is *Varroa*?

Varroa destructor (Acari: Varroidae), formerly known as *Varroa jacobsoni*, is a species of mite – an animal group more closely related to spiders and ticks than to insects. *Varroa* lives as an external parasite of honey bees. Originally confined to the Asian honey bee, *Apis cerana*, it has spread in recent decades to the Western honey bee, *Apis mellifera*.

Why is it a problem?

Unlike *Apis cerana*, our honey bee has few natural defences against *Varroa*. The mites feed on both adult bees and brood, weakening them and spreading harmful pathogens such as bee viruses. Infested colonies eventually die out unless control measures are regularly applied.

Where is it found?

Varroa has spread through movement of infested bees far outside its natural range in Asia. It is now present on all continents except Australia (though it is present in New Zealand). First found in the UK in 1992, it has since spread to affect nearly all apiaries in the UK, though it has not been confirmed in the Isles of Scilly or the Isle of Man and some parts of Scotland.

How did it get to the UK?

We do not know for certain how *Varroa* reached the UK. Inadvertent movement of infested bees in imported goods is thought to be the most likely cause, although deliberate illegal importation of bees from infested countries is also possible.

Do I have to report the presence of *Varroa* in my colonies?

Varroa has been removed from the list of notifiable diseases so beekeepers are no longer obliged to report its presence in their colonies.

Can *Varroa* be eradicated or controlled?

Varroa cannot be completely eradicated but beekeepers can successfully keep productive bees despite the presence of the mite. *Varroa* can be controlled by monitoring the infestation in their colonies and the use of appropriate control methods to keep mite numbers below levels that are harmful.

How do I know how badly infested my colonies are?

The signs of infestation may not be obvious until your colonies are heavily infested – by which stage they are at great risk. However, there are several methods that can be used to detect the mites and estimate their numbers at a much earlier stage. These include counting dead mites that collect on the hive floor, and counting mites inside sealed brood cells. These methods help you plan the control methods to use.

What control methods are available?

Control methods can be divided into two groups: management methods ('biotechnical methods') and chemical controls ('varroacides'). In practice, the best controls result from using a combination of methods at different times of the year depending on the level of infestation. This is commonly known as 'Integrated Pest Management' or 'IPM'.

What are 'pyrethroid resistant' mites?

In recent years *Varroa* mites in many areas have developed resistance to pyrethroids – the active ingredients in the varroacides that until now have most commonly been used to control them. As pyrethroids do not kill such mites other treatments need to be used instead. Resistance has spread widely throughout many parts of the UK – posing a new and significant challenge for beekeepers. This problem has not, however, yet reached the whole of the UK, and in these areas they will still work very well. In some areas where pyrethroids have not been used for several years, mites may become susceptable again. In such areas pyrethroids must not be used repetitively, but occasionally, as part of an IPM programme. The onset of mite resistance to other control substances now being used is very likely.

Feeding

Varroa can feed and survive on both adult bees and their brood. The mites feed on their host's haemolymph (blood) through punctures made in the body wall with their sharp mouthparts.

Reproduction

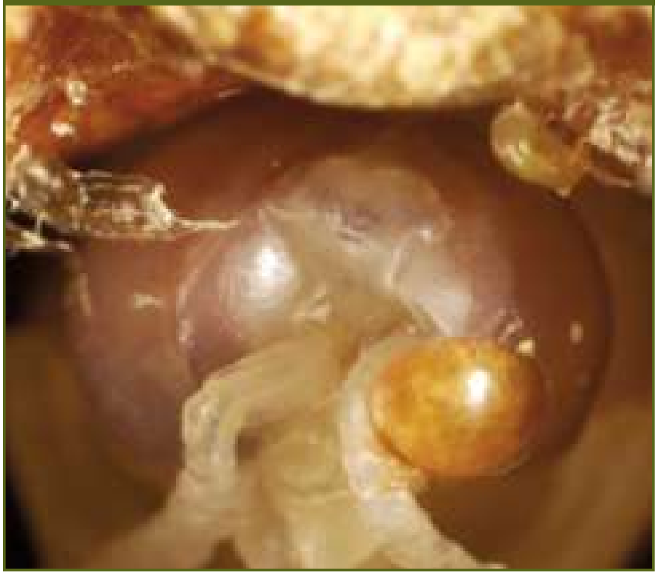
The entire life cycle of *Varroa destructor* mites occurs within the bee hive. It consists of a phoretic stage (transport phase) as a parasite on adult bees and a reproductive stage inside the sealed brood cells. To breed, a gravid (egg-carrying) female mite enters occupied brood cells just before the cell is capped over, where she remains in the brood food under the larva until the cell is sealed. She breathes through a respiritary organ, common in mites, called the peritreme. Five hours after cell capping, the bee larva consumes the rest of the food. Mites prefer to breed in drone brood (10-12 times more frequently), but will also breed in worker brood. About four hours after capping she then starts feeding on the immature bee and establishes a feeding site on this host that her offspring can feed from as they develop. If you look carefully, you will see spots of white faeces or feeding *Varroa* around this site, usually towards the hind end of the developing pupa. These white spots will also be seen on the cell walls. About 60-70 hours after capping the female lays the first of her eggs. For further details please see the life-cycle diagram.

Figure 1: Close up of adult female *Varroa* mite

Figure 2: High magnification electron micrograph of adult female *Varroa* mite

Figure 3: *Varroa* mites in different stages of development on a pupal worker bee

Figure 4: Immature mites on pupa



Developing mites pass through two juvenile stages, known as the protonymph and deutonymph, before becoming adults. Development time from egg to adult for males is 6-7 days and for females 5-6 days. Mating between male and female mite offspring occurs within the cell. Each female lays 5-6 eggs, the first being a male followed by 4-5 female eggs laid at regular 30-hour intervals. The first egg to hatch is the male, then the oldest daughter moults to adulthood 20 hours later. By laying only one male egg, *Varroa* increases the number of females that can reproduce at the next generation. Since the males do not survive outside the cell, females must be fertilised before the bee emerges from the cell, otherwise they remain sterile.

The duration of each reproductive cycle is limited by the development time of the bee, so not all mites reach maturity and mate by the time the bee emerges from the cell. Males and any remaining immature females die, unable to survive outside the sealed cell. With heavy infestation, two or more female mites may enter the same cell to breed, and female mites may produce more than one generation.

Mature female mites leave the cell when the host bee emerges. Some of these may produce a second or third generation of mites by entering new brood cells. The success rate of reproduction (new mature female mites) in worker brood is about 1.7 to 2 but increases to between 2 and 3 in drone brood due to the longer development period. The development and status of a colony affects mite population growth, and depending on circumstances mite numbers will increase between 12 and 800 fold over a season. This means that mite levels can resurge rapidly.

Life-span

The life expectancy of *Varroa* mites depends on the presence of brood and will vary from 27 days to about 5 months. During the summer *Varroa* mites live for about 2-3 months during which time, providing brood is available, they can complete 3-4 breeding cycles. In winter, when brood rearing is restricted, mites over-winter solely on the bodies of the adult bees within the cluster, until brood rearing commences the following spring.

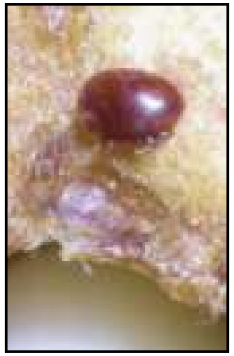
How *Varroa* spreads

Varroa mites are mobile and can readily move between bees and within the hive. However, to travel between colonies they depend upon adult bees for transport – through the natural processes of drifting, robbing, and swarming. *Varroa* can spread slowly over long distances in this way. However, the movement of infested colonies by beekeepers is the principle means of spread over long distances.

The life cycle of the *Varroa* mite (*Varroa destructor*) in the European honey bee *Apis mellifera*

①

Varroa feed on the haemolymph (blood) of the bees by making punctures through the body wall with their sharp mouthparts. Mites have a preference for nurse bees. During the summer mites live for 2-3 months and readily transfer from bee to bee and brood cell to brood cell. In winter mites live much longer and over-winter on adult bees within the cluster until re-entering the brood the following spring. Feeding of the mites can weaken and damage bees and brood.



②

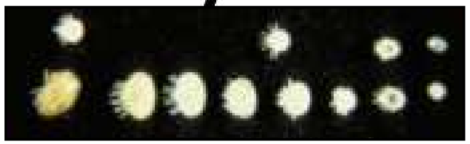
To breed, an adult female mite enters a brood cell just prior to capping, where she remains in the brood food under the larva until the cell is sealed. Mites prefer drone brood but will also breed in worker brood.

③

Four hours after capping the female mite begins to feed off the developing bee, and establishes a feeding site for her offspring. 60-70 hours after capping the female lays the first of her eggs.

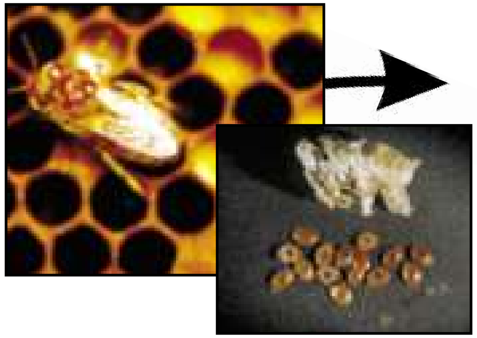
④

Each female mite lays 5-6 eggs, the first always being a male egg followed by 4-5 female eggs laid at regular 30 hour intervals. The male hatches first followed by the females. The male mite then mates with the female offspring within the cell.



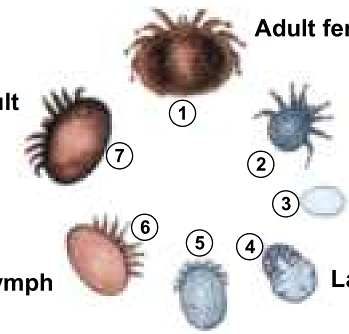
⑤

Development of the mite is through two juvenile stages: the protonymph and deutonymph before becoming an adult. Time from egg to adult for males is 6-7 days and for females 5-6 days.



⑥

The duration of each reproductive cycle is limited by the development time of the bee, so more mites are produced in drone brood than in worker brood. Not all females reach maturity and mate by the time the bee emerges from the cell. Mature female mites leave the cell with the emerging bee. Immature females and the males do not survive outside the cell.



The entire life cycle takes place within the bee hive. It consists of a phoretic stage (transport phase) as a parasite on adult bees and a reproductive stage inside sealed brood cells.

Effects on individual bees

Individual bees infested with *Varroa* during their development usually survive to emergence but may show signs of physical or physiological damage as adults. These include shorter lifespan, reduced weight, shrunken and deformed wings and reduced natural resistance to infections.

Some brood infested by *Varroa* may die, usually at the pupal stage of development, and remain in the cell until removed by adult bees.

Figure 5: Commom symptoms of heavy *Varroa* infestation - a worker bee with deformed wings

Figure 6: *Varroa* damage: normal bee on left, deformed bee on the right

Figure 7: Immature mites on pupa

Varroa, viruses and other pathogens

There are many bee viruses which are naturally present in the bee population at a low level without normally causing significant harm. When *Varroa* feeds, as well as taking essential nourishment away from the developing bee, the mite, acting as the vector, can aid virus spread so that in heavily infested colonies they become much more widespread and potentially harmful by reducing the bees lifespan. *Varroa* may also worsen the harmful effects of other common bee diseases such as Acarapisosis (caused by the tracheal mite, *Acarapis woodi*).

Effects on colonies

Small numbers of *Varroa* mites infesting a colony will usually cause no obvious harm. However, as the level of infestation rises, the risk of harmful effects also rises. In poorly managed colonies where infestation is allowed to increase, signs of damage to the entire colony start to become evident. Severe infestation slows the replacement of old adult bees with healthy young bees, and may lead to the rapid spread of harmful bee viruses in the colony. At this stage, the normal processes of foraging, brood rearing and colony defence diminish and the colony's entire social organisation begins to deteriorate – a process known as colony collapse.

Colony collapse is usually very rapid (taking only a few weeks) and may affect even strong colonies that have shown no outward signs of damage. However, a closer look would reveal many mites on adult bees (with deformities) and heavily infested sealed drone and worker brood, often with many mites per cell.

Colony collapse can occur at any time of the year but in the UK seems to occur most often in August and September. However, spring colony collapse, which in turn leads to mite invasion of neighbouring colonies, can be quite common in March, April, and possibly into May. These mites add to *Varroa* populations already present, which could mean that colony collapse could occur earlier than anticipated i.e. before the end of the summer. It is important to check mite levels in spring to verify whether invasion has occurred.

Figure 8: Electron micrograph of particles of Acute Bee Paralysis Virus (ABPV), representative of any 30nm virus particles in bees

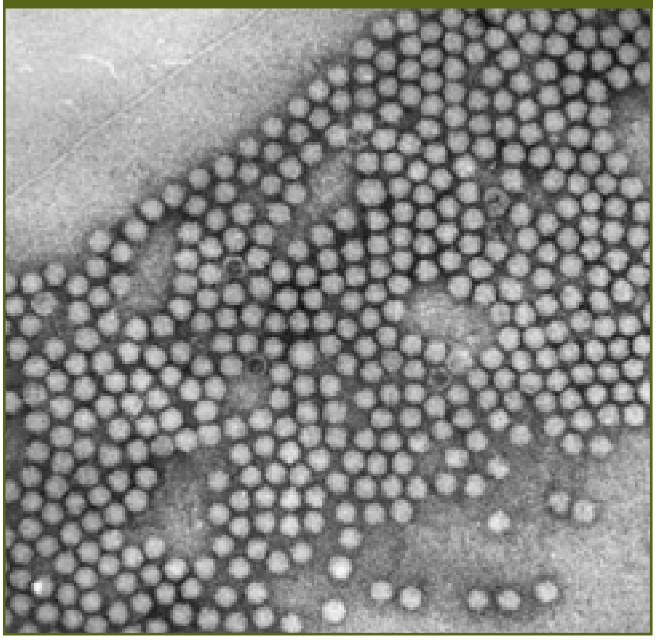


Photo courtesy of Brenda Ball, Rothamstead Research.

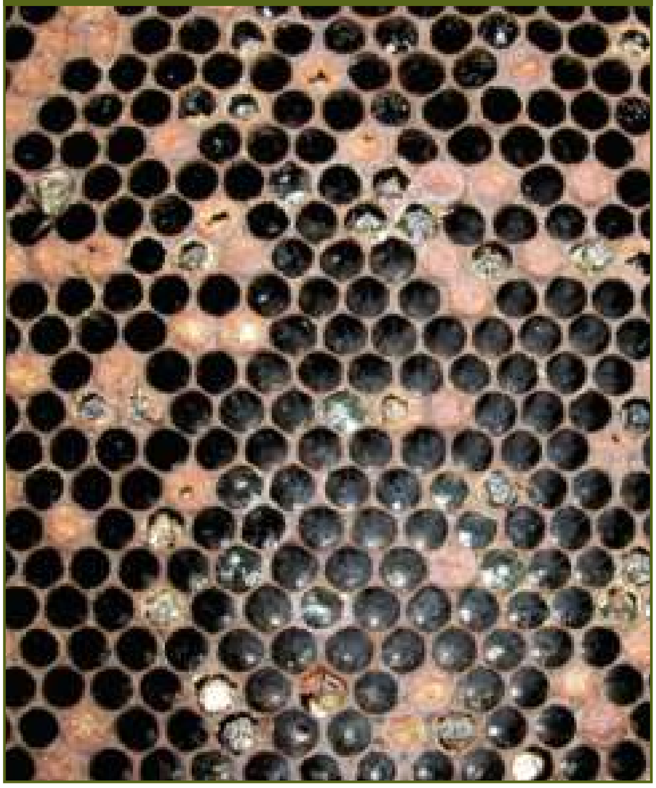
Figure 9: Electron micrograph of the mouth parts of a *Varroa* mite

The signs of colony collapse

- A sudden decrease in the adult bee population, usually with few dead adult bees present
- Bees with deformed wings and abdomens
- Numerous *Varroa* mites on remaining bees, on worker and drone pupae, and on the hive floor
- Various abnormalities of the brood (e.g. bald brood, poor brood pattern, patches of neglected and dead 'emerging' brood often discoloured brown and partly removed by the bees

Caution: make sure that these signs are not caused by foul brood infection (see Fera leaflet 'Foul brood disease of honey bees and other common brood disorders')

Figure 10: Damaged brood: signs of severe infestation, also known as bee parasitic mite syndrome



Harmful mite population threshold

There is no clear harmful threshold beyond which a mite population suddenly causes harm. A mite population that causes no obvious damage to one colony may prove very damaging to another. This can be due in part to differences in the levels and types of bee viruses and other pathogens present in the colonies and the bees' natural ability to tolerate *Varroa*, as well as environmental factors.

However, in the UK researchers agree that it is wise to aim to keep the *Varroa* population below about 1000 mites; above this level the risk of damage from the mites, associated pathogens and the effect of feeding on the bees can quickly become very significant. In Europe and parts of the United States, higher threshold levels of around 4000-5000 mites are generally used.

Mite invasion pressure

The movement of mites between colonies, spread by adult bees, can play a key role in the mite population build-up. It can occur at any time of the year when bees are active. In areas of high colony density with heavily infested colonies, the rate of mite invasion can be extremely high, and populations may build up to damaging levels in a short time – sometimes in a matter of a few weeks or months.

Varroa population increase

Varroa populations in infested colonies increase naturally through two processes – the reproduction of mites in brood cells, and the influx of new mites into the colony through invasion.

Figures 11 to 13 illustrate these two processes. They are based on the assumption that mite populations double through mite reproduction approximately every four weeks – although in reality the situation is more complicated as many factors (such as the amounts of worker and drone brood present) influence the rate of mite reproduction.

Figure 11 illustrates the increase in the mite population for colonies infested with differing numbers of mites at the start of the season (without any mite invasion from outside). During the 180 days shown, mite populations build up steadily. Where only very few mites are initially present the mite population remains well below the harmful threshold of 1000 mites for the entire period shown. However, in colonies starting with larger numbers of *Varroa*, mites build up to harmful levels much faster. It is essential to ensure mite populations are as low as possible at the beginning of the active rearing season.

Figure 11: Effect of initial mite numbers on subsequent population growth

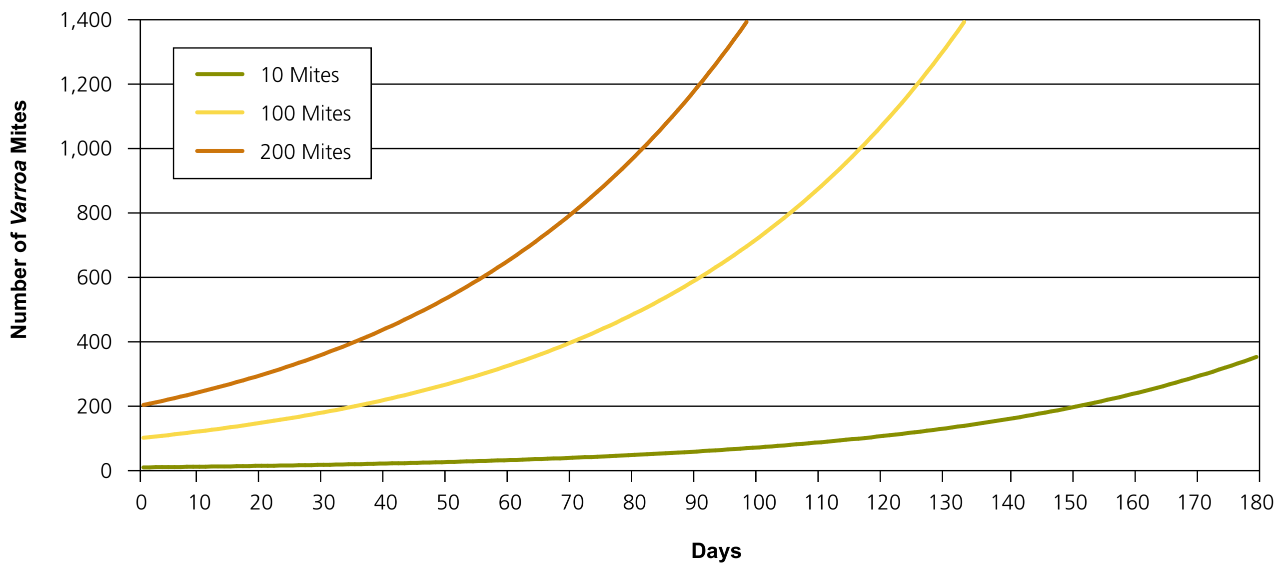


Figure 12 illustrates the effect of mite invasion. Where small numbers of mites are present at the start of the season, and no mite invasion occurs, the mite population remains below 1000 during the whole period shown. However, mite invasion early in the season causes the mite population to reach harmful levels much more quickly – depending on how many mites invade the colony.

Figure 12: Effect of mite invasion on subsequent mite population growth

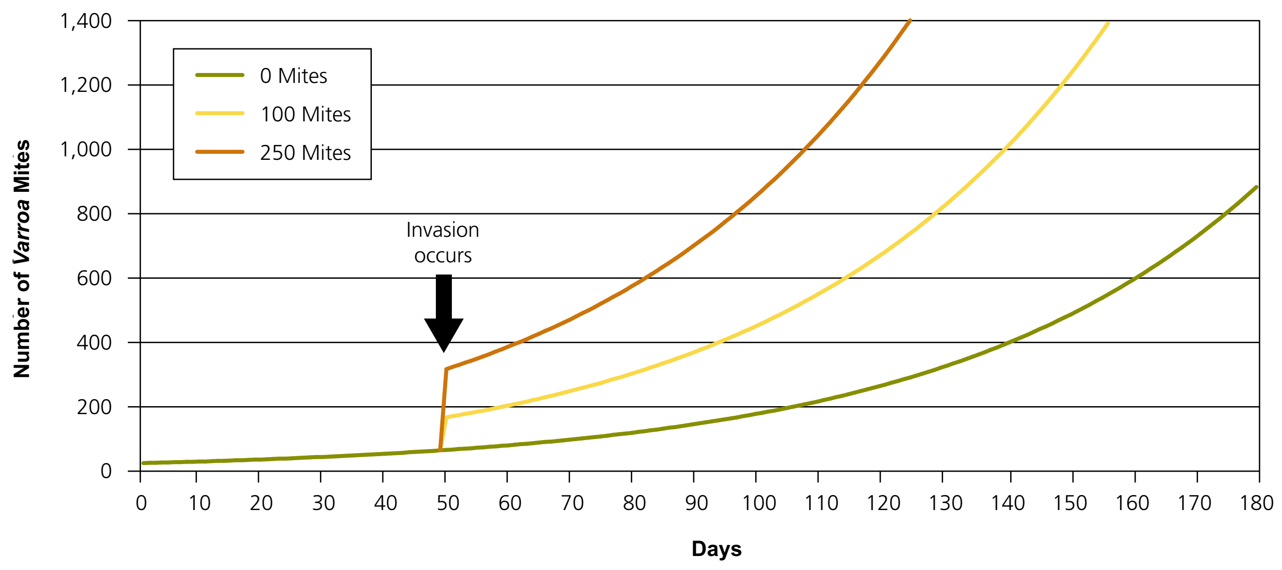


Figure 13 shows the recovery in the mite population that occurs following treatment (for example with a varroacide). The fall in the mite population when treatment is applied depends on the treatment's efficacy. The mite population takes much longer to return to a harmful level when a very effective treatment is applied than it does when less effective treatments are used. Understanding these principles is essential if you are to successfully use the methods of *Varroa* monitoring and control described later in this leaflet.

Figure 13: Effect of treatment efficacy on subsequent mite population growth

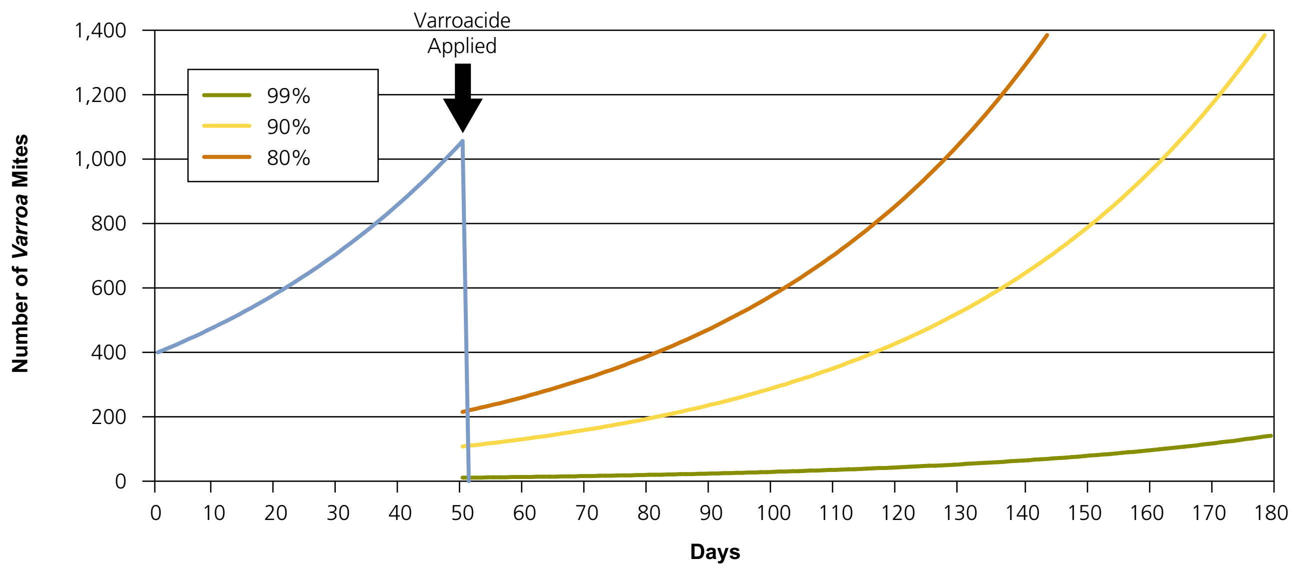
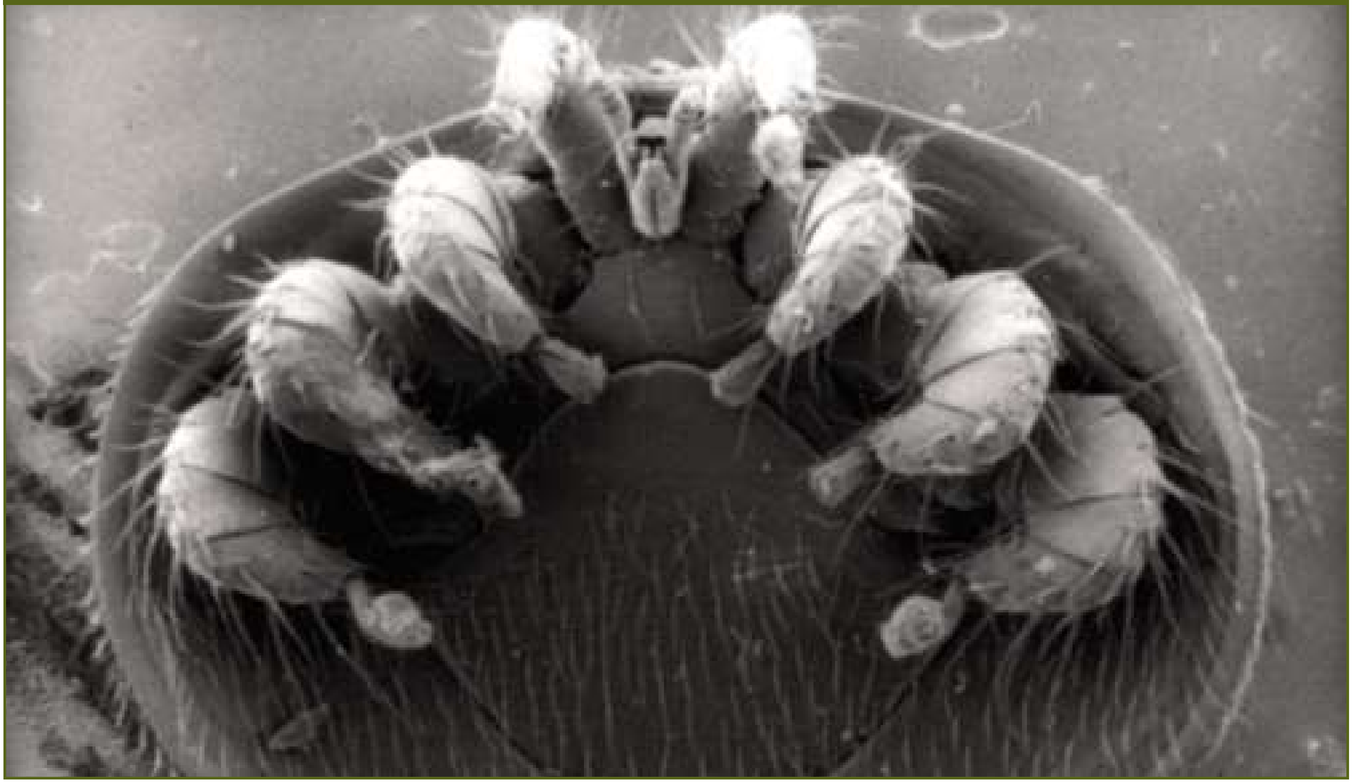


Figure 14: Electron micrograph of a *Varroa* mite showing mouth parts, legs and ventral surface



How to recognise and monitor *Varroa*

Varroa management is an essential part of contemporary beekeeping. All beekeepers need to make sure that they are able to recognise *Varroa* mites in their hive, and to have one or more methods at their disposal for estimating how serious the infestation is.

Figure 15: Close-up of adult female *Varroa* mite

Figure 16: *Varroa* mites visible on the thorax and abdomen of the worker bee in the middle of the picture

Recognising *Varroa*

Female *Varroa* mites are easily recognised by their flat, reddish-brown oval bodies (1.6 x 1.1mm). Male *Varroa* mites exist only in brood cells, and are smaller and pale in colour. Immature female mites are also found inside cells, and are paler than their adult counterparts.

Since *Varroa* mites are very small, if you wear glasses for reading, you will probably need to wear them to see *Varroa*. Some beekeepers find a hand lens helpful too.

Figure 17: *Braula coeca*

Figure 18: *Braula coeca* compared to *Varroa*, *Tropilaelaps* and *Melittiphis*

The bee-louse, *Braula coeca* (a wingless fly that lives harmlessly on adult bees) may be confused with *Varroa* (Figure 17). It can be distinguished from *Varroa* by its more rounded shape and its six legs which are readily visible on both sides of its body. Two other mites that beekeepers need to be able to distinguish are *Tropilaelaps* spp. (bottom image Figure 18) and *Melittiphis alvearius* (far left image Figure 18). *Tropilaelaps* is a serious exotic pest of honey bees and is notifiable (please see Fera leaflet *Tropilaelaps*: parasitic mites of honey bees PB 10780). *Melittiphis* mites are predatory mites, preying on scavenger mites that occur in bee hives. They do not harm honey bees or their brood.

Monitoring *Varroa*

You must learn to regularly estimate the level of infestation throughout each season. Infestation will build up more quickly in some years than in others and more quickly in some apiaries than others. A control programme that was effective one year will not always be effective in another.

Monitoring your colonies routinely can tell you how mite infestation is developing. You can then use this information to decide what and when control methods will be appropriate.

A range of monitoring methods is available to use – ranging from the quick and approximate through to the complex and more accurate. You will have to decide which of these suit your own individual beekeeping practices.

Figure 19: A screened floor suitable for monitoring natural mite fall. A typical floor will have 3mm metal mesh and a mite catching drawer/tray underneath

Figure 20: *Varroa* floor with insert covered in hive debris

Figure 21: Hive floor debris containing mites

Monitoring tips

How often should I monitor?

Ideally, you should aim to monitor at least four times each season: early spring, after the spring honey flow, at the time of honey harvest, and late autumn. If you think significant mite invasion is taking place then the frequency with which you monitor should be increased.

How many colonies should I monitor?

Mite levels vary significantly between colonies so ideally you should monitor all of your colonies. However, this may be impractical for larger scale beekeepers who should instead monitor a representative proportion of colonies in each apiary. Make sure you include some of the strongest colonies as these often have the highest mite populations.

How to monitor colonies for *Varroa*

Table 1: Some commonly used *Varroa* monitoring methods

Method: Monitoring natural mite mortality ('mite drop')	Pros and Cons
1. Maintain the colony on a *Varroa*-floor with a sampling drawer/tray underneath. 2. Remember to remove debris from the drawer/tray regularly during the summer to prevent severe wax moth infestation. 3. At intervals examine the floor debris and count the number of *Varroa* mites. Convert this to a daily 'mite drop' figure by dividing by the number of days since the last measurement. 4. If there is a lot of debris (e.g. after winter) mites will be very difficult to find. Mix the debris with methylated spirit in a large container. Most dead mites will float to the surface whereas wax and propolis particles will sink. 5. Research work in the UK and overseas has shown a natural mite drop in a colony is related to the size of the *Varroa* population. 6. UK research suggests that colony collapse is very likely before the end of the season if average daily mite drop for a normal colony exceeds the following: winter/spring=0.5 mites; May=6 mites, June=10 mites, July=16 mites, Aug=33 mites, Sept=20 mites.	✓ sensitive method capable of detecting very few mites ✓ can give a good idea of infestation level ✓ colony is not disturbed ✗ needs additional equipment ✗ monitoring takes several days ✗ encourages wax moths if debris accumulates

Method: Drone brood uncapping	Pros and Cons
1. Select an area of sealed drone brood at an advanced stage (pink-eyed) as this is least likely to disintegrate when removed. 2. Slide the prongs of a honey uncapping-fork under the domed cappings, parallel to the comb surface, and lift out the drone pupae in a single scooping motion. (see Figures 22-25 below and Figure 54 on page 31). 3. *Varroa* mites are easily seen against the pale drone bodies. Repeat until at least 100 cells have been examined. 4. Estimate the proportion of pupae that have *Varroa* mites on them. 5. Very roughly, if more then 5-10% of drone pupae are infested, then the infestation is serious and the colony collapse may occur before the end of the season.	✓ quick and easy to use ✓ can be used during routine colony inspections ✓ gives instant indication of infestation level ✗ unlikely to detect a very light infestation ✗ results are approximate

Figures 22 to 25: Drone brood uncapping

How to control *Varroa* infestation

The aim of *Varroa* control

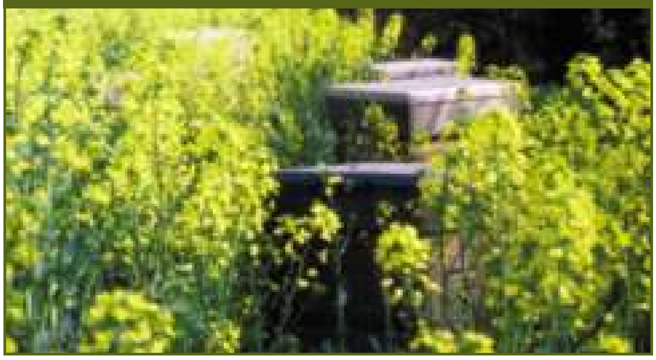
The fundamental aim of *Varroa* control is to keep the mite population below the level where harm is likely, (known as the economic injury level), therefore maintaining healthy colonies of bees for the production of honey and other hive products, and for pollination. It is not necessary to kill every single mite for effective control and it is not usually desirable to attempt this. However, the more mites that are left behind, the quicker they will build up to harmful levels again (see Figure 11). With 80% efficacy the danger level (of 1,000 mites) is reached again in only 65 days, with 90% in 100 days and with 99% efficacy population growth is so slow that assessments can be made the following season.

Figure 26: Beekeeper putting in varroacide medicament strips

Types of control

Current control methods used by beekeepers against *Varroa* can be divided into two main categories:
'Varroacides' – The use of chemicals to kill mites (or otherwise reduce their numbers). These are applied in feed, directly on adult bees, as fumigants, contact strips or by evaporation. These may include authorised proprietary veterinary medicines and unauthorised generic substances.
'Biotechnical Methods' – The use of methods based on bee husbandry to reduce the mite population through physical means alone. Many of the most popular and effective methods involve trapping the mites in combs of brood which are then removed and destroyed. Generally these methods are only suitable for use in spring and early summer. This will reduce the need to use medicines, and be of great benefit in areas with late honey flows (see IPM section page 29).

Figure 27: Oil seed rape, a major UK honey crop



Figures 28 to 30: Successful beekeeping depends on effective *Varroa* management

Table 2: Advantages and disadvantages of biotechnical methods and varroacides

	Advantages	Disadvantages
Biotechnical methods	✓ Do not require the use of chemical varroacides ✓ Can be combined with summer management ✓ Inexpensive or free	× Can be time-consuming × Some need a high level of beekeeping skill × Generally not sufficient if used alone × Misuse can harm colonies
Authorised varroacides	✓ Proven efficacy ✓ Proven safety ✓ Convenient to use	× Mites likely to develop resistance × Residue problems in bee products if misused × Can be expensive
Unauthorised varroacides (generic substances)	✓ Some can be very effective ✓ Usually relatively cheap ✓ Usually natural substances ✓ Many present low residue risk ✓ Some offer control options not currently provided by biotechnical or authorised varroacides	× Use not approved by law in most situations × Efficacy may be low/variable × Safety typically not proven: some present serious risks to bees and beekeeper × Some present risk of residues in bee products

Figure 31: Diagram illustrating the control of *Varroa* using an 'Artificial Swarm'

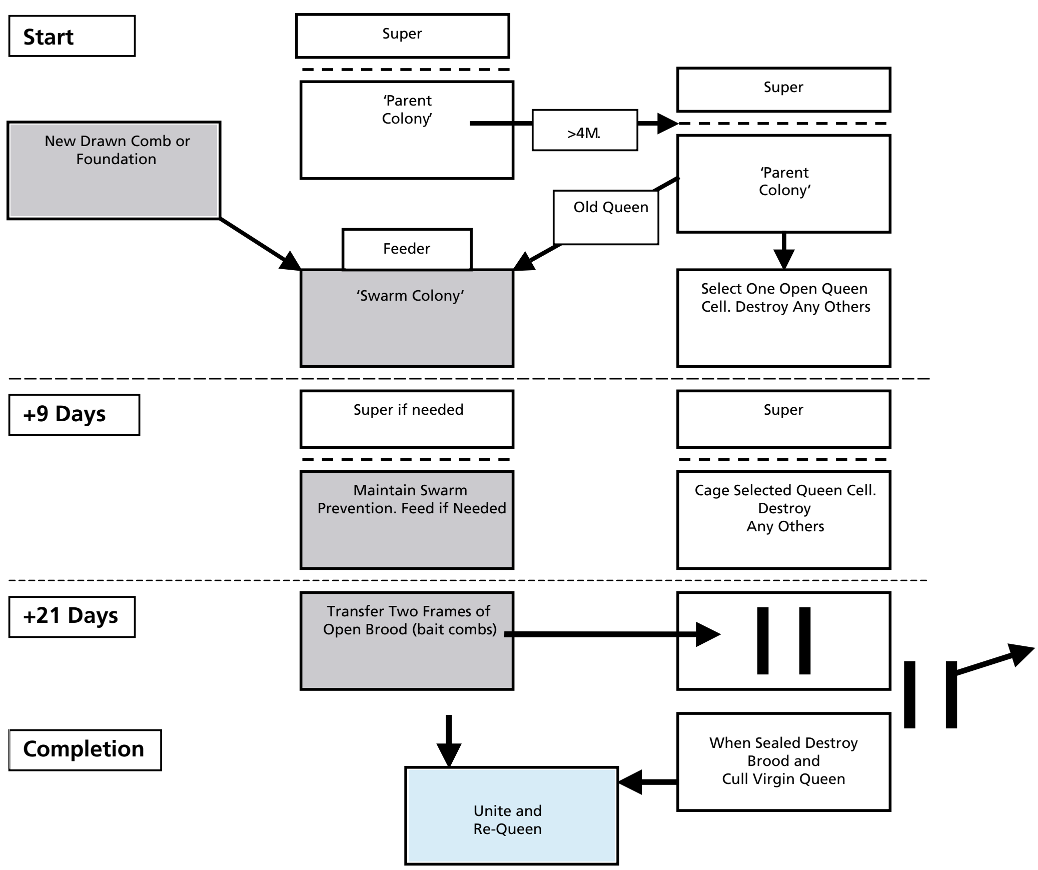


Table 3: Some commonly used biotechnical methods

Method	How to use	Main features
Drone brood removal (see Figures 34 and 35)	1. Place two shallow combs in the brood chamber in spring, and allow the bees to build natural drone comb beneath them. A good time to put these in the colony is when the queen first begins to lay up drone brood. Place the combs into the colony one at a time, and alternate at 9 day intervals (a run of alternating pairs of frames). Another option is to use an empty deep frame fitted with a starter strip of foundation to avoid possible misshapen comb. 2. When a drone comb is full of sealed drone brood (infested with *Varroa*), cut it from the frame **before it emerges** and destroy it. Failure to do this will breed more mites. The frame can be re-used immediately. 3. Repeat the process several times in the season for maximum effectiveness.	✓ easy to use ✓ no special apparatus required ✓ no varroacide used ✓ well tolerated by colony × time-consuming × useful, but limited efficacy
Comb trapping (see Figures 32 and 33)	1. Confine the queen to a worker comb 'A' using a purpose-made comb-cage (available commercially). 2. After 9 days confine her to a new, empty comb 'B' and leave comb 'A' in the brood chamber to become infested with mites. 3. After a further 9 days remove comb 'A' (now sealed). Confine the queen to a new comb 'C', leaving comb 'B' in the brood chamber. 4. After 9 more days remove comb 'B'. Release the queen (or re-queen by introducing another queen) leaving comb 'C' in the brood chamber. 5. After 9 more days, remove comb 'C'.	✓ can be very effective ✓ no varroacide used ✓ more bees recruited to foraging × time-consuming × requires good beekeeping skill × can harm/weaken the colony if used without regard to time of season (e.g. late summer)
Artificial swarm (see Figure 31)	1. Move parent colony to one side of the original site, at least 4 metres away. 2. Place a second hive containing newly drawn combs and the queen (alone) on the original site to house the artificial swarm. Foragers will return to this hive creating the artificial swarm. 3. After 9 days remove all but one queen cell from the parent colony. The cell can be protected in a queen cell nursery cage which prevents the virgin queen from leaving the hive to mate, but allows worker bees access to care for her. 4. After 3 weeks all brood in the parent colony will have hatched. Transfer two bait combs of unsealed brood from the artificial swarm to the parent colony, and when they are capped, remove and destroy them. At this stage, cull the virgin and introduce a new queen to the parent colony. 5. The old queen in the swarm can later be removed and the two colonies reunited.	✓ combines swarm control with *Varroa* control ✓ removes a high proportion of *Varroa* mites present ✓ new queen introduced × only suitable for use in the swarming season × it may be necessary to take precautions to prevent absconding in the artificial swarm – such as placing a queen excluder below the brood chamber for a few days.
Open mesh floors (see Figure 19)	1. Fit a mesh *Varroa*-monitoring floor (without a collection tray) to the hive. 2. Many of the mites falling from the colony are alive. The mesh floor allows these to drop out of the hive rather than returning to the colony. 3. A lower proportion of mites is considered to enter the brood to reproduce. 4. Used in conjunction with other control methods this method helps keep mite numbers down.	✓ open mesh floor removes some live *Varroa* ✓ no debris on floor to encourage wax moths ✓ improves hive ventilation ✓ can use collection tray to measure mite drop when required × not sufficient if used alone

Using biotechnical controls

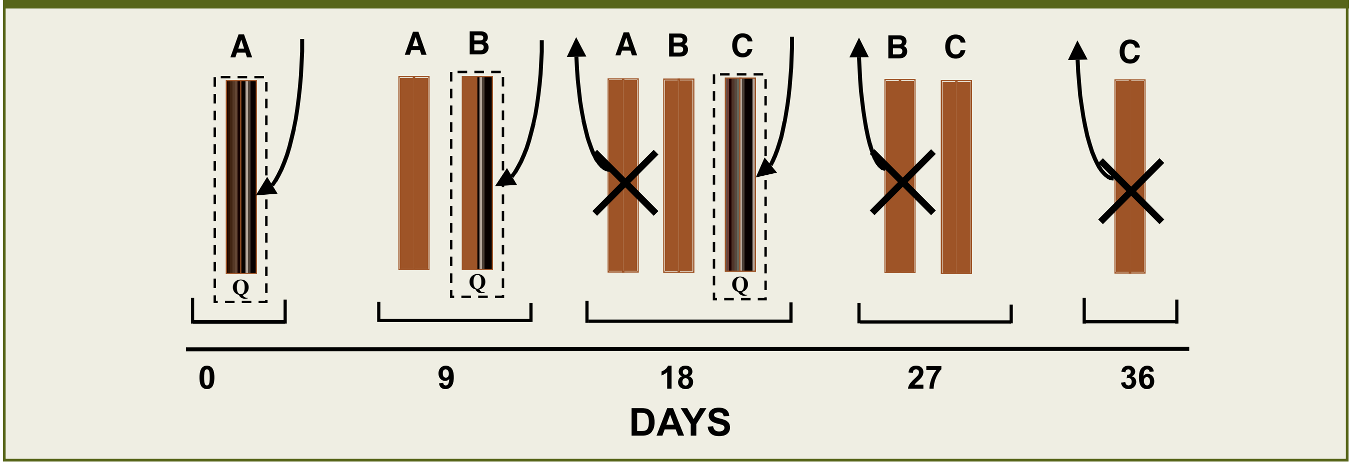
All biotechnical controls exploit the fact that mites reproduce in the bee brood. Unsealed brood can be used to trap and remove *Varroa* from the colony. If a bee colony is broodless, and a frame of open brood is then added, the mites will enter the brood to reproduce (the brood acts as a 'sink'); so when capped over, the beekeeper can remove and destroy the comb along with the enclosed mites. With this procedure removal of more than 90% of the *Varroa* population is commonly achieved.

Biotechnical control methods allow beekeepers to control *Varroa* without the use of chemical varroacides. This makes them especially useful during the active season when supers are on the hive and using a varroacide may not be appropriate. By using biotechnical methods, beekeepers can keep their use of chemical varroacides to an absolute minimum – or enable them to use varroacides that they may prefer but which have relatively low efficacy.

Some sophisticated biotechnical methods such as **'comb trapping'** (see Table 3 and Figure 33) can be extremely successful, with an efficacy similar to that of proprietary varroacides. However, such methods tend to be relatively time consuming and complicated to use and are critically dependant on good timing, so are most suitable for experienced and small-scale beekeepers.

Figure 32: Comb trapping - an effective biotechnical control method

Figure 33: Comb trapping timetable. The queen ('Q') is caged for 9 days on three combs ('A', 'B' and 'C') in succession. They each remain in the colony for a further 9 days while *Varroa* mites enter the brood cells to breed. The combs containing mites 'trapped' in sealed brood are then removed



Other methods, such as **'drone brood removal'** (see Table 3) are much quicker and less complicated to use. Although less effective, they can play a valuable role in slowing mite population build-up, thus reducing the frequency that other control methods need to be used.

One of the advantages of biotechnical controls is that their use can often be naturally combined with other beekeeping operations. For example, drone brood removal fits in well with routine swarm control inspections. There are some very effective methods that combine swarm-control with *Varroa* control (see Table 3). Such methods are likely to grow in popularity as beekeepers become more familiar with them.

Despite these advantages, as a result of their nature, most biotechnical methods are only suitable for restricted periods of the year. Outside these periods they may be ineffective and harmful to the colony. As a general rule, in heavily infested apiaries biotechnical methods are unlikely to provide sufficient control of *Varroa* if used alone and so will need to be used in conjunction with chemical varroacides.

Figure 34: Drone brood removal

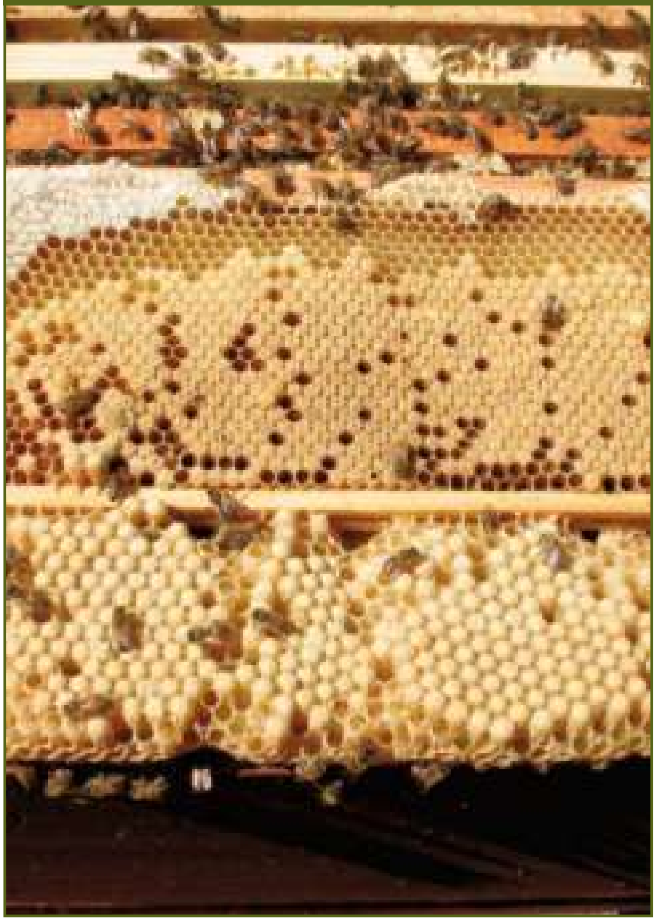


Figure 35: Drone brood removal, cutting away the capped drone brood

Using varroacides

'Hard' versus 'Soft' varroacides

For most beekeepers, varroacides are a key element of their *Varroa* control programme. Some beekeepers like to distinguish between varroacides by calling them 'hard' varroacides (synthesised proprietary chemicals) or 'soft' varroacides (chemicals that may be synthesised but which are also found in nature e.g. formic acid, essential oils). This is misleading. Many so-called 'soft' chemicals are quite harmful in concentration. A better distinction is between authorised varroacides (veterinary medicinal products fully tested for efficacy and safety) and unauthorised alternative varroacides (use of natural, generic substances in non-approved applications).

Authorised varroacides

Under EU law, veterinary medicinal products must be authorised in the Member State concerned before they may be marketed or administered to honey bee colonies. Authorisation requires a thorough scientific assessment of data to show that the product meets statutory levels of quality, efficacy and safety (to the user, bees, consumers of bee products and the environment). In the UK, the Veterinary Medicines Directorate (VMD), an agency under Defra, has responsibility for the authorisation and control of veterinary medicines. Currently authorised varroacides are available from equipment suppliers but this may change to require certification by suitably qualified persons (SQPs). See VMD's Bee information on their website (www.vmd.gov.uk).

The veterinary medicines legislation does not allow a veterinary medicinal product authorised in one Member State to be automatically authorised in another. This is because there may be differences in beekeeping techniques, disease patterns, or environmental factors that may affect its safe and effective use. However, under the principle of 'mutual recognition' a simplified procedure can apply to the authorisation of a varroacide that already has a marketing authorisation in another Member State. In order to obtain an authorisation an application must be submitted in accordance with the requirements in the legislation.

Use of non-approved generic substances

In many European countries, including the UK, some beekeepers have used generic naturally occurring substances including organic acids (such as formic acid, lactic acid and oxalic acid) and essential oils (such as thymol) as part of their *Varroa* control programme.

In most cases, no formal testing of efficacy or safety of these substances has taken place, and therefore there is a danger that they might be ineffective, harmful to bees, the environment or the user, or leave harmful or otherwise undesirable residues in bee products. Beekeepers contemplating their use need to be aware that personal protective clothing (such as gloves, face and eye protection, and respiratory protection) may be necessary. Beekeepers should also be aware that they may be liable to be prosecuted should the routine sampling and testing of products for residues find positive results.

The legal position relating to the use of such generic substances is complex. Under the existing legislation, it is not legal to market or to administer a Veterinary Medicinal Product (VMP) that is not authorised by the VMD. However, exceptions exist under the 'prescribing cascade'. Where no VMP is authorised for a condition in a particular species, this allows a veterinary surgeon acting under the cascade to use a product authorised in another Member State (subject to certain conditions and restrictions), or to use an extemporaneous preparation provided the active ingredient has a Maximum Residue Limit (MRL) defined. As lactic, formic, and oxalic acids all are listed as not requiring an MRL (in Council Regulation No 470/2009) they will be able to be used under prescription by a veterinarian in accordance with the prescribing cascade provisions. Further information on administration controls and the prescribing cascade is available on the VMD website. Advice on the current provisions can be obtained from the VMD.

Misuse of agrochemicals

The active ingredients of many proprietary varroacides were originally developed to control pests of crops or livestock. When marketed as varroacides, they are specifically formulated for safe and effective use with bees. Under the authorisation process the specific formulation, along with the container and packaging (which may affect chemical stability) and the labelling, is assessed for use in accordance with the manufacturer's instructions. Home-made concoctions made with the active ingredients of these (often available as agrochemicals) should never be used. These pose serious risks to the user and to bees, and can leave harmful residues in bee products. Furthermore, misuse of this sort has been attributed to rapid development of resistance in countries overseas.

Chemical residues in bee-products

Any chemical substance applied to bee colonies has the potential to leave residues in bee products. The risk of these being harmful can be minimised by the following rules:

- Use authorised products with a proven track record in preference to alternatives that may lack reliable residue data
- Always follow the label directions supplied with all authorised products
- Never treat immediately before or during a honey-flow, or while supers are on the hive, unless the label directions of an authorised product specifically permit this

Figure 36: Oxalic acid treatment applied with syringe and backpack

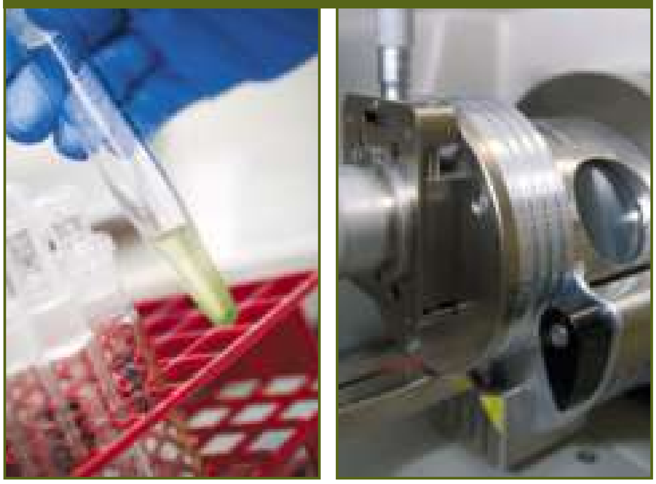
Residues monitoring programme

In the UK, the VMD carries out a National Surveillance Scheme to protect consumers against potentially harmful residues of veterinary medicines and other contaminants in food. Samples for the honey monitoring programme are collected on behalf of the VMD by Fera Bee Inspectors during their apiary visits, and these are analysed for a range of possible contaminants including residues of varroacides.
Individual results are given to the beekeepers concerned, and the overall findings of the programme are published annually by the VMD.

Beekeepers should be aware that they may be liable to be prosecuted should the routine sampling and testing of products for residues find positive results. Keep accurate records of what treatments you give your bees, including all relevant details such as dates, dose, product name and batch number. In the event of a later problem, this legal requirement is your proof that you acted properly.

Figure 37: 'Bagged and securely tagged' honey samples, collected as part of the statutory residue monitoring programme

Figures 38 and 39: Testing honey samples for residue analysis



Varroacides and your responsibilities under the law

- Use UK Authorised varroacides and follow strictly the manufacturer's instructions for their use. By doing so, you can be quite sure that you are remaining within the law.
- The rules for use of generic substances in bee colonies are complex and changing. Make sure that you have reliable and up to date information on the legal status of any other treatment you may be considering.
- Keep accurate records of what treatments you give your bees, including all relevant details such as dates, dose, product name and batch number. In the event of a later problem, this legal requirement is your proof that you acted properly.
- You may be requested to provide a sample of your honey for residue analysis as part of the VMD's residue monitoring programme.

Table 4: Some varroacides commonly used by beekeepers in the European Union

Name	Authorised	Active ingredient (a.i)	How applied	Method of spread	When normally applied	Significant features
Bayvarol® (Bayer)	**UK**	flumethrin (synthetic pyrethroid)	Plastic strips hung between brood combs	Contact	Autumn or early Spring for 6 weeks	Highly effective >95%; can be used during honey flow; too similar to Apistan to use with it as alternating treatment. In many places in UK pyrethroid resistant mites are confirmed
Apistan® (Vita Europe)	**UK**	tau-fluvalinate (synthetic pyrethroid)	Plastic strips hung between brood combs	Contact	Autumn or early Spring for 6-8 weeks	Highly effective >95%; can be used during honey flow; too similar to Apistan to use with it as alternating treatment. In many places in UK pyrethroid resistant mites are confirmed
Apiguard® (Vita Europe)	**UK**	thymol (terpene)	Slow release gel matrix (25% a.i.); two 50g pack treatments with 10-15 day interval	Evaporation, contact, ingestion	Spring or late Summer after honey harvest for 4-6 weeks.	90-95% efficacy with optimum conditions; depends on temperature and bee activity. When using ensure *Varroa* mesh floors are closed and vents in crownboards are covered
Apilife-VAR® (LAIF)	**UK**	thymol, eucalyptol, menthol, camphor	Vermiculite carrier matrix	Evaporation	Autumn for 8 weeks	Temperature dependent; high efficacy up to 70-90% but some variability; easy to apply
Apivar® (Biové)	**Not UK**	amitraz	Plastic strips hung between brood combs	Contact/ systemic	Autumn or Spring/early Summer for 6 weeks	Highly effective; can be used during honey flow
Exomite *Apis*® (Exosect)	**Not UK**	thymol in electrostatically charged powder	Powder in application tray at hive entrance	Contact	Spring or Autumn after honey harvest for 24 days	Efficacy not fully evaluated
Perizin® (Bayer)	**Not UK**	coumaphos (organophosphate)	Solution trickled over bees	Contact/ systemic	Late Autumn/Winter and broodless periods	Ideally needs broodless conditions
Formic acid (generic)	**Not UK (Note 1)**	formic acid (60 or 80% solution)	Evaporator kits (commercially available)	Evaporation	Late Summer/Autumn	Kills mites in sealed brood cells; temperature dependent; efficacy up to 80 to 90% (2 treatments) but high variability; brood and queen loss if misused; highly corrosive
Lactic acid (generic)	**Not UK (Note 2)**	lactic acid solution	Acid solution sprayed over combs of bees	Contact	Winter and broodless periods	Ideally needs broodless conditions; causes skin burns; respiratory irritant
Oxalic acid (generic)	**Not UK (Note 2)**	oxalic acid solution	3.2-4.2% acid solution in 60% sucrose trickled over combs of bees; 2.5ml per brood comb side (5ml per seam of bees)	Contact (not ingestion, despite sugar presence). Sublimation	Winter and broodless periods	Ideally needs broodless conditions; 90% average efficacy possible; sugarless solutions have poor efficacy; danger of significant colony weakening; more scientific trials needed; highly toxic by inhalation, ingestion or skin absorption
Thymovar	**UK**	cellulose sponge strip or "wafer" containing 15g Thymol	Wafers placed directly on top bars of brood nests. For use within an IPM system, e.g.combined with Oxalic acid treatment in winter broodless period	Evaporation	Late summer after honey harvest. Two successive treatments lasting 3-4 weeks	Variable efficacy, best results at daytime temps between 20-25°C. Do not use above 30°C. Not for use during a nectar flow. Avoid contact with skin and eyes. Overdosing may cause mortality of bees and larvae and make the colony "irritable"

Note 1 Not authorised in any EU Member State, except in Germany when used in conjunction with Illertisser mite plates or Nassenheider evaporators only.

Note 2 Not authorised in any EU Member State, but tolerated in many countries.

Contact the Defra Veterinary Medicines Directorate for up-to-date information on which varroacides are authorised for use in the UK. See address at end of leaflet.

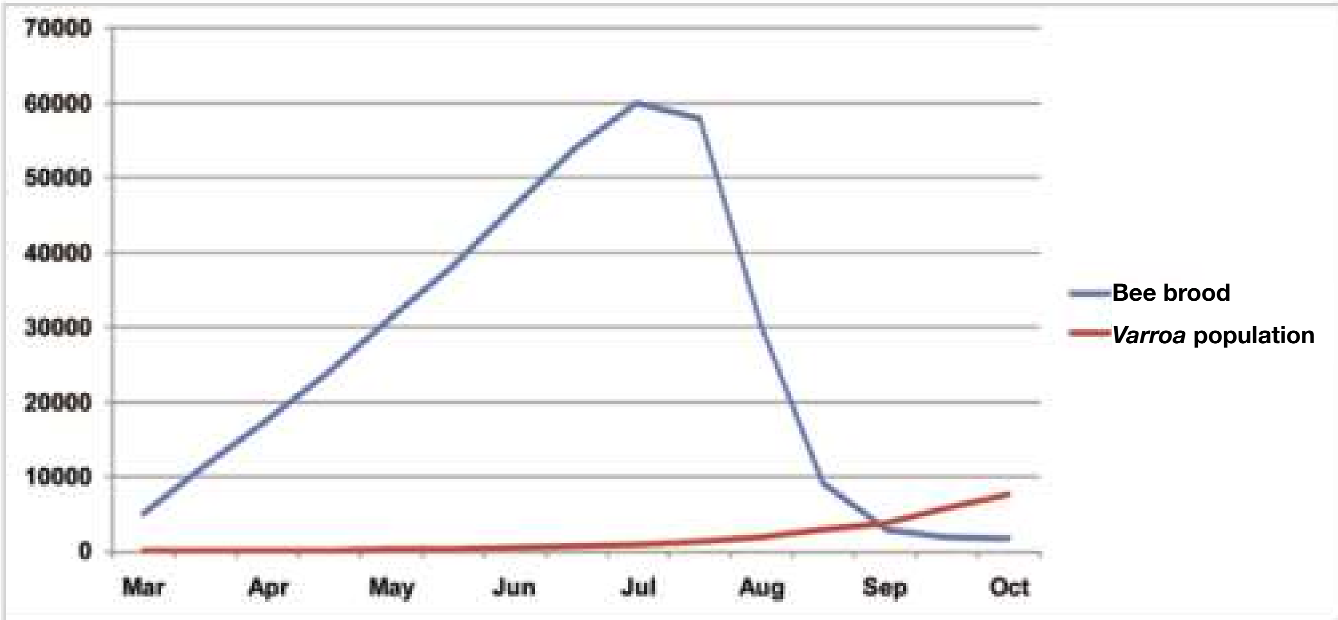
When should you treat?

Figure 40 shows *Varroa* population growth in relation to bee brood during the beekeeping year. There is no single ideal time for treatment with varroacides. However, for most beekeepers the main treatment time is late summer to early autumn – between harvesting honey and preparing colonies for winter. At this time colony size will be reducing while infestation will be continuing to increase. The aim of treatment is to significantly reduce the mite population, thus protecting the last few brood cycles that produce the young bees needed for successful colony survival over winter. If you delay treatment at this time, this may cause the winter bees to carry a higher pathogen load which will mean shorter life spans, causing dwindling and death of the colonies over winter even though *Varroa* has been controlled.

It is also relatively common to treat colonies in the spring – especially where monitoring suggests that they have emerged from winter with a mite population that will pose a serious risk before the late summer treatment.

The choice of treatment may dictate when treatment is applied. Some (e.g. Apiguard) may require warm conditions for maximum efficacy.

Figure 40 : *Varroa* population growth in relation to bee brood



Figures 41 and 42: Propriety varroacide treatment strips in use

Figures 43 and 44: Apiguard treatments

Others (oxalic and lactic acid) require broodless periods to be effective and so are usually applied very late in the year. Generally beekeepers prefer to avoid treating during the active season when supers are on the hive, to minimise the risk of leaving residues in bee products. However, some proprietary treatments (e.g. Apistan and Bayvarol) can be used quite safely during a honey flow if necessary (although not during comb honey production). This is useful if unexpected serious infestation demands emergency treatment.

No mention of alternative, unauthorised, products in this leaflet should be taken as an endorsement of efficacy, safety, or a recommendation to treat. They are referred to because they are commonly available.

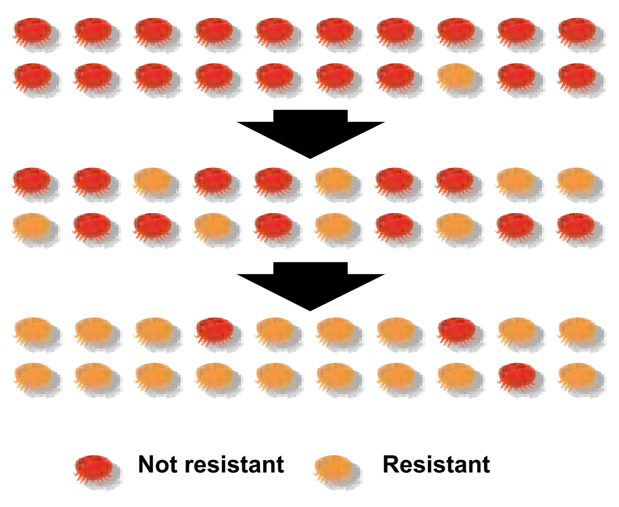
How does resistance arise?

Varroa populations will eventually develop resistance to any chemical varroacide. Individual variation within a mite population may result in small numbers of mites with resistant traits (e.g. a thicker cuticle that prevents entry of the active ingredient, or a metabolism that may break down the treatment before it does the mite damage). These characteristics are genetic and heritable, although often the mites with these unusual traits are reproductively weaker and are initially present as only a tiny proportion of the entire population.

When strong selection pressure is placed on the mite population such resistant traits may begin to dominate. This can happen when a population of mites is repeatedly exposed to a varroacide leaving more of the resistant mites alive to breed. Over many generations these mites will tend to become increasingly common until ultimately they comprise the majority of the mite population.

How long this process takes to occur depends on how often *Varroa* mites are exposed to a varroacide and at what dose. Frequent treatments, especially when misused or when treatment strips are left in the colony for longer than recommended, accelerate the development of resistance.

Figure 45: Development of varroacide resistance. Initially only a very few mites are varroacide resistant. However, these mites and their offspring will survive successive treatments, and so over a period of time become more abundant. Eventually they will comprise the majority of the mite population



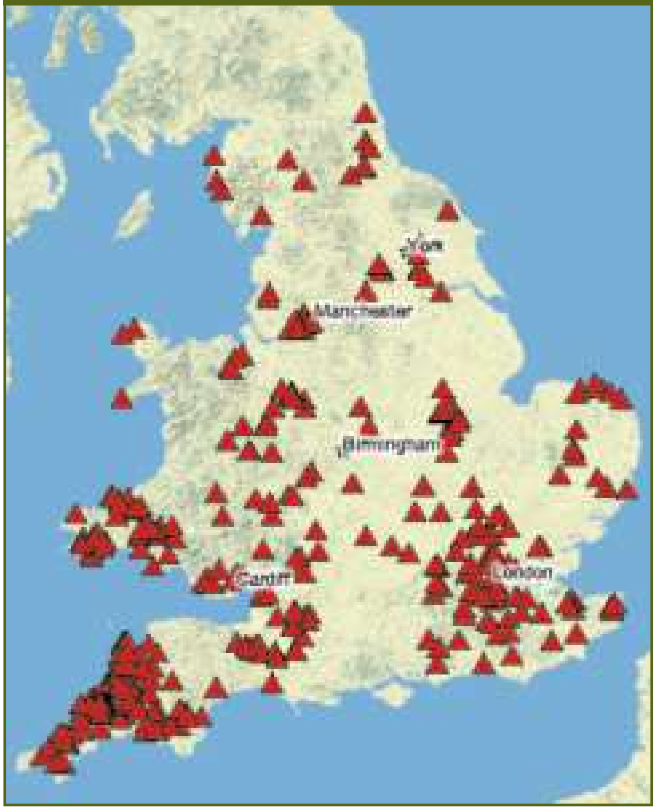
Pyrethroid resistance in the UK

It was always anticipated that *Varroa* would develop resistance to pyrethroids, which are the active ingredients of the widely used varroacides Apistan and Bayvarol. In 2001, the National Bee Unit's (NBU's) resistance surveillance programme found the first confirmed cases of pyrethroid resistance, in Devon. (Read more about the NBU on page 36).

Details of confirmed pyrethroid resistant apiaries are available on BeeBase on-line (www.nationalbeeunit.com). Shown right is an example of the current situation.

Confirmed pyrethroid resistant apiaries

Figure 46: Map showing confirmed pyrethroid resistance in England and Wales (as of August 2009)



Note: Even though a positive test result is not shown in an area it does not mean that resistant mites are not present.

Avoiding Resistance

To delay the development and spread of resistance beekeepers should:

- ✓ treat with the specified dose
- ✓ treat for the period specified
- ✓ treat as little as necessary
- ✓ alternate treatments (where possible) with one or more unrelated treatments

Responding to resistance spread

Beekeepers who have not yet detected pyrethroid resistant *Varroa* in their colonies should start preparing for their arrival without delay. Unless their presence is identified through resistance testing, the first obvious sign is likely to be the collapse of colonies after pyrethroid treatment fails to control mite infestation.

By the time resistant mites are identified in an apiary they generally comprise the vast majority of the mite population. Beekeepers who know they have resistant mites should stop using pyrethroids at once. These will no longer provide effective control and their continued use will only cause resistance problems to worsen. Instead, they should use a non-pyrethroid treatment, biotechnical methods, or both – ideally as part of an Integrated Pest Management (IPM) programme (see page 29).

When pyrethroid resistance is widespread and most beekeepers are using alternative non-pyrethroid varroacides, there is a significant risk that *Varroa* will develop resistance to these also. This is the situation that now exists in several countries worldwide.

The strategies advocated in this leaflet to delay the development of pyrethroid resistance will apply equally to other varroacides that may be used in the future. Ultimately, resistance monitoring is likely to be required for these also.

A range of other products is now being used by beekeepers. These are prescribed under the 'cascade' system (see section 'Using varroacides' on page 20, and the Bee Pages of the VMD's website). Should beekeepers suspect that any product they are using to treat *Varroa* is not working, this should be reported to the NBU immediately.

Figure 47: Pyrethroid resistance test kit in use

Figure 48: Mites knocked down onto sticky insert

Figure 49: Heather moors produce an important UK honey crop, but are also areas where intensive migratory beekeeping is practised

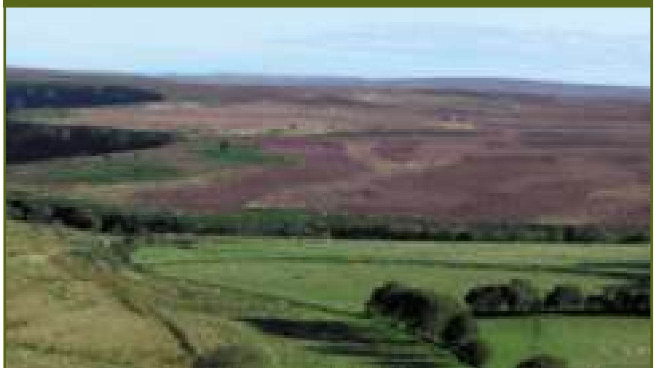


Figure 50: Movement of colonies will speed up the spread of resistance. Be careful before moving or purchasing bees

Testing for pyrethroid resistance

Method: USDA Beltsville Test

1. Cut a 9mm x 25mm piece from an Apistan strip and staple to centre of a 75mm x 125mm index card. Place card in 500ml jar with strip facing inwards.
2. Prepare a 2–3mm light metal mesh cover for jar.
3. Shake bees from 1–2 combs of a colony into an upturned roof. Scoop 1/4 cup of these (about 150) and place in jar.
4. Place a sugar cube in jar. Cover with mesh lid and store upturned in dark, at room temperature.
5. After 24 hours hit upturned jar with your palm over white paper three times. Count dislodged mites.
6. Place upturned jar in a freezer, until bees are dead (1–4 hrs). Count the remaining mites.
7. Calculate % mite kill. Less than 50% indicates you may have resistant mites.

Caution: This method gives a crude indication of resistance, and further confirmatory tests are advisable. Discard results if the total number of mites per jar is below five.

Method: NBU Resistance Test

The NBU field resistance test is a modification of the Beltsville test using a purpose made test cage and low dose Apistan 'Package Bee Strips' (see Figures 47 and 48). The method used is similar. However, a larger sample of bees is taken (approx 200), the test takes a shorter period (4 hours) and the bees are killed by immersion in soapy water, after which dead mites and bees are separated with a stream of water in coarse and fine sieves.

Method: Checking post treatment *Varroa* mite mortality

1. Maintain colony on a mesh *Varroa* floor with collection tray beneath.
2. Treat as usual with pyrethroid strips for 6 weeks.
3. Clean tray and check daily mite drop immediately after treatment finishes.
4. Significant mite drop indicates a mite population remains and therefore your treatment may not have been effective – requiring further investigation.

If you suspect mites are resistant to any other medicines being used this must be reported to the National Bee Unit, either to the laboratory at York (01904 462510) or to your local bee inspector.

What is Integrated Pest Management?

Integrated Pest Management (usually abbreviated to 'IPM') is a principle now widely used in agriculture, especially where it is desirable to keep chemical inputs to a minimum. Significantly, no attempt is made to completely eradicate the pests. Instead, the aim is to keep them below the level where they cause significant harm, by using a combination of controls applied at different times of the year. More or fewer controls are employed depending on the levels of pests present. This is a much more effective approach than the alternative of waiting until pest numbers have reached a damaging level before applying controls, or applying the same controls each year regardless of pest numbers.

An IPM programme for *Varroa*

IPM can be readily applied to control many bee diseases, and to *Varroa* in particular. Potential benefits include:

- Control at several points of the year makes it harder for the mite population to reach harmful levels
- Use of management methods can reduce the need for varroacides
- Using two or more unrelated varroacides will delay the development of mite resistance
- Control strategies can be easily altered to reflect changing infestation levels

Unfortunately, there is no single IPM *Varroa* programme suitable for all circumstances. This is because there are enormous variations in infestation level, mite invasion, climate and beekeeping practices.

Figure 51 shows some of the combinations that are commonly used by beekeepers in the UK and overseas. Note that it would not normally be necessary or appropriate to use all the options. As a rule when infestation is serious more control and monitoring will be needed than at other times.

Figure 51: Examples of integrated control methods used throughout the year by UK and EU beekeepers (See Table 4 for information about authorisation for use of varroacides in Member States)

Control	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Open mesh floor	■	■	■	■	■	■	■	■	■	■	■	■
Drone brood removal				■	■	■	■					
Queen comb trapping				■	■	■	■					
Formic acid					■	■	■	■				
Apiguard/Apilife VAR/ Thymovar								■	■	■		
Apistan/Bayvarol/Apivar								■	■	■		
Lactic/Oxalic Acid	■											■

Good husbandry

Good husbandry should be a starting point for IPM control of *Varroa*. Keep a close eye on the health of your bees, and in particular make sure you can recognise the signs of *Varroa* infestation. Maintain apiaries to minimise the effects of robbing and drifting. Aim to keep strong vigorous colonies and try to select strains that seem to show some *Varroa* tolerance.

Slow mite population growth

Employ methods that slow the growth of the *Varroa* population in your colonies – such as drone brood removal and use of mesh floors. These will have a less dramatic effect than other controls, but will delay the point when the infestation reaches a damaging level, allowing you to treat a little later, or to use less efficacious varroacides.

The effective use of open mesh floors and drone brood culling should result in an efficacy of 50%. Comb trapping and control using the artificial swarm technique should result in an efficacy of 90% (Figure 52). Their use is helpful to reduce reliance on chemical controls, and can be essential where late crops such as heather or Himalayan balsam are sought.

Using monitoring to choose the level of controls to employ

An important principle of IPM is to adjust the level of control to suit the level of infestation. Low mite levels need no action; intermediate levels may require some moderate intervention; high mite levels require more urgent and effective action.

The monitoring methods shown in Figures 19 to 21 and 53 illustrate these principles, using daily mite drop to assess the severity of infestation and determine what action should be taken. Table 5 illustrates the same principle applied to monitoring using drone brood uncapping. Figures quoted are based on the Fera mathematical model of mite populations, and aim to maintain a level of less than 1000 mites during the beekeeping season. However, be aware that the levels shown early in the season mean that a colony is safe at that time but may require control before the end of the season, and also be aware that if an invasion of mites occurs then the mite levels could increase rapidly.

In this context, **light control** means using biotechnical methods or varroacides that have relatively low efficacy and therefore have a fairly limited effect on the mite population. **Effective control** means using varroacides or biotechnical methods that are very effective and greatly reduce the mite population.

Figure 52: The effects of application of biotechnical control methods on *Varroa* populations

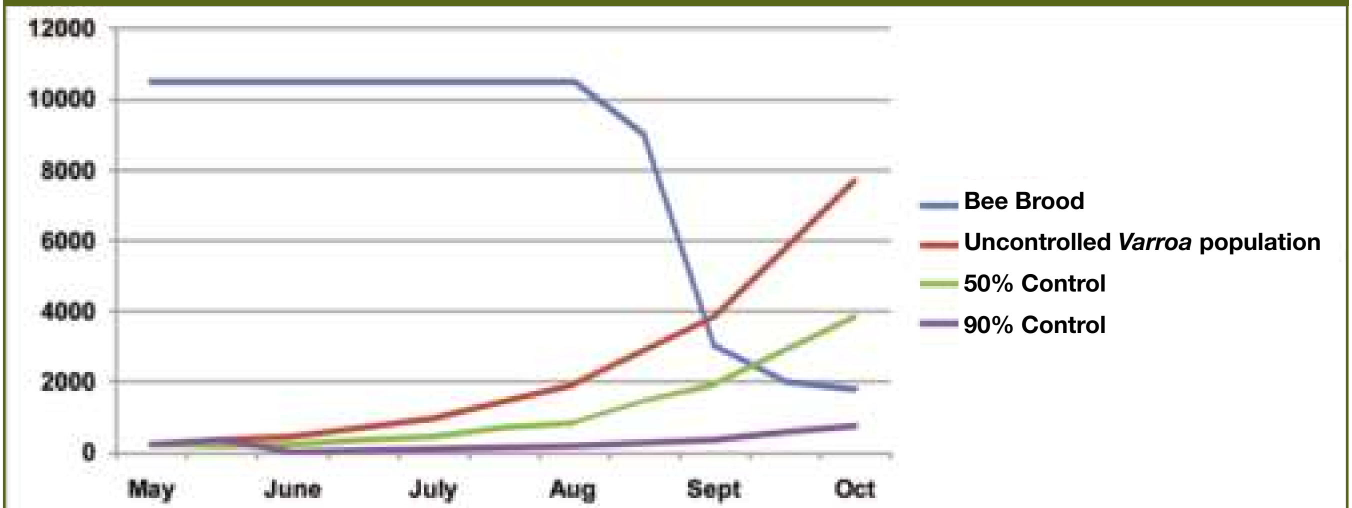


Figure 53: Using mite drop monitoring to decide appropriate level of controls to employ

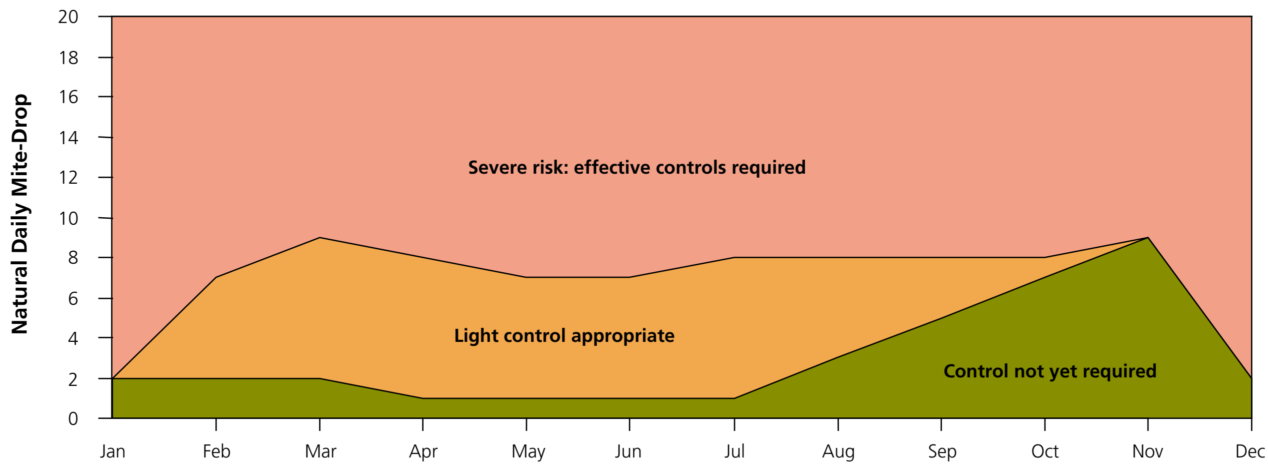
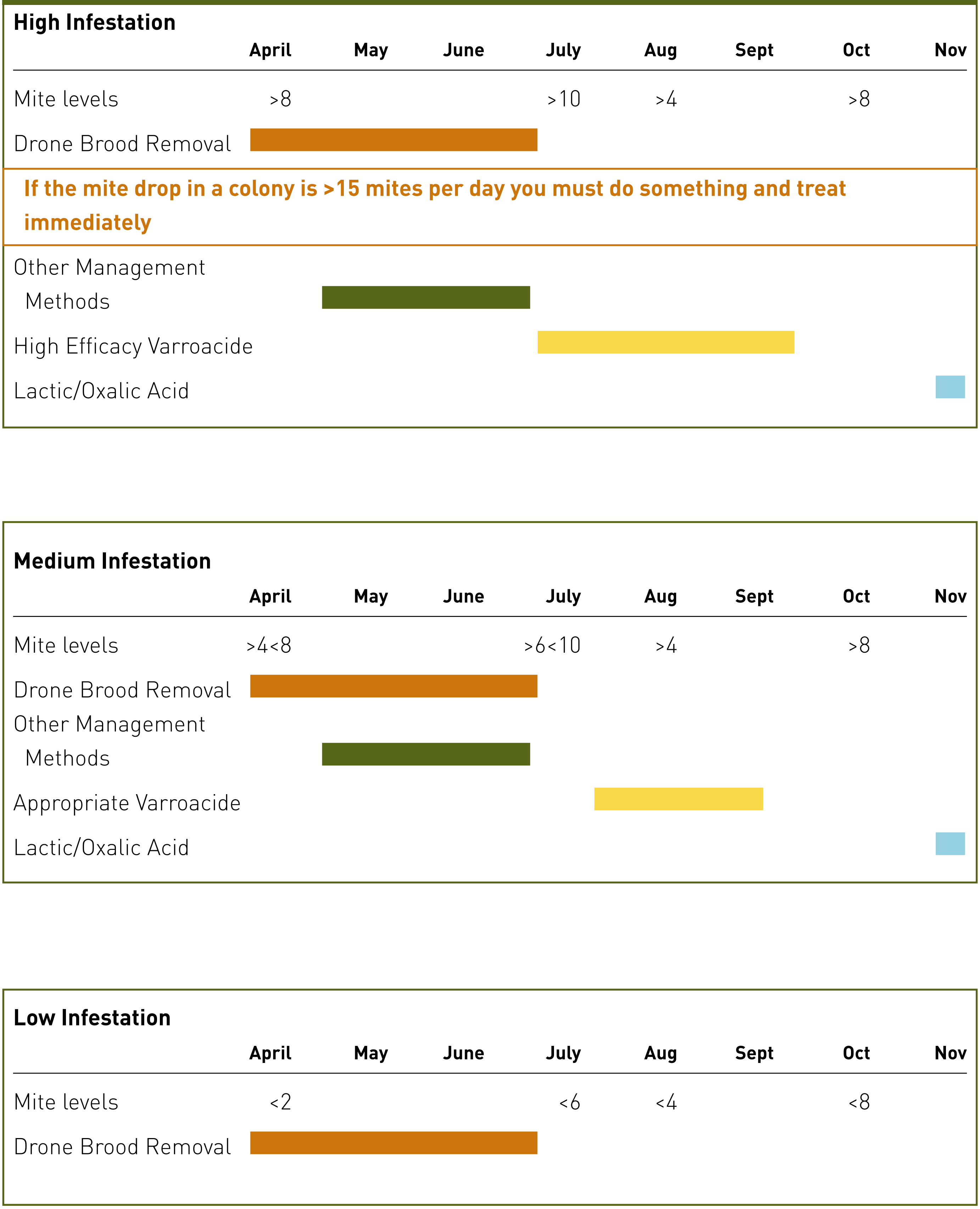


Table 5: Using drone brood monitoring to decide appropriate level of controls to employ

	Proportion of infested drone pupae		
April, May, June	**Less than 2%** (<1 mite in 50) No action	**2% – 4%** (Between 1 mite in 25 and 1 in 50) Plan controls for season	**More than 4%** (>1 mite in 25) Consider control
June, July	**Less than 3%** (<1 mite in 30) No action	**3% – 7%** (Between 1 mite in 15 and 1 in 30) Light control	**More than 7%** (>1 mite in 15) Effective control Severe risk
August	**Less than 5%** (<1 mite in 20) No action	**5% – 10%** (Between 1 mite in 10 and 1 in 20) Light control	**More than 10%** (>1 mite in 10) Effective control Severe risk

Figure 54: Drone brood uncapping, a popular and easy method for routine *Varroa* monitoring. *Varroa* mites are easily seen against the pale drone bodies

Figure 55: IPM control options selected taking into account mite levels (as assessed by monitoring daily mite mortality) and the time of year - as used by beekeepers in European countries



Living with *Varroa*

The experience of beekeepers in the UK dealing with *Varroa* has changed significantly over the period since the mite's initial discovery.

For the first few years, most beekeepers found *Varroa* relatively easy to control with a single autumn treatment, often applied quite late in the season. However, this was followed by an acute phase in which *Varroa* became much harder to control as mite levels were unexpectedly found to increase quickly. In particular, this occurred where untreated managed and feral-colonies respectively, were causing mite invasion problems. Beekeepers then found that it was vital to treat quickly after the end of the honey flow in late summer and, in some cases, again in the spring. Many who delayed treatment, or used controls that were not sufficiently effective, lost their bees – up to 50% of colonies in some areas.

After this phase of widespread losses, beekeepers found that *Varroa* again became somewhat easier to control – probably because mite invasion had reduced following the loss of feral or poorly managed colonies. For a period of several years colony losses due to *Varroa* were relatively infrequent. However, mite levels sometimes still increased, requiring a swift and effective response.

The development and spread of pyrethroid resistant *Varroa* has presented beekeepers with serious and significant new challenges. Beekeepers have again found *Varroa* difficult to control, and some have lost their colonies to the infestation.

As resistance is spreading, all beekeepers are having to learn and adopt new methods of monitoring and controlling the infestation in their hives. However, the experience of beekeepers coping effectively with the development of resistance demonstrates that they are able to adapt to the changing circumstances, and to continue beekeeping as successfully as ever.

Figure 56: It is vital that honey bee colonies go into the autumn and winter with young healthy bees and low mite populations

Key strategies for effective *Varroa* control

1. Monitor the infestation in your hives. You need to know if the mite population is building up faster than you thought or your treatments are not proving effective. Don't just treat and leave it to chance.

2. Talk to other local beekeepers about the *Varroa* problems you experience and the control strategies you are using. It may then be helpful to work together – for example in co-ordinating treatments.

3. Practice Integrated Pest Management (IPM) using a combination of varroacides and biotechnical methods. This will give the most effective control.

4. Slow the development and spread of resistant *Varroa*, and minimise the risk of treatment residues by treating no more often than is necessary – monitoring will help you decide how often this should be.

5. Use UK authorised varroacides. These have proven efficacy against varroa, and proven safety for bees, beekeepers, consumers and the environment. Always follow the label instructions.

6. Where possible rotate the use of two or more unrelated varroacides. This is an effective strategy to slow the development of resistance. Avoid using the same varroacide year after year.

7. Remember that the use of unauthorised chemicals in your colonies or the misuse of authorised varroacides may leave harmful and detectable residues in your bee products.

8. Be prepared to check for *Varroa* resistance. Learn to test for resistance and gain experience of using other controls. When resistance arrives you will have to stop using those medicines to which mites are no longer susceptible, and rely on alternatives.

9. Be flexible and adaptable in your control of *Varroa*. Methods that work well in some circumstances may not work well in others.

10. Keep up to date with new developments in the control of *Varroa* – as the situation develops you need to make sure you have the latest information to help you respond appropriately.

11. Select for and retain bees that appear to show increased tolerance to *Varroa*.

New developments in *Varroa* management

Over the coming years we can expect new developments that will change the way we control infestation with *Varroa*. These are likely to include:

- **New varroacides**
  Most are likely to be based on active ingredients of existing veterinary medicines and pesticides re-formulated for *Varroa* control. Novel varroacides based on other (often naturally occurring) active ingredients are also under development

- **New treatment systems**
  The development of methods for administering existing varroacides, particularly organic acids, to allow safer and more effective controls with fewer adverse effects

- **Pheromones**
  The development of synthetic pheromones (natural chemical messages) to provide control over *Varroa* – for instance by inhibiting their feeding or reproduction

- **Biological controls**
  Research continues to identify naturally occurring fungi and bacteria that could kill *Varroa* mites within the bee colony, and to develop these into practical control methods

- **Biotechnical techniques**
  Development of more sophisticated and effective biotechnical controls. These are likely to become part of routine colony management

- **Tolerant bees**
  Breeding programmes in many countries are aiming to select and develop bees that are more tolerant of *Varroa*. These bees may either be able to naturally maintain better control over the mite population, or may be more tolerant to the presence of the mites and their associated pathogens.

Figure 57: In the future bees may become more tolerant of *Varroa* and mites may become less virulent, leading in time to more of an equilibrium between host and parasite

Further help and advice

National Bee Unit

The National Bee Unit (NBU) is part of the Defra Food and Environment Research Agency (Fera). Established in 1946 the NBU has a long history in practical beekeeping and bee health, providing research, diagnostic, consultancy and extension services to government departments, commerce and beekeepers in the UK and overseas.

Recent research interests include European foul brood control, varroacide development and molecular methods for bee disease diagnosis, including exotic pests, in support of surveillance programmes and contingency planning. Current Research and Development projects are outlined on BeeBase (www.nationalbeeunit.com).

The NBU's network of Inspectors provides an inspection service for foul brood and exotic pests, advice and assistance to beekeepers year round and training courses in disease control and bee husbandry.

Although *Varroa* is now endemic in the UK and is no longer a statutory notifiable disease, the NBU will continue to offer advice on its control as it does for other serious non-statutory diseases.

BeeBase

BeeBase is the NBU's award winning website. BeeBase contains all the apicultural information relating to the statutory bee health programme in England and Wales. Most recently, the information for the Scottish inspections programme has also been incorporated into BeeBase. BeeBase contains a wide range of beekeeping information such as the activities of the NBU, the bee related legislation, pests and diseases information including their recognition and control, interactive maps, current research areas, publications, advisory leaflets and key contacts. Beekeepers can register online and view their own apiary records, diagnostic histories and details.

Why is it so important to register on BeeBase?

As well as containing useful information on beekeeping, BeeBase is a vital tool in the control of bee diseases and pests. Where statutory pests are confirmed (European foul brood, American foul brood), the NBU can use BeeBase to identify apiaries at risk in the local area and as a result target control measures effectively. By knowing where the bees are, we can help you manage disease risks in your apiaries. Such risks could include the incursion of serious new pests such as the Small hive beetle, *Tropilaelaps* mites, or Asian hornets.

To access this information visit the NBU website www.nationalbeeunit.com

Beekeeping associations

In many areas, beekeeping associations operate disease control schemes and provide practical advice to members on bee disease recognition and control. Contact your local beekeeping association for details or your local bee health adviser or Disease Liaison Contacts (DLC).

Figure 58: Training beekeepers at Fera Sand Hutton

Useful addresses

Fera National Bee Unit (NBU)
The Food and Environment Research Agency
National Bee Unit, Sand Hutton, York, North Yorkshire, YO41 1LZ
Tel: 01904 462510
Fax: 01904 462240
Email: nbu@fera.gsi.gov.uk
Web: www.nationalbeeunit.com

Office of the Chief Veterinary Officer
Welsh Assembly Government Officer
Hill House Picton Terrace
Carmarthen SA31 3BS
Tel: 01267 245 007
Web: www.wales.gov.uk

Scottish Government
Pentland House
47 Robbs Loan
Edinburgh
EH14 1TY
Tel: 0131 244 6178
Web: http://www.scotland.gov.uk/

Science and Advice for Scottish Agriculture
SASA, Roddinglaw Road
Edinburgh EH12 9FJ
Tel: 0131 244 8890
Fax: 0131 244 8940
Email: info@sasa.gsi.gov.uk
Web: www.sasa.gov.uk

Welsh Beekeepers' Association
Web: www.wbka.com/

Chemicals LAIF
Industria Bio-chimica
Via dell'artigianato,
1335010 Vigonza (PD)
Italy
Web: http://www.beekeeping.org/chemical-laif/index.htm

World Organisation for Animal Health
Office International des Epizooties (OIE)
Web: www.oie.int

Department of Agriculture and Rural Development
Northern Ireland (DARDNI)
Dundonald House, Belfast
BT4 3SB,
Northern Ireland
Tel: 02890 24488
Web: www.dardni.gov.uk

Defra Veterinary Medicines Directorate
Woodham Lane
New Haw
Addlestone
Surrey
KT15 3LS
Tel: +44 01932 336911
Web: www.vmd.gov.uk

British Beekeepers Association (BBKA)
(county and local beekeeping associations) National Agricultural Centre, Stoneleigh Warwickshire, CV8 2LZ
Tel: 01203 696679
Web: www.britishbee.org.uk

Scottish Beekeepers Association
Web: www.scottishbeekeepers.org.uk
Email: secretary@scottishbeekeepers.org.uk

World Organisation for Animal Health
Office International des Epizooties (OIE)
Web: www.oie.int

Office of Public Sector Information
(European Community and UK Legislation)
Web: www.opsi.gov.uk/

Ulster Beekeepers Association
Web: http://www.ubka.org/

Bee Farmers Association (BFA)
Web: www.beefarmers.co.uk

International Bee Research Association
(library and beekeeping information services)
18 North Road, Cardiff, Wales
CF10 3DT
Tel: 02920 372409
Web: www.ibra.org.uk

Vita (Europe) Ltd
21/23 Wote Street
Basingstoke
Hants RG21 7NE
Tel:e +44 (0)1256 473175
Fax +44 (0)1256 473179
Web: http://www.vita-europe.com/

Bayer (UK and Ireland) Ltd
Web: http://www.bayer.co.uk/

Biové
Laboratoires Biové
Rue de Lorraine
P.O.Box 45
62510 Arques
France
Web: http://www.beekeeping.com/biove

European Community and UK Legislation
The Stationery Office
51 Nine Elms Lane
London
SW8 5DR
Tel:e +44 0870 600 5522
Web: www.hmso.gov.uk/stat.htm

Thymovar
Web:
http://www.biovet.ch/ea/Imkerei/thymovar.html

References and acknowledgements

References

A number of references were used in the development of this advisory leaflet and/or may be useful as further sources of information:

Calis, J.N.M., Boot, W.J., Beetsma, J., van den Eijnde, J.H.P.M., de Ruijter, A., van der Steen, J.J.M. (1998) Control of *Varroa* by combining trapping in honey bee worker brood with formic acid treatment of the capped brood outside the colony. J. Apic. Res. 37(3): 205-215.

Calis, J.N.M., Boot, W.J., Beetsma, J., van den Eijnde, J.H.P.M., de Ruijter, A., van der Steen, J.J.M. (1998) Effective biotechnical control of *Varroa*. J. Apic. Res. 38(1-2): 49-61.

Charrière, J.D., Imdorf, A., Bachofen, B., Tschan, A. (2003) The removal of capped drone brood: an effective means of reducing the infestation of *Varroa* in honey bee colonies. Bee World 84(3): 117-124.

Donzé, G., Guerin, P.M. (1994) Behavioural attributes and parental care of *Varroa* mites parasitizing honey bee brood. Behav. Ecol. Sociobiol. 34: 305-319.

Gallai N., Salles J.M., Settele J., Vaissière B.E. (2009) Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological Economics (NLD): 810-821.

Klein,. A.M., Vaissière, B.E., Cane, J.H., Steffan-Dewenter, I., Cunningham, S.A., Kremen, C., Tscharntke, T. (2007) Importance of Pollinators in changing landscapes for world crops. Proc. Biol. Sci. 274: 303-313.

Rosenkranz, P., Aumeier, P., Ziegelmann, B. (2010) Biology and control of *Varroa destructor*. Journal of Invertebrate Pathology 103: S96-S119. www.elsevier.com/locate/jip

Thompson, H.M., Brown, M.A., Ball, R.F., Bew, M.H. (2002) First report of *Varroa destructor* resistance to pyrethroids in the UK. Apidologie 33: 357-366.

Wilkinson, D., Smith, G.C. (2002) A model of the mite parasite *Varroa destructor* on honey bees (Apis mellifera) to investigate parameters important to mite population growth. Ecological Modelling 148: 263-275.

Acknowledgements

Leaflet updated by Mike Brown and Gay Marris of Fera NBU, on behalf of Defra and the Welsh Assembly Government. All photographs supplied by Fera National Bee Unit. David Crossley is the Fera photographic contact. Additional technical information supplied by Ivor Flatman, Richard Ball, Selwyn Wilkins and Andrew Wattam. Leaflet design by Linda Crossley, Fera, York.

Sand Hutton, York
YO41 1LZ, UK

Tel +44 (0)1904 462 000
Fax +44 (0)1904 462 111

E-mail info@fera.gsi.gov.uk
www.defra.gov.uk/fera

B0058/1110

The Food and Environment Research Agency