Animal & Plant Health Agency

The National Bee Unit

Managing *Varroa*

Pollination

Insect pollinators provide almost incalculable economic and ecological benefits to humans, flowering plants, and wildlife. Pollination by bees and other insects is the first step in the flowering/ fruiting process, resulting in the production of vegetables and fruits. This essential nutrition comprises approximately 35% of the human diet. The production of 84% of crop species cultivated in Europe depends on pollinators to some extent; 70% of the 124 main crops used directly for human consumption in the world are dependent on pollinators[1].

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

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 and essential part of bee husbandry. This leaflet describes the biology of the mite, how it can be recognised and monitored, and the approaches beekeepers can use to control the infestation in their hives.

Varroa destructor was first reported in Western Europe in the late 1970s. The mite causes parasitic mite syndrome, a serious and complex infestation of honey bees. It has caused massive economic losses and expense for beekeepers. *Varroa* remains the number one management problem for beekeepers and will continue to be a serious threat to the long-term sustainability and prosperity of European apiculture, and to the environment through the disruption of pollination.

Acronyms

ABPV	Acute Bee Paralysis Virus
APHA	Animal and Plant Health Agency
BBKA	British Beekeepers' Association
BDI	Bee Diseases Insurance Ltd
BFA	Bee Farmers' Association
DARDNI	Department of Agriculture and Rural Development, Northern Ireland
Defra	Department for Environment, Food and Rural Affairs
DWV	Deformed wing virus
IPM	Integrated Pest Management
ISO	International Standards Organisation
MAQS	Mite Away Quick Strips
MAVIS	Marketing Authorisation Veterinary Information Services
MRL	Maximum Residue Limit
NBI	National Bee Inspector
NBU	National Bee Unit
OIE	World Organisation for Animal Health
OMF	Open Mesh Floor
RBI	Regional Bee Inspector
SASA	Science and Advice for Scottish Agriculture
SBI	Seasonal Bee Inspector
SIC	Special Import Certificate
SQP	Suitably Qualified Person
VMD	Veterinary Medicines Directorate
VMP	Veterinary Medicines Product
VRC	Veterinary Residues Committee
WBKA	Welsh Beekeepers' Association

Contents

Help and advice

The National Bee Unit

The National Bee Unit (NBU) provides a statutory and advisory service to beekeepers in England and Wales. It operates the Bee Health Programmes on behalf of the Department for Environment, Food and Rural Affairs (Defra) and Welsh Government (WG).

Most staff are trained practical beekeepers, as well as scientists, and are supported by teams of specialists across the rest of the Animal and Plant Health Agency (APHA) and Fera Science Limited.

This inspectorate comprises of a network of fully trained Bee Inspectors who operate to ISO 17020, and deliver statutory inspections and an apiary surveillance programme for exotic pests. Bee Inspectors provide free advice and assistance to beekeepers on a range of bee health issues and run training courses for beekeepers on disease recognition, disease control and good husbandry, often in conjunction with local Beekeeping Associations. Bee Inspectors also assist with field trials for a range of Bee health research projects. The NBU works in partnership with many universities and organisations, both in the UK and overseas, to achieve shared research goals.

Scientific and diagnostic support is provided by Fera Science Limited. Fera Science Limited are the UK National Reference Laboratory (NRL) for bee health; an EU-wide network of laboratories that develop standards for methods in bee health and research. The honey bee diagnostic laboratories are fully compliant with ISO 9001 quality schemes to ensure a high professional standard.

For further information, visit the NBU's BeeBase website key contacts pages: www.nationalbeeunit.com/contact-us/.

BeeBase

BeeBase is the NBU's website and database, which contains all the apicultural information relating to the statutory bee health programmes in England and Wales. In June 2010, the information for the Scottish inspections programme was also incorporated into BeeBase. The website facilitates the registration of beekeepers and 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. To access this information, please visit the website: www.nationalbeeunit.com. Many beekeepers find this website to be a useful source of information and advice. In addition to the public pages, registered users can view their own records 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 disease and pests. Where statutory pests or diseases (for example, foulbrood) are confirmed, the NBU uses BeeBase to identify apiaries at risk in the local area and, as a result, conduct surveillance and target control measures effectively. By knowing where colonies are, we can help you manage disease risks in your apiaries. Such risks include the incursion of serious exotic pest threats such as the small hive beetle and the Asian hornet. The more beekeepers who are registered, the more rigorous our bee health surveillance is and, crucially, the better our chances of eliminating pests and diseases.

How to sign up to BeeBase

If you are not yet registered, please visit the public pages of BeeBase where you can sign up online: www.nationalbeeunit.com. Otherwise, you can get in touch with the NBU office team who will be happy to help. You can email us at: nbu@apha.gov.uk or contact us by telephone on: +44 (0) 300 303 0094. By telling us who you are, you will be playing an important part in helping to maintain and sustain honey bees for the future.

How do I know that my details will be secure?

All the information that you provide for the purposes of registration on BeeBase is covered by the Public Service Guarantee on Data Handling. In addition, all data will be handled according to rules stated in the UK GDPR & Data Protection Act 2018. A copy of our Data Privacy Notice can be found on BeeBase. All levels of access to BeeBase are protected in the same way as online banking. Your personal access is password protected. When you first register, you are allocated a temporary password, which is valid for your first visit only. You will then be prompted to set your own password. You need to ensure that your own password remains confidential. You will also be allocated a personal ID number, which relates solely to you. As a personally registered beekeeper, once you have received an inspection visit, you can view and check your own record on BeeBase. The SBI, RBI, NBI and NBU staff at APHA will have access to your records, but no member of NBU staff will ever disclose to others that you have been inspected or any details about your bees or beekeeping without your consent.
No member of the public has access to your, or other beekeepers', details.

Beekeeping Associations

In many areas, Beekeeping Associations operate disease training schemes and provide practical advice and advisory leaflets to members on bee disease recognition and management. Contact your local Beekeeping Association for details:

England
British Beekeepers' Association
www.bbka.org.uk

Scotland
Scottish Beekeepers' Association:
www.scottishbeekeepers.org.uk/

Wales
Welsh Beekeepers' Association:
www.wbka.com

The Bee Farmers' Association
http://beefarmers.co.uk/

Introduction to *Varroa*

This section gives a simple introduction to the *Varroa destructor* 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*[2], 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 and acts mainly as a parasite of brood. Originally confined to the Asian honey bee, *Apis cerana*, it spread to the European honey bee, *Apis mellifera,* in the middle of the last century.

Why is it a problem?

Unlike the Asian honey bee, the European honey bee has few natural defences against *Varroa*[3]. The mites feed on the brood, weakening them, and are also involved in increased transmission of the viral pathogen, deformed wing virus[4]. Infested colonies usually die out within 2 to 3 years unless control measures are appropriately applied[5].

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. It was first found in the UK in 1992 and has since spread to affect nearly all apiaries in the UK. It has not been found in the Isles of Scilly or the Isle of Man, or some remote parts of Scotland.

How did it get to the UK?

We do not know for certain how *Varroa* reached the UK. Movement of infested bees in imported goods is thought to be the most likely cause.

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

Although present since 1992, the mite was not reportable until 2021. As of 2021, beekeepers in the UK must report the presence of *Varroa* in their colonies to the NBU: (www.nationalbeeunit.com/diseases-and-pests/varroa/report-varroa/).

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 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 mites and estimate their numbers. These include counting dead mites that collect on the hive floor and counting mites inside sealed brood cells or on adult bees. These methods help to plan the appropriate control methods to use.

What control methods are available?

Control methods can be divided into two groups: management methods (husbandry) and medicinal 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 known as 'Integrated Pest Management' or 'IPM'.

Varroa Biology

Feeding

Varroa can feed and survive on both adult bees and brood, but they can only reproduce on brood. The mites feed on their host through punctures made with their sharp mouthparts into the abdomen of the bee. The mites feed on the host's fat body, a nutrient-rich organ that plays an important role in hormone regulation and immunity in honey bees[6].

Reproduction

The reproductive cycle of *Varroa* mites occurs entirely within brood cells. To breed, a gravid (egg-carrying) female mite enters an occupied brood cell just before the cell is capped over, where she remains in the brood food under the honey bee larva until the cell is sealed. *Varroa* prefer to breed in drone brood but will also breed in worker brood. About four hours after capping, the female mite starts feeding on the immature bee, establishing a feeding site on the host, from which her offspring can feed as they develop. Approximately 60 to 70 hours after capping, the female lays the first of her eggs[7].

Development time from egg to adult is 5 to 6 days for males and 6 to 7 days for females. Each female lays 5 to 6 eggs; the first will hatch into a male, followed by 4 to 5 more eggs laid at 30-hour intervals that will develop into female mites. Mating between the male and female offspring occurs within the cell. Since the males do not survive outside the cell, females must be fertilised before the bee emerges from the cell, otherwise they will remain sterile. For further details, please see the life cycle diagram on page 6.

The duration of each reproductive cycle is limited by the development time of the bee. 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.

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

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

Figure 3: Immature mites on a bee pupa

Figure 4: Worker bee with a *Varroa* mite on her abdomen

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 mite reproduction in worker brood is about 1.7 to 2 new mites per mated female, but this increases to between 2 and 3 in drone brood, due to the longer development time.

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 after treatment.

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[7].

In this way mites can spread slowly over long distances. However, the movement of infested colonies by beekeepers is the principle means of spread over long distances.

Lifespan

The life expectancy of *Varroa* mites depends on the presence of brood. When brood is present, the average lifespan is 27 days. Lifespan may be to up to 100 days during broodless periods[8].

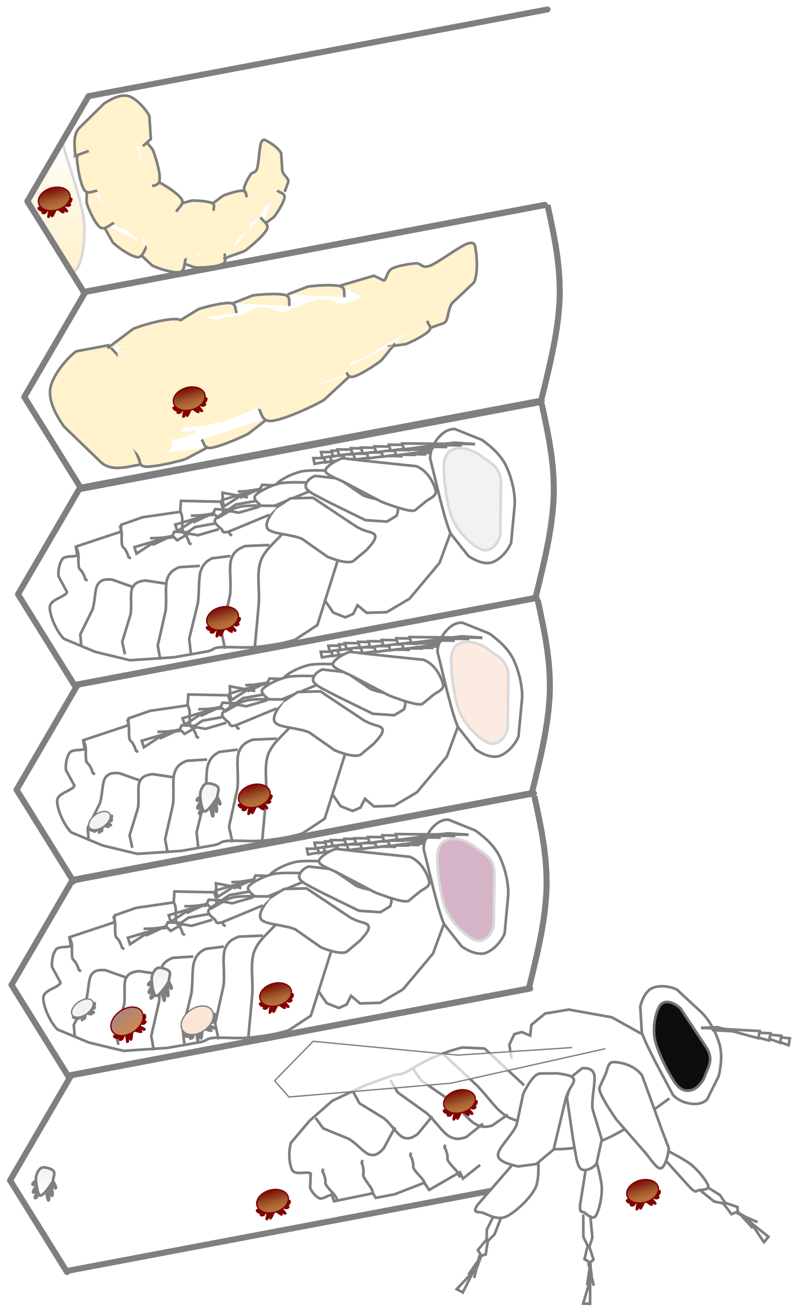
During the summer, providing brood is available, *Varroa* mites may complete up to four breeding cycles, but two is more usual[9]. In winter, when brood rearing is restricted, mites can over-winter solely on the bodies of the adult bees within the cluster, until brood rearing commences the following spring.

Viruses

Varroa mites act as a vector for viruses. The most significant of these is deformed wing virus (DWV). DWV is a virus that is found in most honey bee colonies in the UK. In the absence of *Varroa*, it is usually only found at low levels and rarely causes symptoms of disease. However, when *Varroa* levels in a colony increase, the levels of DWV also increase[4]. This leads to symptomatic DWV, which causes the death of pupae and shrivelled wings in adults.

The life cycle of *Varroa destructor*

1. The adult female mite enters a brood cell just prior to capping, where she remains in the brood food until the cell is capped
2. Four hours after capping, the female mite establishes a feeding site for her and her offspring on the host
3. Approximately 60 to 70 hours after capping, the female lays her first egg followed by 5 to 6 more eggs at 30-hour intervals
4. The first egg develops into a male mite, the following 4 to 5 eggs will develop into females
5. The male hatches first, followed by the females. The male mite then mates with the female offspring within the cell
6. Mature female mites leave the cell with the emerging bee. Immature females, and males, do not survive outside the cell



Harmful effects of *Varroa*

Effects on individual bees

Individual bees infested with *Varroa* during their development often survive to emergence but will suffer from physiological damage as adults. Infested bees will suffer from a shorter lifespan and reduced weight upon emergence, as well as an increased susceptibility to infections. Some adults may emerge with deformed wings as a result of infection with DWV.

Adult bees with deformed wings will die within 3 days of emergence.

Some brood infested by *Varroa* may die at the pupal stage of development, usually as a result of DWV. They will remain in the cell until removed by adult bees and may appear partly cannibalised in their cells.

Figure 5: A worker bee with deformed wings

Figure 6: *Varroa* damage on worker bees, with a deformed bee on the right

Figure 7: Damaged brood in a comb from a colony suffering from heavy *Varroa* infestation; including nibbled cappings, neglected brood and partially cannibalised pupae

Parasitic mite syndrome

There are many bee viruses that are naturally present at a low level in honey bees that do not normally cause significant harm. When *Varroa* feeds, as well as taking essential nourishment away from the developing bee, it acts as a vector for transmission of viruses, especially DWV.

As colonies become more heavily infested with mites, levels of DWV increase. At high levels, DWV kills pupae and causes developmental defects in adult bees. Due to the loss of pupae, an uneven, ‘pepperpot’ brood pattern will occur. As brood dies, there may be an insufficient number of young bees coming through to tend the brood, so neglected brood may become apparent. There may also be a lack of eggs and early brood stages.

Together, high levels of *Varroa* and DWV can result in a colony-level condition called ‘parasitic mite syndrome’. This condition signifies the terminal decline of the colony.

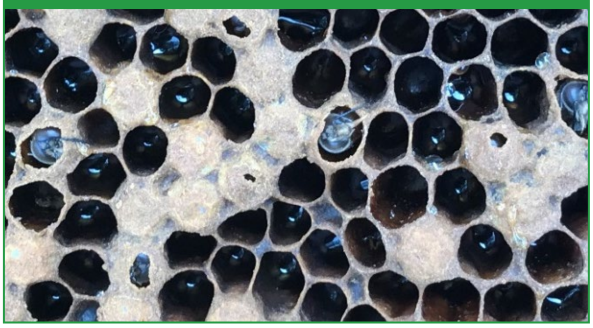
Figure 8: Bees with deformed wings are a common sight in colonies with heavy *Varroa* infestation

Effects on colonies

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

Colony collapse is usually very rapid (taking only a few weeks) and can affect 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, it is most common 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 sometimes into May. These mites add to *Varroa* populations already present, which means that colony collapse can occur earlier than anticipated i.e., before the end of the summer.

Figure 9: Signs of heavy mite infestation include nibbled cappings and an irregular brood pattern



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 shortened abdomens
- Numerous *Varroa* mites on adult bees, on worker and drone pupae and on the hive floor
- Brood abnormalities such as bald brood, poor brood pattern, patches of neglected and dead 'emerging' brood, often discoloured brown and partly removed by the bees

Note: You can check that these signs are not caused by foulbrood infection in NBU's leaflet '*Foulbrood disease of honey bees and other common brood disorders*'.

Harmful mite population threshold

There is no clear threshold beyond which a population of *Varroa* mites 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, researchers agree that in the UK it is wise to aim to keep the *Varroa* population below 1000 mites per colony; above this level, the risk of damage from the mites and associated pathogens can quickly become significant[10]. In Europe, and parts of the United States, higher threshold levels of around 3000 to 4000 mites are generally used.

Mite invasion pressure

The spread of mites between colonies, by adult bees, plays a key role in 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 through two processes: reproduction of mites in brood cells and influx of new mites through invasion. Figures 11 to 13 illustrate these two processes; based on the assumption that mite populations double through reproduction approximately every four weeks — although in reality the situation is more complicated as many factors (such as the amounts of brood present) influence the rate of mite reproduction[11].

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

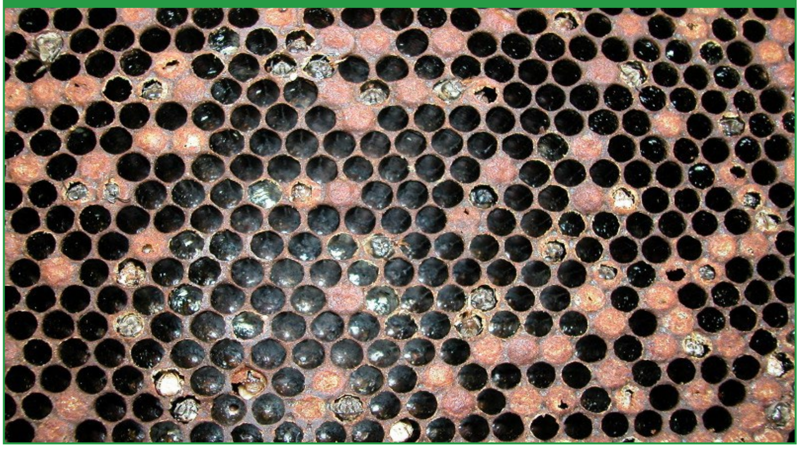


Figure 11 illustrates the increase in the mite population for colonies infested with differing numbers of mites at the start of the season (without any mite invasion from outside). During the 180 days shown, mite populations build up steadily. Where only very few (e.g. 10) mites are initially present the mite population remains well below the harmful threshold of 1000 mites for the entire period shown (the blue line). However, in colonies starting with larger numbers of *Varroa* (100 or 200 mites — the orange or grey lines respectively), the build up to harmful levels is 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

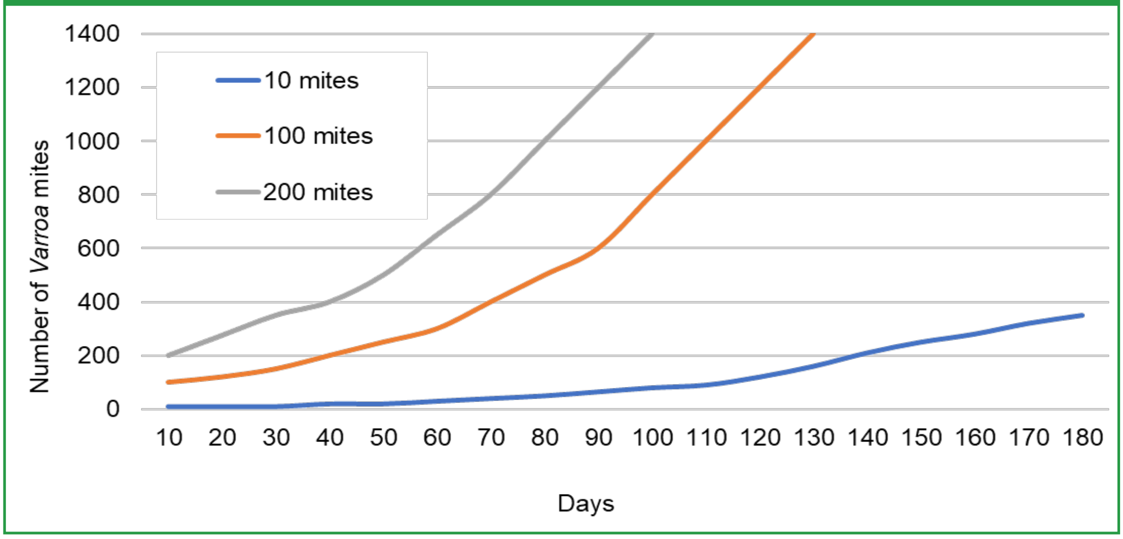


Figure 12 illustrates the effect of mite invasion (indicated by the arrow). Where small numbers of mites are present at the start of the season, and no mite invasion occurs, the mite population remains below 1000 during the whole period shown (the blue line). However, mite invasion early in the season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

Figure 12: Effect of mite invasion (arrow) on subsequent mite growth

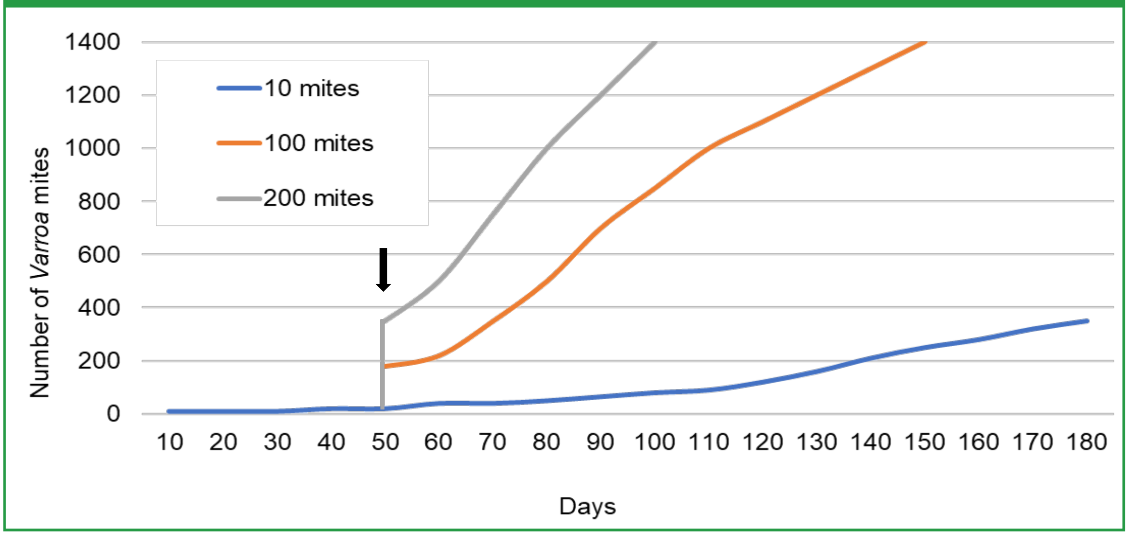


Figure 13 shows the recovery in the mite population that occurs following treatment with a varroacide (indicated by the arrow). The fall in the mite population when treatment is applied depends on the treatment's efficacy. When a very effective treatment is applied (the blue line), the mite population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

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

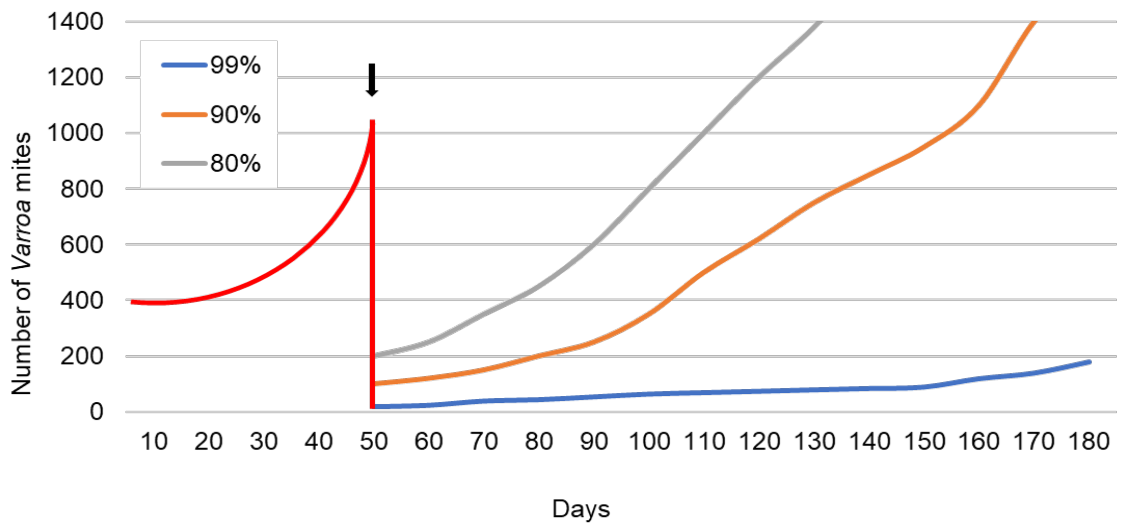


Figure 14: Electron micrograph of a *Varroa* mite, showing mouthparts, legs, and ventral surfaces

How to recognise & monitor *Varroa*

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

Recognising *Varroa*

Female *Varroa* mites are easily recognised by their flat, reddish-brown, oval bodies (1.6 x 1.1 mm). 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.

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

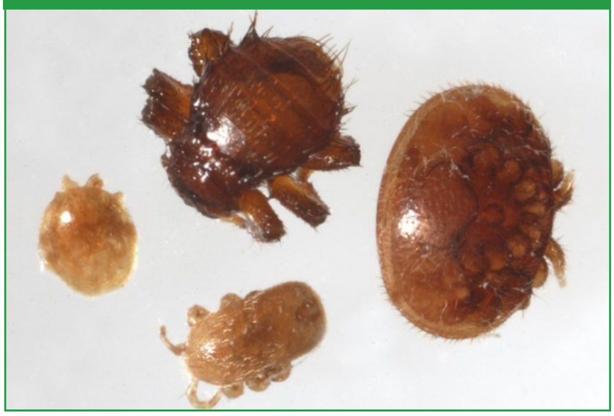
The bee louse, *Braula coeca*, is a wingless fly that lives harmlessly on adult bees (Figure 17) but may be confused with *Varroa* as they are similar in size. It can be distinguished from *Varroa* by its more rounded shape, and by its six legs that are readily visible on both sides of its body. Braula are rare in the UK, but, where present, they often prefer living on the queen.

Figure 15: A female *Varroa* mite

Figure 16: *Varroa* mites on an infested bee

Figure 17: *Braula coeca* on the surface of a bee

Figure 18: *Braula coeca* (top), *Varroa* (right), *Tropilaelaps* (bottom) and *Melittiphis* (left)



There are two other mite species that may be found in colonies: *Tropilaelaps spp*. and *Melittiphis alvearius* (Figure 18). *Tropilaelaps* are a serious exotic pest of honey bees and are notifiable (please see NBU's leaflet *Tropilaelaps*: parasitic mites of honey bees). *Tropilaelaps* are not currently present in the UK or Europe.

Melittiphis mites are pollen feeders, consuming stored or fallen pollen in bee hives. They are present in the UK, but do not harm honey bees or brood.

Monitoring *Varroa*

It is important 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 using an open mesh floor (OMF) and a sticky insert or a sheet of card coated with petroleum jelly in the removeable tray will tell you how mite infestation is developing. You can then use this information to decide which control methods will be appropriate, and when to apply them.

A range of monitoring methods are available to use — from the quick and approximate through to the complex and more accurate. You can decide which of these best suit your own individual beekeeping practices.

Figure 19: A screened open mesh floor for monitoring mite drop

Figure 20: A *Varroa* floor with sticky insert being examined for mites

Figure 21: Hive floor debris containing dead 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 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*

Monitoring natural mortality through mite drop

Figure 22: Colony debris that has fallen through the mesh floor onto the floor board

1. Ensure that the colony has an open mesh floor and has a removeable tray or floorboard for monitoring.

2. Clear the floorboard using a hive tool and leave for 7 days.

3. After 7 days, collect the debris and count the number of mites present. If there is a lot of debris, pour it into a large white tray; the mites will be more obvious against a white background. A light source and magnifying glass may help.

4. Calculate daily mite drop by dividing the number of days since the floorboard was cleared by the number of mites.

5. Multiply the daily mite fall figure by one of the following to calculate an approximate infestation level in the colony:

November to February:	**x 400**
May to August:	**x 30**
March, April, September, and October:	**x 100**

The maximum threshold of mites per colony before serious harm occurs is 1000 — treatment should be applied before reaching this level (see figure 44 on page 32)

Figure 23: The monitoring tray is placed on a level surface so that mites can be counted

Pros and Cons

✓ colony is not disturbed
✓ can be performed at any time of year

✗ monitoring takes many days
✗ results are approximate

Monitoring through drone brood uncapping

1. Select an area of sealed drone brood at an advanced stage of development (pink-eyed) as this is least likely to disintegrate when removed.

2. Slide the prongs of an uncapping-fork under the domed cappings, parallel to the comb surface, and lift out the drone pupae in a single scooping motion.

Figure 24: Using an uncapping fork, carefully remove the drone brood

Figure 25: *Varroa* mites will be noticeable against the pale bodies of the drones

3. Repeat until at least 100 cells have been examined, using up to 300 cells. The calculation is more accurate if 300 drones are sampled. *Varroa* mites are easily seen against the pale drone bodies, but it may help to transfer them onto a white surface. Count the number of mites per 100 pupae.

4. If more than 5 to 10% of drone pupae are infested, then the infestation is serious, and treatment is urgently needed. An acceptable level of infestation is usually below 3% (see Table 3 on page 32)

Figure 26: *Varroa* mites are obvious on the pale brood

Pros and Cons

- ✓ **fast and easy to perform**
- ✓ **results are accurate**
- ✓ **can be used during routine inspections**

- ✗ **kills 100 to 300 drone brood**
- ✗ **can only be performed when drone brood is abundant in the colony**

Monitoring using the alcohol-wash method

The following items are needed for this method:

- a large bowl
- a half-cup scoop
- a sampling container (>200 ml volume) with lid
- mesh with approx. 2 mm pore size to allow mites through
- alcohol, i.e. 70% ethanol (added to sampling container)

1. Collect a brood frame from the colony and knock the bees from it into the bowl. *Ensure that the queen is not accidentally collected*.

2. Scoop half a cup of bees from the bowl into the container of alcohol. Half a cup should accommodate between 300 and 400 bees.

3. Place the lid on and shake the bees vigorously for a few minutes. The samples can be assessed immediately, or can be left for up to 24 hours, for example, if you want to take the samples elsewhere to examine them away from the apiary.

4. Shake the samples again before pouring the bees through the mesh into the bowl. It will help to rinse water over the bees to dislodge any remaining mites. Count the mites to calculate infestation rate.

5. If there are more than 5 mites per 100 workers (5%), then the infestation is serious, and treatment is urgently needed. An acceptable level of infestation is below 3%.

Figure 27: Select a brood frame to collect worker bees for sampling

Pros and Cons

✓ **results are fairly accurate**
✓ **can be performed at any time of year**

✗ **kills approximately 300 bees**
✗ **more time-consuming and expensive than other methods**

View a practical demonstration of how to perform the alcohol wash method in this video: https://youtu.be/mVB5_bclyus

Monitoring using the sugar-roll method

The following items are needed for this method:

- a large bowl
- a half-cup scoop
- a sampling container (>200 ml volume) with mesh lid
- mesh for lid: approx. 2 mm pore size to allow mites through
- two to three tablespoons of powdered sugar (added to sampling container)

1. Collect a brood frame from the colony and knock the bees from it into the bowl. *Ensure that the queen is not accidentally collected*.
2. Scoop half a cup of bees from the bowl into the container of sugar. Half a cup should accommodate between 300 and 400 bees.
3. Place the lid on and roll the bees in the sugar for two to three minutes.
4. Invert the container onto a white surface so that the dislodged mites fall through the mesh. Count the mites to calculate infestation rate.
5. If there are more than 5 mites per 100 workers, then the infestation is serious, and treatment is needed. An acceptable level of infestation is below 3%.

For more information on *Varroa* monitoring, please refer to our fact sheet:

www.nationalbeeunit.com/assets/PDFs/3_Resources_for_beekeepers/Fact_Sheets/Fact_13_Estimating_Varroa_mite_populations.pdf

Pros and Cons

✓ **results are fairly accurate**
✓ **can be performed at any time of year**
✓ **bees can be returned to the colony**

✗ **can be difficult if sugar clumps due to humidity**

Figure 28: Collect workers from a brood frame for sampling

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, therefore maintaining healthy colonies of bees. 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). Current control methods used by beekeepers against *Varroa* can be divided into two main categories, each of which have pros and cons: 'varroacides' and 'husbandry methods'.

Varroacides

Varroacides are veterinary medicines that kill mites. These can be applied as contact strips or pads, by trickling or by sublimation. These are authorised proprietary veterinary medicines. Unauthorised generic substances which have not been licensed for the use as a *Varroa* control should not be used.

Husbandry methods

Husbandry methods involve the use of physical methods to reduce the mite population. Many of the most effective methods involve trapping the mites in brood, which is then removed and destroyed. Generally, these methods are only suitable for use in spring or early summer. They reduce the need to use medicines and are of great benefit in areas with late honey flows.

Integrated pest management

The optimal way to control *Varroa* involves a combination of husbandry and medicinal approaches, together with an active monitoring program. Husbandry methods tend to be less effective at reducing mite populations, but when combined with varroacides, can improve the effectiveness of either treatment alone.

Figure 29: *Varroa* on drone brood removed as part of mite control

Figure 30: Synthetic pesticide strips applied to a colony in autumn

Figure 31: Oxalic acid; an organic acid for *Varroa* treatment

Using husbandry methods

Husbandry methods for controlling *Varroa* exploit the fact that mites reproduce in the brood. Unsealed brood can be used to trap and remove *Varroa* from the colony. If a 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.

Husbandry methods allow the control of *Varroa* without the use of chemical varroacides. This makes them especially useful during the active season when supers are on hives and using a varroacide may not be appropriate. By using husbandry methods, use of varroacides can be kept to an absolute minimum — or enable use of preferred varroacides with a low efficacy.

One of the advantages of husbandry techniques 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 effective methods that combine swarm control with *Varroa* control.

Despite these advantages, as a result of their nature, most husbandry 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 husbandry methods are unlikely to provide sufficient control of *Varroa* if used alone and will need to be used in conjunction with varroacides for maximum effectiveness.

Figure 32: Unsealed brood can be used as a bait to trap *Varroa*

Figure 33: The tray can be removed so that mites fall outside the hive

Open mesh floors

Many modern hives have an open mesh floor (OMF) rather than a solid floor with a removeable tray for *Varroa* monitoring. There are two benefits to hives with OMFs versus solid floors; one is that the collection tray can be used to measure natural mortality in mites for *Varroa* monitoring, and the other is that there is some modest reduction in the mite population[11]. In order to benefit from this reduction, the collection tray should be removed from the hive. When the tray is taken out, the living and dead mites that fall from the hive will fall through the mesh onto the ground below. The living mites will be unable to return to the hive, resulting in a small effect of reducing the mite population in the hive. This is not a highly effective method of controlling mites, so it should not be relied upon as a primary method of control.

Drone brood removal

Varroa mites have a preference for drone brood, so culling a small amount of drone brood in late spring or early summer can reduce mite numbers. This method can be up to 50% effective at reducing mite numbers[13] and has the benefit of being a means of mite control when supers are on the hive.

To perform drone brood removal, frames containing drone foundation will be needed. A super frame is also effective as the bees will build drone comb beneath them. A good time to put these in the colony to be drawn out is when the queen first begins to lay drone brood.

1. Remove a frame from the edge of the brood nest and replace with a frame of drone brood foundation or a super frame. If the colony is on double-brood boxes, the procedure can be applied to both brood boxes at the same time.

2. Return to the colony in approximately 18 to 20 days to check if the drone brood are capped. If the majority of drone brood are capped, remove the frame from the colony. Destroy the frames by freezing or burning.

3. If they are not yet capped, return to the colony regularly to check, and discard the frame once it is full of capped drone brood. Do not leave the drone brood for more than 24 days without checking, as they will emerge, releasing trapped mites into the colony.

4. The procedure can be repeated once more with another frame of drone brood foundation, up until July. After July, drone brood removal is not recommended.

Figure 34: A hive tool can be used to cut off excess drone brood

Figure 35: The excess drone brood can then be destroyed

For more information on drone brood removal, please refer to our fact sheet:

www.nationalbeeunit.com/assets/PDFs/3_Resources_for_beekeepers/Fact_Sheets/Fact_26_Using_Drone_Brood_Removal_as_a_Varroa_Control.pdf

Pros and Cons

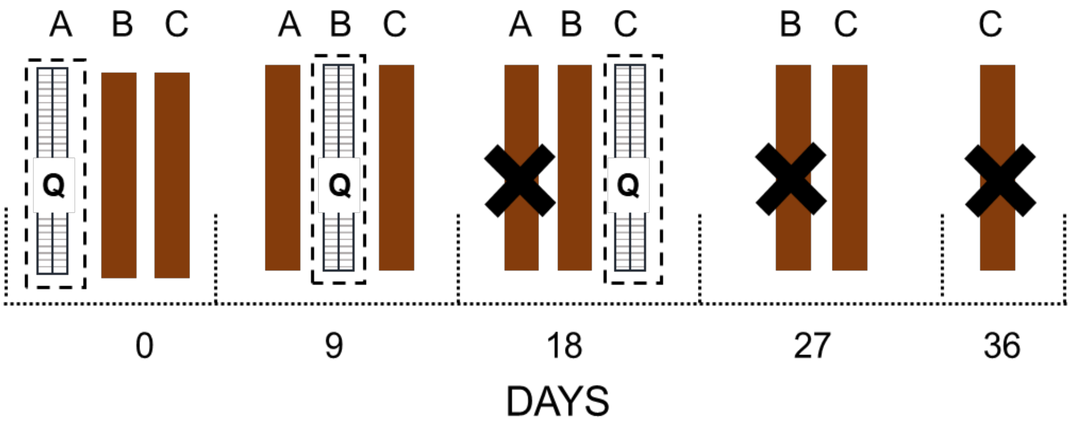
- ✓ **fast and easy to perform**
- ✓ **no varroacides or specialist equipment needed**

- ✘ **limited effectiveness**
- ✘ **only possible during drone brood rearing season**

Comb trapping

Comb trapping, also called queen caging, is a method for inducing a brood break by trapping the queen inside a cage. This method should only be used on strong colonies and limited to between May and July in the UK. Although the mites will be unable to reproduce during the brood break, they can survive for weeks on adult bees and recolonise the colony. Combining comb trapping with oxalic acid will significantly increase the efficacy of this method.

Figure 36: Comb trapping timetable. The queen (Q) is caged for 9 days on three combs (A, B and C) in succession. The combs containing mites trapped in the sealed brood are then removed (marked with black X)



1. Confine the queen to a frame of worker comb inside a frame cage; ‘A’ at day 0 in Figure 36. Ensure that the cage is wide enough for workers to enter and exit but not the queen.

2. After 9 days, transfer the queen and the queen cage onto a new empty frame: ‘B’. Place frame ‘A’ back into the brood chamber where it will become infested with mites.

3. After a further 9 days, remove frame ‘A’, which should now be sealed and will contain *Varroa* mites; this frame can be destroyed or frozen. Transfer the queen and the queen cage onto a new empty frame; ‘C’. Place frame ‘B’ back into the brood chamber.

4. After 9 more days, remove frame ‘B’ for destruction or freezing. Release the queen from frame C and remove the queen cage from the colony. Place frame ‘C’ back into the brood chamber; removing it when a further 9 days have passed.

Pros and Cons

✓ **can be very effective if combined with oxalic acid treatment**
✓ **more bees recruited to foraging**

✗ **time consuming**
✗ **can harm the colony if performed incorrectly**
✗ **requires confidence handling the queen**

Artificial swarm

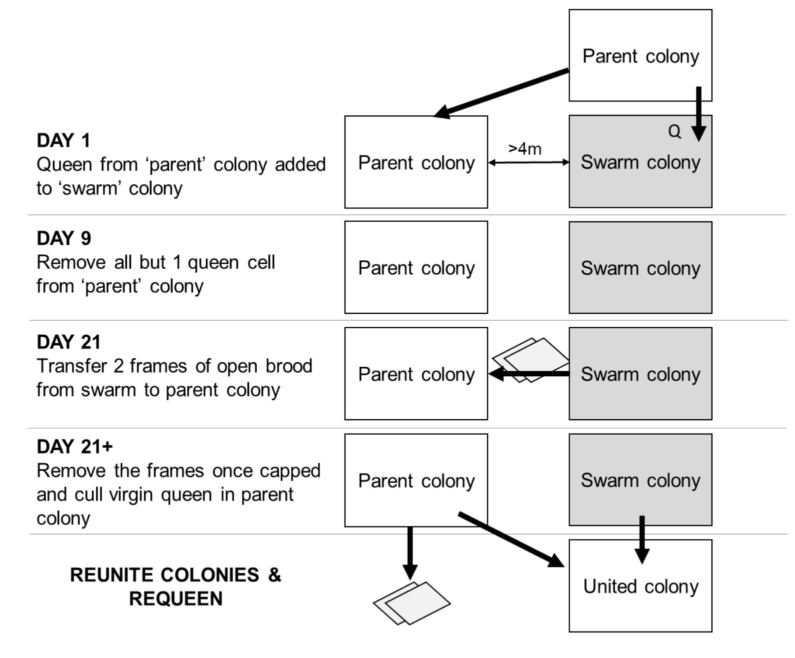


Figure 37: Diagram illustrating the control of *Varroa* using an artificial swarm

1. Move the colony which you plan to split to one side of its original site, at least 4 metres away; this is the '*parent colony*'.

2. Place a new hive containing freshly drawn-out combs at the site of the original '*parent colony*'. Find the queen in the '*parent colony*' and transfer it to this empty hive — this is the '*swarm colony*'. Foragers will return to this '*swarm colony*', 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 to prevent the virgin queen from leaving the hive to mate but allowing the worker bees to care for her.

4. After 21 days, all the brood from the '*parent colony*' will have hatched. Transfer two bait combs of unsealed brood from the '*swarm colony*' to the '*parent colony*'. When they are capped, remove and destroy them.

5. Cull the virgin queen and introduce a new queen into the parent colony. The old queen in the swarm can later be removed and the two colonies reunited.

Pros and Cons

- ✓ **combines swarm control with *Varroa* control**
- ✓ **new queen introduced**

- ✗ **only suitable for use in the swarming season**
- ✗ **may be necessary to take precautions to prevent absconding**

Using varroacides

Types of varroacide

Varroacides should be a key element of any *Varroa* control programme. The most important distinction between different varroacide products is whether it is a synthetic pesticide or not. Synthetic pesticides have a significant risk of resulting in pesticide resistance in *Varroa*, whereas other products based on organic acids (formic acid and oxalic acid), or the essential oil, thymol, have a far lower chance of this occurring. At the time of writing, no cases of *Varroa* resistance to thymol, oxalic acid or formic acid have been reported.

Authorised varroacides

Veterinary medicines must be authorised 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: https://www.gov.uk/government/organisations/veterinary-medicines-directorate

Use of non-approved generic substances

Although naturally occurring substances such as organic acids (formic acid and oxalic acid) and essential oils (such as thymol) can be acquired from other sources than authorised medicines, **it is not legal to apply 'home-made' remedies to honey bees**. In most cases, no formal testing of efficacy or safety of these substances has taken place, and, therefore, there is a danger that they are ineffective, harmful to bees, the environment, or the user, or leave harmful or otherwise undesirable residues in bee products. Individuals are liable to prosecution should routine sampling and testing of products for residues find positive results.

The Cascade Principle

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). In order to import and use a veterinary product under the Cascade, veterinary surgeons must apply for a Special Import Certificate (SIC). Information about products available under the SIC can be found at: www.gov.uk/guidance/bee-medicines-availability-in-the-uk.

Misuse of agrochemicals

The active ingredients of some 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.

Chemical residues in bee products

Any chemical substance applied to honey 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 specificied in the label directions of an authorised product.

Figure 38: NBU honey sampling on behalf of the VMD as part of Defra's statutory residue monitoring programme

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 APHA Bee Inspectors during their apiary visits. These are analysed for a range of possible contaminants, including varroacide residues. Individual results are provided, and the overall findings of the programme are published annually by the VMD, within the Marketing Authorisation Veterinary Information Service (MAVIS) reports and through the Veterinary Residues Committee (VRC).

Beekeepers should be aware that they are liable to prosecution should the routine sampling find positive results. It is a legal requirement to 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 these records are your proof that you acted properly. You can download a copy of the record sheet from: www.nationalbeeunit.com/assets/PDFs/3_Resources_for_beekeepers/Fact_Sheets/Fact_28_Veterinary_Medicine_Administration_Record.pdf

Varroacides and your responsibilities under the law

! It is only legal to use UK authorised varroacides applied according to the manufacturer's instructions on honey bee colonies.
! It is illegal to use generic substances in a 'home-made' format.
! It is a legal requirement to keep accurate records of treatments used, and all relevant details including date, dose, supplier, product name and batch number, for up to 5 years after the date of application, even if you no longer own the treated colonies.
! Only vets and authorised companies can import medicines. It is illegal for anyone else to import products into the UK.
! Make sure that you have reliable and up to date information on the legal status of any treatment you may be considering; available on the VMD website at: www.gov.uk/guidance/bee-medicines-availability-in-the-uk
! You may be requested to provide a sample of your honey for residue analysis as part of the VMD's residue monitoring programme.

Table 1: Varroacides authorised for use in honey bee colonies in the United Kingdom

Name	Active ingredient	Mode of application	When to apply	Significant features
Apiguard (Vita Europe)	Thymol	Place open tray above brood nest	Spring or late summer; for 14 days (repeat x1)	Ensure OMFs are closed. Most effective when outside temp >15°C
Apilife Var (Chemicals LAIF)	Thymol	Break tablet into 4 pieces and place in corners of the brood box	Spring or late summer; for 7 to 10 days (repeat x1)	Ensure OMFs are closed. Most effective when outside temp >15°C
Thymovar (Andermatt BioVet)	Thymol	Cut one strip into two and place on top bars of frames but not above brood nest	Spring or late summer; for 3 to 4 weeks (repeat x1)	Ensure OMFs are closed. Most effective when outside temp >15°C
Mite Away Quick Strips/MAQS and Formic Pro (NOD Apiaries)	Formic acid	Place strips on top bars near the outer edges of the brood nest	May to August	Ensure colony is well ventilated and contains >6 frames of bees. Do not use when outside temps exceed 30°C
Api-Bioxal (Chemicals LAIF)	Oxalic acid	Trickling: 5ml per frame space of bees Sublimation: Use 2.3 g	Winter & broodless periods	Lethal to open brood. Ensure outside temp is over 3°C. Very effective
Oxuvar (Andermatt BioVet)	Oxalic acid	Trickling: 5ml per frame space of bees Spraying: 4 to 5 sprays per side of frame	Winter & broodless periods	Lethal to open brood. Ensure outside temp is over 3°C. Very effective
OxyBee (Veto Pharma)	Oxalic acid	Trickling: 5ml per frame space of bees	Winter & broodless periods	Lethal to open brood. Ensure outside temp is over 3°C. Very effective
DANY's Bienenwohl powder (DANY Bienenwohl GmbH)	Oxalic acid	Trickling: 5ml per frame space of bees	Winter & broodless periods	Lethal to open brood. Ensure outside temp is over 3°C. Very effective
VarroMed (BeeVital)	Formic acid and oxalic acid	Trickle between brood frames; 5 ml per frame space	Spring, autumn or winter	Ensure outside temp is over 3°C
Apivar (Veto Pharma)	Amitraz	Place plastic strips between frames close to the cluster, but more than 2 frames apart	Any season for 6 to 10 weeks, but not during honey flow	Most effective when less than 2 frames of brood and at >10°C
Apistan (Vita Europe)	Tau-fluvalinate	Place one strip between frames 3 & 4, and the other between frames 7 & 8	Autumn or early spring; for 6 to 8 weeks	Should only be used once every 3 to 5 years
Apitraz (Laboratorios Calier)	Amitraz	Place plastic strips between frames more than 2 frames apart	Autumn or early spring; for 6 to 10 weeks	Most effective when less than 2 frames of brood and at >10°C

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, a particularly important time to treat is late summer — between harvesting honey and preparing colonies for winter. At this time, the colony size will be reducing while mite 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 winter bees needed for successful colony survival over winter. If treatment is delayed at this time, this may cause the winter bees to be heavily parasitised and carry a higher DWV 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 medicines are applied. Some treatments (e.g. Apiguard, MAQS) may require warm conditions for maximum efficacy.

Figure 39: Diagram illustrating *Varroa* population growth relative to bee brood, where mite levels are low in spring, but the colony isn't treated during summer. In this scenario, there may be many mites while the important winter bees are developing in late summer

Can the chemicals in varroacides harm bees?

There are concerns about whether varroacides can have unpleasant side-effects on the bees; they are designed to kill invertebrates after all. Authorised products have very little off-target detrimental effects on the honey bees, providing that the instructions are strictly followed. Some products may result in a small loss of brood or a small number of dead bees. For example, occasional adult[14] or brood[15] mortality has been observed with the use of thymol-based treatments, while formic acid can cause adult bee mortality if it is accidentally overdosed through improper use[16]. The loss of a few hundred bees is unlikely to exceed the rate of egg laying or have long term adverse impacts on the colony. Meanwhile, high levels of *Varroa* infestation have demonstrable adverse effects on the colony.

Resistance management

How does resistance arise?

Varroa have developed resistance to synthetic pesticides; amitraz and tau-fluvalinate (Apivar, Apitraz and Apistan). Individual variation within a mite population may result in small numbers of mites with resistance traits. These characteristics are genetic and thus heritable, although often the mites with these unusual traits suffer a fitness cost 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 the same synthetic pesticide, 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 depends on how often *Varroa* mites are exposed to a pesticide 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.

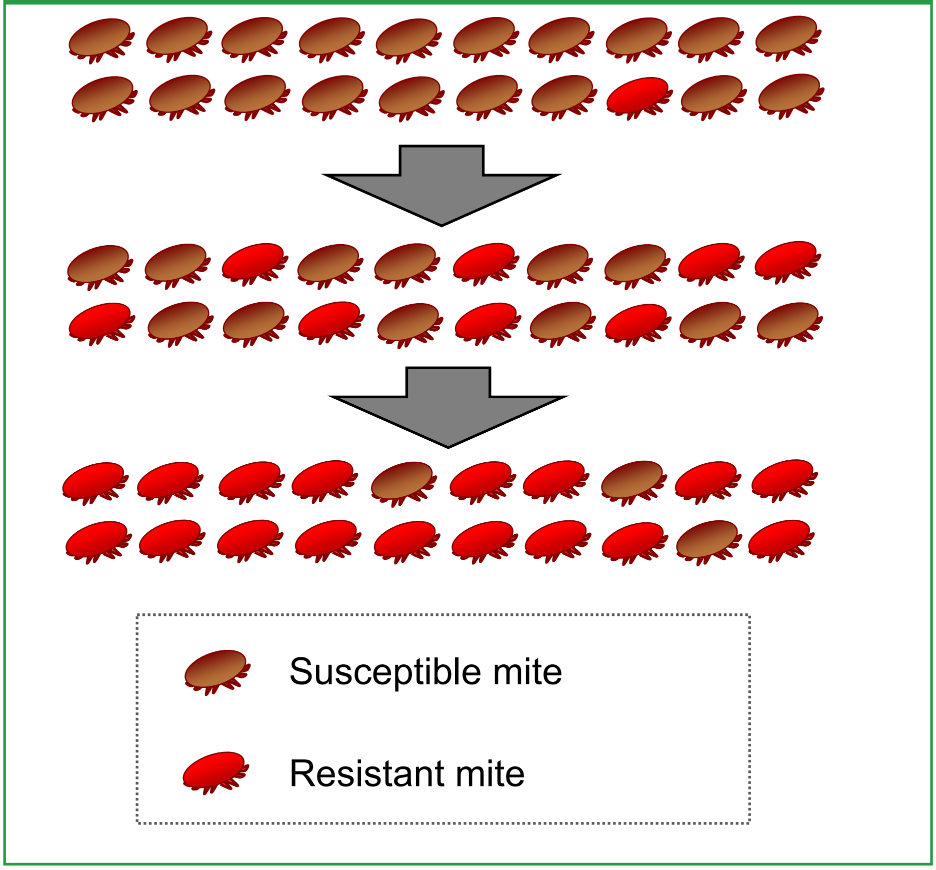
Figure 41: Pesticide strips can be effective, but run a high risk of causing resistance in *Varroa*

Figure 40: Oxalic acid trickling is an effective mite treatment with a low risk of causing resistance in *Varroa*

Can mites become resistant to all varroacides?

While it is possible, in theory, for mites to become resistant to any treatment; chemical or otherwise, the probability that they will become resistant to thymol, oxalic acid or formic acid is significantly lower than that of developing resistance to synthetic pesticides such as amitraz or tau fluvalinate. This is because of how the treatments work. Synthetic pesticides target only a single gene, so the mite only needs to posses one simple mutation to develop resistance to it. Meanwhile, non-synthetic pesticides have a complex mode of action and affect many pathways globally in the mite. A viable reproductive mite with the ability to evade a chemical with many targets, is significantly less probable. For example, thymol disrupts the functions of many proteins and cell membranes in the mites. A single gene mutation that evades these effects is highly improbable. To date, there is a strong body of evidence demonstrating that *Varroa* mites are, or can become, resistant to the synthetic pesticides, amitraz and tau fluvalinate. However, so far, there is no evidence of resistance of mites to thymol, oxalic acid, or formic acid.

Figure 42: Development of pesticide resistance: initially, only a small number of mites are resistant, but these mites and their offspring will survive successive treatments and become more abundant



Managing resistance

Before using a synthetic pesticide, it is possible to monitor for resistant mites in colonies. Unless the presence of resistant mites is identified through testing, the first obvious sign is likely to be the collapse of colonies after treatment fails to control mite infestation. To help monitor for mite resistance to a treatment, monitor mite levels before and after treatment to gauge how effective a particular treatment has been. By the time resistant mites are identified in an apiary, they generally comprise the majority of the mite population. If resistant mites are present, the synthetic pesticide should no longer be used as it will no longer provide effective control and its continued use will only cause resistance problems to worsen. Instead, use an alternative varroacide.

Avoiding resistance

To delay the development and spread of resistance, it is recommended to:

- Treat using the precise dose specified by the manufacturer.
- Treat only for the period specified on the instructions.
- Treat only when necessary, in response to the results of active mite monitoring.
- Alternate between different treatment types; this is especially important for synthetic pesticides which should be rotated with a non-synthetic pesticide to kill resistant mites.
- Do not use out-of-date products.

Testing for resistance

Method: USDA Beltsville Test

1. Cut a 9 mm x 25 mm piece from a pesticide strip and staple to centre of a 75 mm x 125 mm index card. Place card in 500 ml jar with strip facing inwards.
2. Prepare a 2 to 3 mm light metal mesh cover for the jar.
3. Shake bees from 1 to 2 combs of a colony into an upturned roof. Scoop 1/4 cup of these (about 150 bees) and place in a 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 to 4 hours). Count the remaining mites.
7. Calculate percentage mite kill. Less than 50% indicates you may have resistant mites.

Caution: This method gives only 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'. The methods used are 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 pesticide strips for 6 weeks.
3. Clean tray and check daily mite drop immediately after treatment finishes.
4. Significant mite drop after the treatment has ceased indicates a mite population remains and therefore your treatment may not have been effective — requiring further investigation.

For more information on resistance testing, please refer to our fact sheet:

www.nationalbeeunit.com/assets/PDFs/3_Resources_for_beekeepers/Fact_Sheets/Fact_07_Beltsville_and_Pyrethroid_Resistance_Testing.pdf

Integrated pest management

What is Integrated Pest Management?

Integrated Pest Management (usually abbreviated to 'IPM') is a principle widely used in agriculture, especially where it is desirable to keep pesticide use to a minimum. Significantly, no attempt is made to completely eradicate the pest. Instead, the aim is to keep pests below the level where they cause significant harm, by using a combination of methods 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 waiting until pest numbers have reached a damaging level before applying controls or applying the same controls each year regardless of pest numbers.

Good husbandry

Good husbandry should be the starting point for IPM control of *Varroa*. Keep a close eye on the health of your bees and make sure you regularly monitor *Varroa* levels in the colony. 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* resistance.

An IPM programme for *Varroa*

IPM can be readily applied to control many bee pests and diseases, particularly *Varroa*. Benefits include:

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

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.

Table 2 shows the combinations of controls that may be used. It would not normally be necessary or appropriate to use all the options. Please note that some treatments may be used outside the *optimal* months, depending on conditions and treatment.

Table 2: Optimal times for using *Varroa* controls (months highlighted in green)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Open mesh floor	■	■	■	■	■	■	■	■	■	■	■	■
Drone brood removal				■	■	■	■					
Queen caging				■	■	■	■					
MAQS/Formic Pro					■	■	■	■				
Apiguard/Apilife Var/Thymovar								■	■	■		
Api Bioxal/ Oxuvar/Oxybee	■											■
Apivar/Apitraz/ Apistan			■	■				■	■	■		
VarroMed	■	■	■	■	■				■	■	■	■

Slowing down mite population growth

It is helpful to employ husbandry methods to slow the growth of the *Varroa* population in your colonies — such as drone brood removal and the use of open 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 effective varroacides.

The use of open mesh floors (OMF) and drone brood culling should result in a mite population reduction of 50%. Their use is helpful to reduce the population when use of a varroacide may not be possible. However, mite levels will build back up quickly, so a treatment later in the season is necessary. Figure 44 is a theoretical graph showing that drone brood removal in June *could* keep mite levels below a damaging threshold until August. A varroacide would be recommended before mite levels reach 1000. MAQS (approximately 97% effective) used in July or a thymol treatment (upwards of 85% effective) could be applied to prevent mites from being at high levels during the crucial period in early September, when winter bees are developing.

Reactive monitoring for mite control

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 and high mite levels require more urgent and effective action.

Figure 45 and Table 3, on the next page, illustrate these principles, using daily mite drop or drone brood monitoring to assess the severity of infestation and determine what action should be taken.

Figures quoted are based on the mathematical model of mite populations and aim to maintain a level of less than 1000 mites/colony 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, also be aware that if an invasion of mites occurs then the mite levels could increase rapidly.

In this context, **light control** means using husbandry methods or varroacides that have relatively low efficacy. **Effective control** means using varroacides or husbandry methods that are very effective and greatly reduce the mite population.

Figure 43: A theoretical demonstration of how timing of controls can reduce mite populations. Drone brood removal reduces mite levels by 50% and keeps the mites below a damaging threshold until a varroacide can applied later in the season

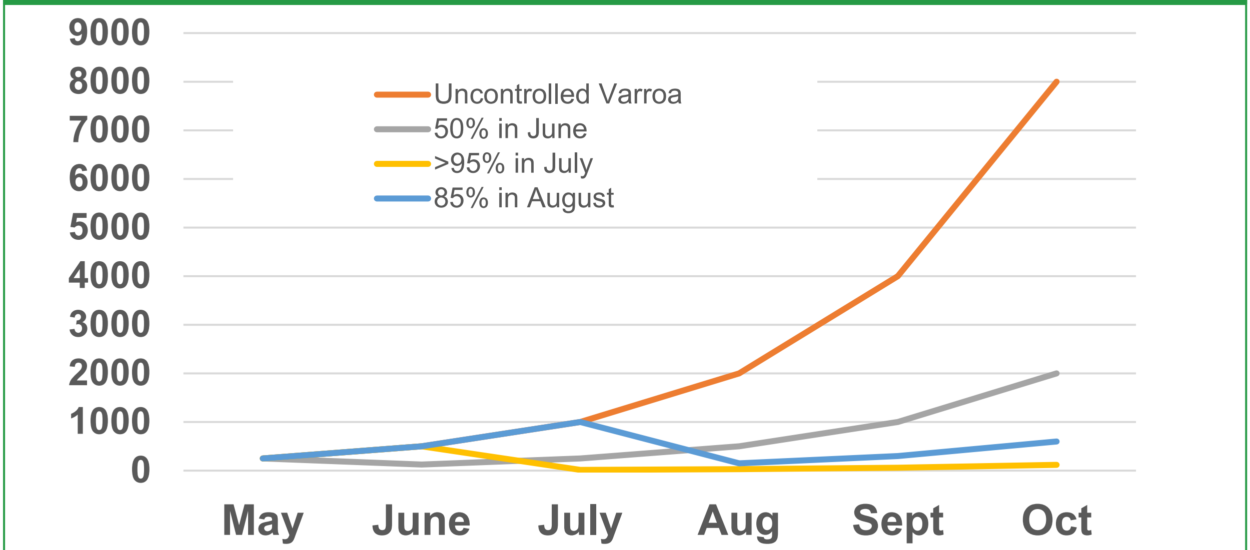


Figure 44: Using daily mite drop to determine whether to apply controls

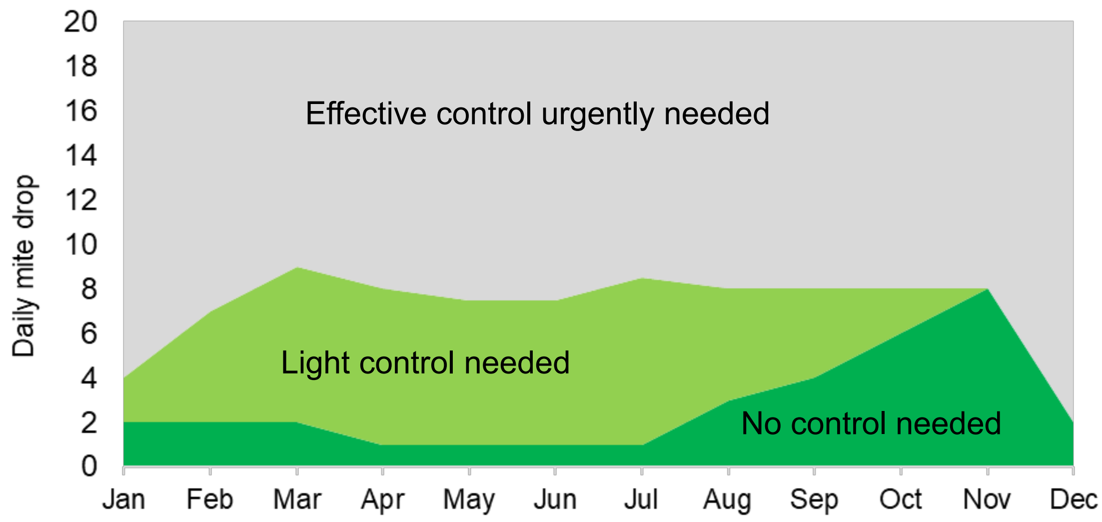


Table 3: Using drone brood monitoring to decide when to apply appropriate controls

	Proportion of infested drone brood		
April, May, June	**Less than 2%** No action needed	**2% to 4%** Plan controls	**Over 4%** Consider control
June, July	**Less than 3%** No action needed	**3% to 7%** Light control	**Over 7%** Effective controls needed
August	**Less than 5% No** action needed	**5% to 10%** Light control	**Over 10%** Effective controls needed

Living with *Varroa*

Why we treat

It has been shown that most honey bee colonies that are not actively managed to prevent *Varroa* population growth will succumb to the combined effects of parasitisation and deformed wing virus within 2 to 3 years[5,17]. *Varroa* mites cannot be eradicated, but with careful management, can be kept below the threshold that harms the colony. Continuous monitoring and a combination of varroacide and husbandry techniques to control mite numbers are needed to keep mite levels to a minimum, while preventing overuse of varroacides.

Apis mellifera do not naturally possess the complex collection of behaviours necessary to resist the mite, that their evolutionary cousins, *Apis cerana*, do. These include high levels of grooming behaviour, hygienic behaviour, and entombment of infested drone brood. Additionally, *Apis cerana* have a shorter post-capping period which reduces the reproductive success of the mites, and *Varroa* cannot reproduce in *Apis cerana* worker brood. Together, these factors allow *Apis cerana* to have a balanced relationship with *Varroa* that does not result in excessive colony deaths, which is not the case for *Apis mellifera*.

Going treatment free

Research across many countries is using selective breeding for the development of mite resistant strains of honey bee, by selecting for traits that are observed to reduce mite fertility. Selective breeding often requires geographic isolation or artificial insemination to preserve the resistance traits being selected for, as well as large numbers of colonies to ensure that the resulting strains maintain good genetic diversity. This is different to non-treatment *without selection*.

While there is some evidence for partial resistance traits developing in honey bees that are not treated for *Varroa*, large proportions of honey bee stocks are lost during the initial years of non-treatment, and breeding isolation plays a key role in the maintenance of resistance. The open mating structure of most apiaries in the UK can counteract the development of resistance due to the influx of non-resistant alleles from drones of unknown provenance from surrounding apiaries. If bees are not treated for *Varroa* in an attempt to create resistant bees, in an area that is not geographically isolated from other beekeepers who are treating, the queens from the untreated colonies will mate in an open mating system with drones from many apiaries, unless artificial insemination is used. Virgin queens mate in drone congregation areas (DCAs) in the first two weeks of life, which consist of thousands of drones for potential mating. One study in Germany found that drones from one DCA originated from approximately 240 different colonies[18].

A queen will mate with many drones but is unlikely to mate with drones from the original apiary; a natural mechanism to prevent inbreeding. Therefore, in the case of the non-treating apiary, the female offspring of a queen with possible resistance traits, may have lesser traits as 50% of their genetics comes from the drone of unknown provenance. Currently, there is no published scientific evidence of an established strain of honey bees in the UK that can be maintained without treatment. We recommend that beekeepers continue to treat for *Varroa*.

Key strategies for effective *Varroa* control

1. Monitor the mite levels 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.

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 husbandry 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.

6. Always follow the manufacturer's instructions for varroacides and don't use two different varroacides at the same time.

7. Rotate the use of synthetic varroacides (such as Apistan or Apivar) with the other varroacides that use thymol or organic acids as the active ingredient. This is an effective strategy to prevent the development of resistance.

8. Remember that it is illegal to use unauthorised chemicals in your colonies or to misuse authorised varroacides as they may leave harmful and detectable residues in your bee products.

9. Be prepared to check for pesticide resistance in *Varroa*. When the mites become resistant to a product class, those medicines are no longer useful for control and alternative methods are needed.

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

11. Keep up to date with new developments in the control of *Varroa,* to make sure you have the latest information to help you respond appropriately.

Useful contacts

National Bee Unit (NBU)
NAFIC, Sand Hutton, York,
North Yorkshire, YO41 1LZ
Tel: 0300 303 0094
Email: nbu@apha.gov.uk
www.nationalbeeunit.com

Bee Disease Insurance Ltd (BDI)
National Beekeeping Centre, NAC
Stoneleigh Park
Warwickshire CV8 2LG
Tel: 08718 112337
www.beediseasesinsurance.co.uk

Bee Farmers' Association (BFA)
36 The Green
Long Whatton
Loughborough
Leicestershire LE12 5DB
www.beefarmers.co.uk

British Beekeepers' Association (BBKA)
National Agricultural Centre,
Stoneleigh Warwickshire,
CV8 2LG
Tel: 024 7669 6679
www.bbka.org.uk

Chemicals LAIF
Industria Bio-chimica
Via
dell'artigianato,
1335010
Vigonza (PD) Italy
https://chemicalslaif.it/

Department of Agriculture, Environment and Rural Affairs
Northern Ireland (DAERA)
Dundonald House,
Belfast BT4 3SB,
Northern Ireland
Tel: 02890 24488
www.daera-ni.gov.uk/

European Community and UK Legislation
The Stationery Office
51 Nine Elms Lane London
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Tel: +44 0870 600 5522
www.legislation.gov.uk/uksi

International Bee Research Association
1 Agincourt Street,
Monmouth, NP25 3DZ
Tel: 02920 372409
https://ibra.org.uk/

Office of the Chief Veterinary Officer
Welsh Government
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Email: info@sasa.gov.uk
www.sasa.gov.uk

Veterinary Medicines Directorate
Woodham Lane
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Addlestone Surrey
KT15 3LS
Tel: 01932 336911
www.gov.uk/government/organisations/veterinary-medicines-directorate

Vita (Europe) Ltd
Vita House, London St,
Basingstoke
RG21 7PG
Tel: 01256 473175
www.vita-europe.com

Useful websites

Andermatt Home and Garden
Tel: 01273 082195
https://andermattgarden.co.uk/

Bayer (UK and Ireland) Ltd
www.bayer.co.uk

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

Scottish Beekeepers' Association
www.scottishbeekeepers.org.uk

Ulster Beekeepers' Association
www.ubka.org

Welsh Beekeepers' Association
www.wbka.com/

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

References and further reading

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Further reading

To learn more about differentiating the signs of parasitic mite syndrome from foulbrood, please view our advisory leaflet entitled '*Foulbrood disease of honey bees'*:

www.nationalbeeunit.com/assets/PDFs/3_Resources_for_beekeepers/Advisory_leaflets/Foulbrood_2017_Web_version.pdf

To learn more about the invasive parasitic mite, *Tropilaelaps* spp., please view our advisory leaflet entitled '*Tropilaelaps*: *parasitic mites of honey bees'*:

www.nationalbeeunit.com/assets/PDFs/3_Resources_for_beekeepers/Advisory_leaflets/Tropilaelaps_2017_web_version_.pdf

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