A review of varroa mite biology and management

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Varroa destructor, the main pest of honey bees in Britain, has two life stages: a reproductive phase that occurs on developing pupae within a capped honey bee brood cell and a phase on the adult honey bees during which the mites can transfer between bees and spread to other colonies via robbing.

Varroa feed on both adult bees and developing pupae. It was previously thought that varroa fed on the haemolymph of bees. However, recent work on adult honey bees has demonstrated that varroa feed on the nutrient-rich fat body through the membrane between the bee's abdominal segments. Varroa prefer feeding on nurse bees rather than foragers or newly emerged bees as mites that feed on nurses go on to produce more reproductive daughter mites.

In addition to the direct removal of fat body tissue during feeding, varroa also acts as vector for deformed wing virus (DWV). DWV naturally infects honey bees at a low prevalence but the introduction of varroa has increased DWV levels in colonies and reduced the diversity of DWV to three master variants: DWV-A, DWV-B (previously *Varroa destructor* virus 1), and DWV-C. DWV is consequently a serious problem for honey bees and must now be controlled via varroa treatments.

DWV is named according to the symptoms of deformed wings visible on adult bees (Photo 1). However, DWV infections also kill developing pupae and can have invisible deleterious effects such as reduced learning ability, precocious foraging (workers foraging at a very young age) and reduced lifespans. DWV infections thereby reduce the populations of bees in colonies, leading to smaller colonies and dead colonies if left untreated.

All three variants of DWV occur in the UK, although the viral loads of DWV-C in colonies are reported to be low. Recent work has demonstrated an increase in the incidence of DWV-B compared with DWV-A in the UK. This increase may be due to evolutionary advantages of DWV-B, such as being less virulent to pupae and being able to replicate more than DWV-A, possibly in the varroa mite itself. However, more work is needed to ascertain whether DWV-B can outcompete DWV-A.

Reproductive cycle and feeding behaviour

Researchers have observed a sophisticated pattern of mite behaviour under the capped cell, presumably adapted to prevent the death of the developing bee and therefore the mites. Adult female mites enter brood cells just prior to capping. A single female usually enters an uncapped cell but, with heavy infestations, two or more female mites may enter the same cell to breed.

After entering the cell, the female mite will remain in the brood food at the bottom of the cell until the cell is capped. As the bee larva unfolds to eat the remaining brood food, the mite climbs on to the larva to feed and avoid being trapped as the larva spins a cocoon. The female mite initially deposits its faeces at a single spot on the cocoon and rests here, moving onto the immature bee for short feeding bouts before returning to the faecal spot.

As the bee pupa develops, the mite uses its legs to 'push' away the bee appendages from the faecal spot on which it rests to create space. Between 60 and 70 hours after the cell is capped, the female mite starts to lay eggs on the anterior wall of the cell. Developing eggs are therefore protected from the developing pupa's extending legs and antennae. The female mite sticks the eggs to the cell wall and checks the eggs are secure before moving away. Eggs are laid at intervals of 30 hours, with the first to hatch being a male, followed by female mites.

The male is sexually mature when the first female mite becomes an adult. Mating then occurs on the faecal spot between mite offspring (brother and sister) while the next female mite matures. After pupation of the honey bee larva, the parent female mite establishes a single feeding site on the pupa for the immature mites to feed. Once matured, female mites leave the cell when

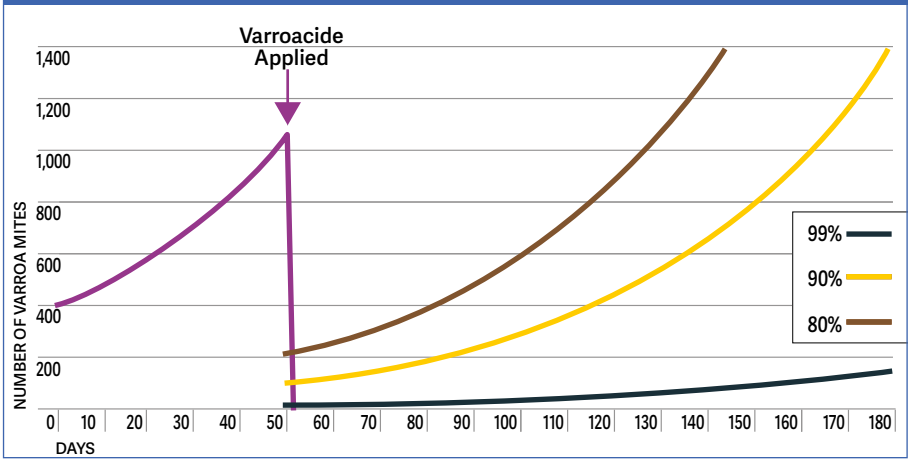
1 Deformed wing virus (DWV) symptoms

2 Varroa mites exposed on a honey bee pupa

Photos: Richard Rickitt

Table: Timings for monitoring and control options for varroa												
Monitoring	J	F	M	A	M	J	J	A	S	O	N	D
Open mesh floor	■	■	■	■	■	■	■	■	■	■	■	■
Drone brood uncapping					■	■						
Control												
Drone brood removal				■	■	■	■					
Formic-acid based MAQ strips					■	■	■	■				
Thymol-based varroacides (eg Apiguard, Apilife Var, Thymovar)								■	■			
Amitraz-based varroacides (eg Apivar, Apitraz)								■	■			
Oxalic-based varroacides (eg Api-Bioxal, Oxuvar)	■	■										■

Diagram: Illustration of exponential growth of the varroa population in a colony with the application of a varroacide at three different efficacies (80%, 90% and 99%). *Managing Varroa, The Animal and Plant Health Agency* © Crown copyright 2020



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Dr Ben Jones, senior scientist bee health at Fera, obtained his PhD at Exeter University and has worked in honey bee-related jobs in both the private and public sector.

the host bee emerges, and the cycle starts again. Males and any remaining immature female mites die as they are unable to survive outside the capped cell.

Exponential increase

Varroa populations increase exponentially during the beekeeping season (see diagram). Monitoring is therefore vital as damage can happen quickly, with mite numbers increasing well above the threshold that colonies can withstand. In the UK, it is recommended to keep varroa loads below a threshold of 1000 mites in colonies.

Monitoring and treatment

Monitoring the levels of varroa infestation in colonies is an extremely important part of modern beekeeping as the population of mites can be very high by the time symptoms are observed on the adult bees. Luckily, monitoring methods are effective and can be easily incorporated into routine colony assessments.

Using open mesh floors on colonies (or on a representative proportion of colonies in large operations) allows beekeepers to monitor the natural mortality of varroa over a known number of days in order calculate the remaining varroa population in the colony. The floor consists of a mesh that allows dead mites to fall through onto a collection tray that can be taken out without disturbing the colony.

Drone-brood uncapping involves piercing an area of capped drone brood with an uncapping fork to lift out the developing brood. The beekeeper can then see and count any varroa mites infesting the cells against the pale bodies of the drone pupae (Photo 2).

Varroa loads can be assessed quickly with drone-brood uncapping, as a single count of mites can be used to calculate the varroa population. However, the method may not pick up light infestations and drone brood may not be available in the colony. Using open-mesh floors can pick up light varroa infestations and can be used all year round but takes several days for mite loads to be assessed. In either case, beekeepers can input the number of observed mites into the varroa calculator on BeeBase to assess if treatment is needed: nationalbeeunit.com/public/BeeDiseases/varroaCalculator.cfm.

Varroa can be treated with biotechnical methods that involve removing sealed brood containing varroa mites (eg, drone-brood removal) or by using authorised varroacides. Varroacides are a valuable tool for beekeepers as they are readily available, easy to use and inexpensive when compared to the value of a colony. It is extremely important to use only authorised varroacides and to follow the label instructions, as these have proven high efficacy against varroa and are formulated to be safe for honey bees.

It is recommended that colonies are treated twice a year, once within the beekeeping season and once over winter when the colonies are broodless and all mites are on the adult winter bees. A regime of two treatment bouts limits the exponential increase of the mite population during the season (see Diagram) and protects the next year's first generation of bees from mites that would otherwise transfer from the winter bees. The table above demonstrates a typical year with timings for monitoring and some examples of control options. A full list of products authorised for use in the UK is available on the VMD website. Search for 'Bees': www.vmd.defra.gov.uk/productinformationdatabase/search.