

Foul brood disease of honey bees: recognition and control



AFB ropiness test

Honey bee colonies are subject to a number of diseases that affect their brood. This leaflet describes the recognition and control of the two most serious of these, American foul brood and European foul brood, along with other common but less serious brood disorders.

Honey bees and disease

Honey bees play a vital role in the environment by pollinating both wild flowers and many agricultural crops as they forage for nectar and pollen. The value of such crops grown in the UK is estimated at billions of pounds annually - and this is in addition to production of honey and beeswax worth millions of pounds. The essential and valuable activities of bees depend upon beekeepers maintaining a healthy population of honey bees.

Fig 1 Honey bee colonies pollinating Oil Seed Rape



As with other forms of livestock, honey bees are subject to a range of harmful diseases. Some of these affect adult bees, others affect immature stages of the bees' development (larvae and pupae) and these are referred to as brood diseases. There are several such brood diseases that affect honey bee colonies in the UK. These include the two extremely serious and infectious

foul brood diseases together with a range of common and less harmful disorders.

Foul brood

The term 'foul brood' covers two diseases of the honey bee larvae, one known as American foul brood (AFB), and the other European foul brood (EFB). The names bear no relation to the geographical distribution of the diseases: both occur in the British Isles and the damage done by them annually to our beekeeping industry is considerable. American foul brood is considered the most destructive brood disease in Great Britain. However, European foul brood is currently the most widespread, and where it occurs it often spreads rapidly and is difficult to eradicate unless prompt measures are taken.

Minor brood diseases

There are several other brood diseases and disorders that, although much less serious than foul brood, are extremely widespread. It is essential that beekeepers are able to recognise these and distinguish them from foul brood.

Varroosis

Infestation of honey bee colonies by the parasitic mite *Varroa destructor* is the subject of a separate CSL/MAFF leaflet, *Managing Varroa*.

Beekeeper responsibility

All colonies in the UK are at risk of contracting foul brood. If disease occurs but is not detected and controlled, the infection will normally spread quickly through the apiary and into adjacent apiaries belonging to other beekeepers. However if the infection is spotted at an early stage, no further spread is likely to occur.

Beekeepers have a responsibility to ensure that their bees are healthy and that they are not unwittingly spreading any infection through their beekeeping practices.

You should be familiar with the signs and causes of the diseases that may affect your bees, the action to take if foul brood is suspected, and the measures you should take to help keep your colonies healthy and productive.

The Bee Inspectors from the CSL National Bee Unit (NBU) cannot examine all colonies of bees each year, and it is therefore essential in the control of foul brood for you to regularly inspect your own colonies for signs of brood disease. If you suspect foul brood, you must contact the NBU for assistance. It is also very good practice to inform other local beekeepers of the problem so that they can check for signs in their own bees.

10 RULES FOR FOUL BROOD CONTROL

1. **Make sure you are familiar with the signs and causes of foul brood and other brood disorders.**
2. **Inspect your colonies every spring and autumn, specifically to check for brood disease. If you are unsure, seek expert advice.**
3. **Never transfer combs between colonies, or divide colonies, without first checking for signs of brood disease.**
4. **Never bring colonies, combs or beekeeping equipment into the apiary unless you are sure that they come from a disease-free source.**
5. **Never buy old combs. Always sterilise second-hand hives by thoroughly scorching with a blow lamp before use.**
6. **Control robbing in the apiary. Never leave combs or honey exposed to robbing bees. Never feed honey from another source to your bees.**
7. **If a colony of bees dies out at any time, seal the hive to prevent the remaining stores being robbed out, pending examination of the brood combs for signs of disease.**
8. **If any colony appears not to be thriving, and the reason is not already known, examine the brood for signs of disease.**
9. **Be suspicious of stray swarms. Hive them on foundation rather than drawn comb, and inspect them for disease once they have become established.**
10. **Regularly and systematically replace old brood combs in the apiary by melting them down and replacing them with frames fitted with foundation.**

UK BEE DISEASE LEGISLATION

Both AFB and EFB are subject to statutory controls in the UK. The Bee Diseases Control Order 1982 empowers the appropriate agriculture departments of Great Britain to take measures to control both diseases. Beekeepers should be familiar with the provisions of the Order (SI 1982 No 107), copies of which are available from HMSO. Website <http://www.hmso.gov.uk/>

Any beekeeper in England or Wales who suspects the presence of either AFB or EFB in a colony for which they are responsible is legally required either to contact the Central Science Laboratory National Bee Unit (NBU) to have the colony officially examined, or to submit a suspect disease sample for analysis. Beekeepers elsewhere in the UK should contact the local office of the relevant government agriculture department.

The National Bee Unit operates an apiary inspection programme in England and Wales. CSL Bee Inspectors inspect bee colonies for foul brood, free of charge. When disease is suspected, a sample is taken for laboratory analysis and a Standstill Notice is issued, prohibiting the removal of bees and equipment from the apiary. If foul brood is confirmed an inspector returns to carry out the necessary disease control measures. For further information, see the CSL/MAFF/NAW leaflet *Statutory procedures for controlling foul brood* (PB3054).

Further details about the National Bee Unit and its advisory and training services are given at the end of this leaflet.

Fig 2 Bee disease recognition training



How to examine a honey bee colony for brood disease

- Wear full protective clothing and have a smoker well lit.
- Keep the colony subdued with smoke.
- Remove the hive roof and place it on the ground by the hive.
- If there are supers on the hive, remove them and place them on the upturned roof, keeping them covered to prevent robbing.
- Remove any queen excluder and examine the underside for the queen. If she is present return her to the colony.

- Where two boxes are used for the brood nest examine the bottom one first.
- Remove the outside comb, which is unlikely to contain brood, and lean it against a front corner of the hive - you will then have room to work.
- Take each comb in turn, and holding it by the lugs within the brood chamber, give it a sharp shake. This will deposit the bees on the bottom of the hive without harming them, the queen or brood.

- Any bees on a comb may be concealing infected brood from the beekeepers' view. On combs free from bees, any abnormality is easily spotted
- Examine the brood, both sealed and unsealed, quickly but carefully, for any signs of abnormality - such as discoloured larvae or perforated cappings.
- Look for AFB scales (see page x) by holding the combs towards the light and scanning the bottom walls of any open cells

- Look inside any sealed cells with abnormal looking cappings after opening the cell with a corner of the hive tool.
- To establish the consistency of any dead remains present, probe these with a matchstick. Dispose of the used matchstick in the smoker.
- Continue until you have examined all the brood combs; then reassemble the hive.
- **If you suspect EFB or AFB may be present, contact the NBU immediately for assistance** (see contacts information for details).

Fig 3 Opening the hive for disease inspection



Fig 4 Shaking adult bees from the comb into the hive



Fig 5 With bees removed the brood is clearly visible



Fig 6 Examining comb for scales



HEALTHY BROOD

All beekeepers should be familiar with the appearance of healthy worker brood, so that they can recognise abnormalities, which may indicate the presence of foul brood or other brood diseases.

- The queen lays eggs at the base of cells in the brood nest. These hatch after three days and develop into tiny translucent larvae lying at the base of the cell in a bed of milky brood food.
- After six further days of development, the larvae have increased in size to almost fill the base of the cell.
- Healthy larvae are **pearly-white** in colour. They lie in a distinct '**C**' shape, with the head and tail curled towards one another.
- The body of the larva can be seen to be divided along its length into a series of segments.
- When larvae are nine days old, the cell opening is sealed by adult bees with a cap of wax, and development into an adult bee occurs inside the sealed cell.
- The wax cappings on healthy worker brood vary in colour from very light to dark brown, and they are dry looking and slightly convex.
- Drone brood can be distinguished from worker brood by its larger cells and domed cappings.
- A good brood pattern, with very few empty cells within patches of brood suggests that the queen is laying well and nearly all the larvae are developing normally.
- Even where the brood pattern is more haphazard, as results from an old or failing queen for instance, the individual larvae and cell cappings should still have a normal appearance.

Fig 7 Eggs and young larvae

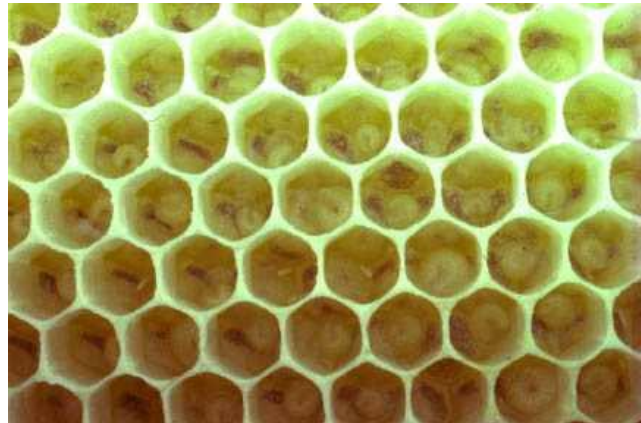


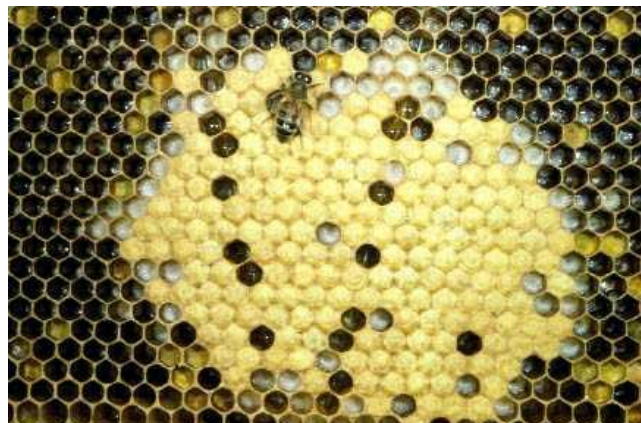
Fig 8 Healthy larvae shortly before sealing



Fig 9 Sealed healthy brood



Fig 10 Healthy brood in all stages



AMERICAN FOUL BROOD

Cause

American foul brood is caused by a spore-forming bacterium called *Paenibacillus larvae* subspecies. *larvae*. Young honey bee larvae become infected when they consume *P. larvae* spores in their food. The spores germinate in the gut; bacteria then move into the tissues, where they multiply enormously in number. Infected larvae die after their cell is sealed, and millions of infective spores are formed in their remains. These remains dry to form 'scales' which adhere closely to the cell wall and cannot easily be removed by bees. Consequently brood combs from infected colonies are inevitably severely contaminated with bacterial spores.

The spores are very resistant to extremes of heat and cold, and to disinfectants. They retain their powers of germination for many years in honey, in old combs kept in store, or in derelict hives, skeps or boxes.

Once a colony is infected the disease will progress until most of the brood is affected. The colony then becomes unable to replace the ageing adult bee population, causing it to become weakened, and finally to die out. The disease may develop for months before the colony succumbs, and death may occur at any time of the year.

Spread

The beekeeper is the chief spreading agent of the disease. If combs, honey or hive equipment are transferred from an AFB-infected colony to a healthy colony, it becomes infected. Bees robbing honey from infected colonies also transmit the disease. Swarms from infected colonies may also carry infection with them and become diseased after they are hived.

Control

AFB is a notifiable disease under the Bee Diseases Control Order 1982 and is subject to official control by a programme of apiary inspections and compulsory destruction of infected colonies. For confirmation of AFB a sample (eg brood comb, suspect larvae in plastic

tube) is sent to the NBU laboratory where larval remains are examined microscopically for the presence of the causative bacteria.

Infected colonies are destroyed by burning under the supervision of a bee inspector. The bees are killed, and together with the combs are burned in a deep pit (Fig 11).

Hives and appliances can be sterilised by thoroughly scorching them with a blow lamp. Gloves, overalls, footwear and the smoker are washed in hot soapy water.(Fig 12).

Methods of control of AFB using antibiotics that are used in some overseas countries are not effective, as they suppress signs of the disease without eradicating it, and they are not permitted in the UK.

Fig 11 Destruction of AFB infected colony



Fig 12 Sterilisation of hive boxes



Signs of American foul brood

- AFB affects only sealed brood. When infected larvae die within the sealed cell, the appearance of the cell cappings changes.
- Cappings become sunken and perforated when adult bees nibble holes in them. These perforations tend to be jagged and irregular in shape.
- Some cappings may become moist or greasy looking and slightly darker in colour than other cells.
- At first only very few cells may show signs of disease, and the colony will appear normal in other respects.
- Eventually much of the sealed brood will become affected by the disease, causing a patchy or 'pepper pot' brood pattern. There may then be an unpleasant smell.
- At the sunken capping stage the dead larval remains are light to dark brown in colour, and have a slimy consistency.
- If a matchstick is inserted and slowly withdrawn, the remains can be drawn out in a brown, mucus-like thread or 'rope' 10-30mm long. This is called the 'ropiness' test and is a reliable test for AFB.
- The ropy condition is followed by a tacky stage as the larval remains in the cell gradually dry up and the colour changes to dark brown.
- The proboscis of dead pupae may sometimes remain intact, protruding upwards from the bottom edge of the cell.
- Further drying leads to the final stage, which is a very dark brown, rather rough scale lying on the lower side of the cell and extending from just behind the mouth of the cell right back to the base.
- The scales can be detected if the comb is held facing the light: they reflect the light from their rough surfaces and can easily be seen, even when their colour is almost the same as the comb itself.

Fig 13 AFB – perforated cappings

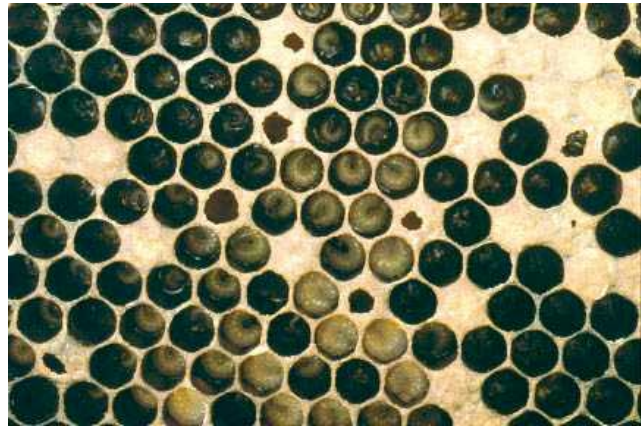


Fig 14 AFB – “pepper pot” brood

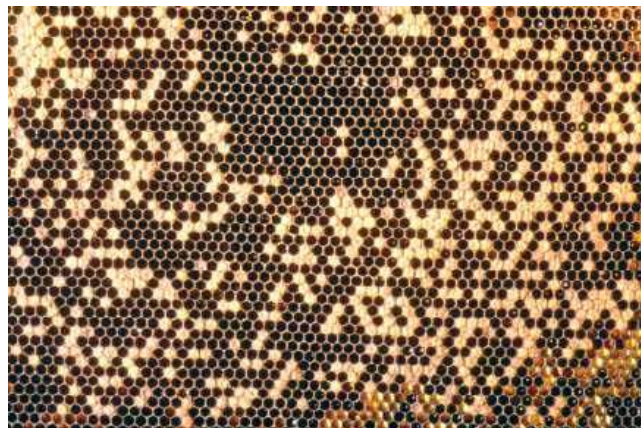


Fig 15 AFB ropiness test



Fig 16 AFB scales in comb



EUROPEAN FOUL BROOD

Cause

European foul brood is caused by the bacterium called *Melissococcus plutonius*. The bacteria multiply in the mid-gut of an infected larva, competing with the larva for its food. They remain in the gut and do not invade the larval tissue; larvae that die from the disease do so because they have been starved of food. This normally occurs shortly before their cells are due to be sealed. Subsequently other species of bacteria may multiply in the remains of dead larvae as 'secondary invaders'.

Progression of the disease

The development of the disease within a colony is complex, and still not fully understood. It appears that infection can develop over a period of months or years, debilitating but not killing the colony. During this time, signs of the disease may become more or less severe, or disappear altogether. Frequently there is a seasonal pattern, with signs becoming most obvious in late spring.

This is thought to be because when there are many larvae relative to the number of nurse bees, larvae tend to receive less brood food overall, and those infected with EFB are more likely to suffer from starvation. At other times, larvae that are infected but receive an abundance of brood food may survive the infection, and develop into healthy adult bees. However, when such larvae pupate, they void their gut contents into the cell, contaminating the comb with millions of infective bacteria. Eventually the disease is likely to reach the stage where a high proportion of the brood is affected and the colony will be weakened and ultimately killed.

Spread

The beekeeper is the chief spreading agent of the disease. If combs, honey or hive equipment are transferred from an EFB infected colony to a healthy colony, it is likely to become infected. Bees robbing honey from infected colonies also transmit the disease. Swarms from infected colonies may also carry infection with them and become diseased after they are hived.

Diagnosis

European foul brood cannot be reliably identified visually, as the disease signs can easily be confused with various other brood abnormalities. A sample brood comb is sent to the NBU laboratory where larval gut contents are examined microscopically for the presence of the causative bacteria (Figures 17 & 18.)

Control

EFB is a notifiable disease under the Bee Diseases Control Order 1982 and is subject to official control by the examination of colonies for signs of disease and compulsory treatment or destruction of diseased colonies. Weak colonies and colonies with a high proportion of diseased brood are destroyed, as with American foul brood, but lightly diseased colonies may be treated with an antibiotic. Treatment must be carried out only by an Appointed Officer under the Order, using drugs officially dispensed following confirmation of European foul brood in a disease sample submitted for diagnosis at an approved laboratory.

Fig 17 & 18 Laboratory diagnosis



Signs of European foul brood

- EFB affects mainly unsealed brood, killing larvae before they are sealed in their cells.
- The EFB infected larva moves inside its cell instead of remaining in the normal coiled position characteristic of a healthy larva of the same age.
- When it dies it lies in an unnatural attitude - twisted spirally around the walls, across the mouth of the cell or stretched out lengthways from the mouth to the base.

- The dead larva often collapses as though it had been melted, turning yellowish-brown and eventually drying up to form a loosely attached brown scale.
- The gut of infected larvae may be visible through the translucent body wall of the larvae. It has a creamy white colour caused by the mass of bacteria living within it.

- When a high proportion of the larvae are being killed by EFB, the brood pattern will often appear patchy and erratic as dead brood is removed by the bees and the queen lays in the vacant cells.
- A very unpleasant odour may sometimes accompany severe EFB infection, depending on the presence of certain other species of bacteria in the remains of dead larvae.

- A minority of infected larvae may die after the cell is sealed. In such cases, there may be sunken perforated cappings resembling AFB infection. However, the cell contents although brown and sticky can not be drawn into a 'rope' as with AFB.
- Where larval remains dry to form scales, these are variable in colour, loose within the cell and somewhat rubbery, unlike the hard black firmly attached scales of AFB.

Fig 19 EFB affected unsealed brood



Fig 20 EFB - twisted and discoloured larvae



Fig 21 EFB – severe infection and patchy brood pattern



Fig 22 EFB – dead brood with scales



Controlling an outbreak of foul brood in your colonies

If you keep bees for long enough, it is very likely that you will someday have to deal with an outbreak of EFB or AFB in your colonies. When this happens, your Bee Inspector will visit you several times to help bring the infection under control - first inspecting your colonies for signs of disease, then treating or destroying infected colonies, and later returning to make sure that signs of disease have not reoccurred in the apiary. Please see leaflet *Statutory procedures for controlling foul brood*.

However, you have an equally important role in bringing the disease under control. This entails using some common-sense methods to avoid spreading the infection between colonies, and making sure that any new cases of disease are recognised before they can spread to other colonies.

Both EFB and AFB are infectious diseases, and can spread without the intervention of the beekeeper by the natural processes of robbing, drifting etc. Despite this, unfortunately in practice the main agent of spread is the beekeeper, as he moves combs, brood, bees and other disease carrying materials between colonies.

If careless, an infection that may only affect one colony in the apiary at the start of the beekeeping season, may easily affect all the colonies by the end. Conversely, however, experience has shown that even very severe outbreaks of foul brood affecting many colonies in large beekeeping outfits can be successfully brought under control so long as cases of foul brood are found and dealt-with faster than new cases are allowed to develop.

Key strategies for controlling an outbreak of foul brood in your bees

1. **Learn to recognise the signs of foul brood.**

This is a skill that takes a little time and practice to acquire. Start by working with your bee inspector, as he inspects your bees. He will be glad to point out the signs that distinguish diseased and healthy brood. Then

every time you inspect your bees, make a point of always checking the brood for signs of disease. Your aim should be to spot one diseased larva in a comb of several thousand. You can send individual suspect larvae to the NBU for diagnosis using larval tube sampling kits (available from your bee inspector).

2. **Use quarantine systems to avoid spreading disease**

When colonies with signs of foul brood have been found and dealt with, there is still a significant risk that other colonies may be infected but not yet showing signs of disease. Many beekeepers have found 'quarantine systems' to be very effective in minimising the spread of infection between colonies while a foul brood outbreak is brought after control. These will also help minimise the scale of any new outbreaks that may subsequently occur.

For instance:

- **Colony quarantine** - avoid moving any combs, bees or equipment from one colony to another. It will be necessary to mark super frames and boxes so that they can be individually identified and returned to the same colonies after extraction. This is the most effective quarantine system, and the most appropriate for colonies that are at particular risk - such as those that have been previously treated, and those that have had close contact with infected colonies - but involves significant effort to carry out on a large scale.
- **Apiary quarantine** - avoid moving any bees, combs or equipment between apiaries, but allow some movement (e.g. super combs) within the apiary. This will not prevent spread within the apiary but involves less work than colony quarantine to implement on a large scale and helps prevent moving disease between apiaries.
- **'Isolation apiaries'** - where an EFB outbreak extends between several apiaries managed by a single beekeeper, it can often be advantageous to move all known infected colonies, and other

colonies believed to be at particular risk to a single apiary (under licence from the NBU). This keeps to a minimum any contact between diseased and healthy colonies, and makes it easier to operate quarantine systems appropriate to the level of risk in each apiary.

- **Disinfecting equipment** - where it is necessary to move items between colonies, treat them to reduce the risk of spreading disease. Wooden hive parts can be made safe by scorching with a blowlamp. Hive tools, gloves, the smoker etc. can be soaked in or scrubbed with a strong solution of washing soda.

3. Transfer colonies to new comb

The pathogens responsible for both AFB and EFB can exist in a colony's combs for long periods and remain capable of causing disease to develop. This is particularly true of colonies which have been treated against EFB with antibiotic. A significant proportion of such colonies can suffer a reoccurrence of disease within a year or so as a result of live bacteria remaining in the colony after treatment.

Any method that removes such contaminated

comb from colonies and replaces it with new comb will be helpful in reducing the risks of disease. However, the more rapid and complete the transfer, the more effective it will be.

The 'Shook Swarm' method aims to completely remove by transferring the colony to entirely new combs in one operation. This is done by shaking the adult bees into a clean hive fitted with frames of foundation before the end of the season. The removed combs are then destroyed by burning. Although this method involves significant labour and expense, recent research at the NBU suggests that it is extremely effective at combating EFB.

Many beekeepers have found that colonies when treated as shook swarms are capable of quickly building up to gather a good crop of honey, and that the reduced risk of reoccurrence of EFB makes it a sensible strategy for dealing with colonies that have been treated for EFB, and other colonies thought to be at particular risk.

For further details of methods that can be used to help control foul brood contact the National Bee Unit or your local bee inspector.

COMMON BROOD DISORDERS

In addition to the foul brood diseases, there are also less serious honey bee brood disorders such as sacbrood, chalkbrood, bald-brood, laying workers and drone-laying queens. It is important that beekeepers are able to distinguish between these and foul brood.

SACBROOD

Sacbrood is a very common virus disease affecting brood. In most diseased colonies relatively few larvae are visibly affected, and it rarely causes measurable harm to colonies. However, its signs can sometimes be mistaken for those of AFB.

Disease signs

Larvae that have died from sacbrood become like fluid-filled sacs, stretched on their backs with their heads towards the top of their cells. Adult worker bees eventually uncap them.

Diseased larvae turn from the normal pearly-white colour to pale yellow and the head curls up as the body dries to a thin, dark brown scale lying along the bottom wall of the cell. These are referred to as 'Chinese Slippers'

Fig 23 Sacbrood infected larva (cell mouth enlarged for photograph)



The scale of a sacbrood infected larva has a distinctive gondola shape and is easily removed in one piece from its cell using a matchstick

Treatment and control

There is no specific treatment for sacbrood. When much of the brood is obviously affected, the queen should be replaced by one from a colony showing no signs of the disease. Combs can be re-used; any

sacbrood virus present on them becomes non-infectious within a few weeks.

Fig 24 Sacbrood "Chinese slipper" (removed from cell for photograph)



VARROOSIS

Colonies that are severely infested with varroa mites (*Varroa destructor*) frequently suffer from death of brood. This is normally most apparent in colonies that are very severely infested, especially those that are collapsing from the infestation in poorly treated or unmanaged colonies. The damage results not from the mites themselves, but from viruses that are triggered by the infestation or, in the case of collapsing colonies, from the bees failing to care adequately for their brood.

Disease signs

Signs of damage to brood in varroa infested colonies can be very variable. Most commonly sealed brood appears affected, with dead and discoloured brood in various stages below perforated cappings. The larval remains may be firm or watery, but **never** ropy (as with AFB). Close examination will reveal numerous varroa mites in floor debris, brood cells and on adult bees.

Fig 25 Varroa – comb from collapsing colony



CHALKBROOD

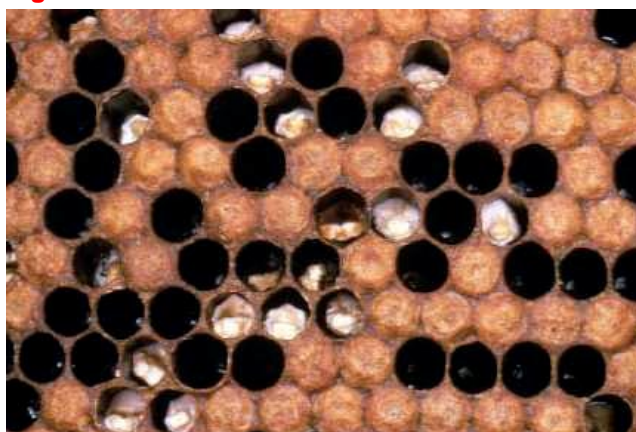
Chalkbrood is an extremely common brood disease caused by the fungus *Ascosphaera apis*. The thread-like, vegetative growths ('hyphae') of the fungus invade the body tissues of infected larvae, killing them after they have been capped over in their cells.

Disease signs

Adult bees usually tear down the brood cell cappings to remove the dead larvae. These appear as hard, chalky-white or mottled grey remains ('mummies') lying along the length of the cell.

Infected larvae often take on the hexagonal shape of the cell itself before shrinking in size, at which point the bees are able to remove them from the comb. They are often noticeable on the hive floor or at the hive entrance.

Fig 26 Chalkbrood infected brood



The spread of chalkbrood

Larvae affected by chalkbrood may release millions of spores that all have a sticky coating, enabling them to adhere to combs and to adult bees. These are the dormant phase of the fungus and can remain infectious for three years or more.

Fig 27 Chalkbrood "mummies" on a hive floor



Both the transfer of combs by the beekeeper and the drifting of bees transmit chalkbrood spores between colonies.

Signs of chalkbrood are probably present in the majority of colonies at some time, and spores of *A. apis* can be detected even in apparently unaffected colonies. However, it is rarely a serious disease, and the effect on most colonies is slight. Chalkbrood is most likely to be serious in colonies that are finding it difficult to care adequately for their brood, and is therefore most prevalent in weak colonies and during early spring.

Treatment and control

There are no specific treatments for chalkbrood. The most effective control results from avoiding the conditions favourable to its increase by maintaining strong and vigorous colonies, and bees that show marked hygienic behaviour. In severe cases, re-queening with a queen from a chalkbrood-free colony is recommended.

BALD BROOD

Normally pupae are sealed in their cells under wax cappings until they are ready to emerge as adults. Colonies with bald brood may have small patches of live and normal looking pupae in cells that are incompletely capped. The partial capping frequently has a raised lip that protrudes from the comb.

Fig 28 Bald brood



The cause of bald brood is not always clear; however the most common reason is infestation of brood combs by wax moth larvae. These can often be found tunnelling below the surface of the comb close to patches of bald brood.

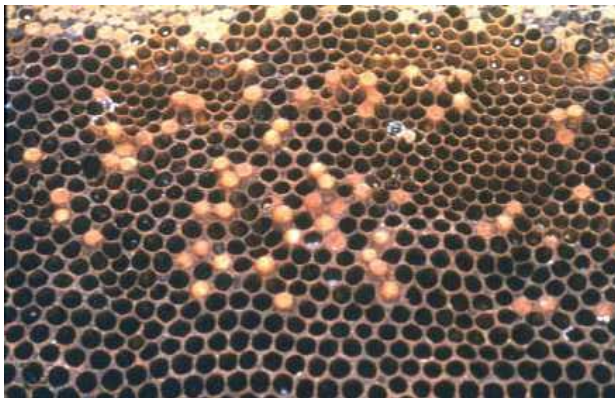
DRONE BROOD IN WORKER CELLS

The characteristic domed cappings of sealed drone brood are present in virtually all colonies during the summer months on areas of drone comb, usually situated at the edge of the brood nest. However, there are common abnormalities that can cause drone brood to be reared in worker cells along with, or in place of, worker brood. Such drone brood is usually very irregular; capped pupae are interspersed with either vacant cells or cells containing larvae at every stage of development. There are two possible causes - a drone-laying queen or laying workers. Beekeepers often confuse these conditions with serious brood diseases.

Drone-laying queen

Worker bees develop from eggs that have been fertilised, before they are laid, by sperms stored in the queen's sperm sac (spermatheca). If the supply of sperm becomes exhausted, only unfertilised eggs are laid, which develop into drone brood. Hence, queens may become drone-layers in later life or earlier if they have not properly mated. Such queens should be replaced with one of proven fertility.

Fig 29 Domed cappings of drone brood in worker cells



Laying workers

When colonies lose their queen and have no young worker brood from which to rear a replacement, the workers may develop functional ovaries and begin to lay eggs. These eggs, being unfertilised, develop into drones; the signs are similar to those of the drone-laying queen, except that the brood pattern is often less compact. Also, there may be several eggs present in some cells,

often on the walls as well as at the bottom of the cell. Colonies with laying workers are very difficult to requeen, and are usually in poor condition. It is generally advisable to unite them with a strong colony, or to destroy them.

Chilled brood

Sometimes relatively large areas of brood in all stages die at the same time and turn very dark in colour. This is usually diagnosed visually as 'chilled brood'. However, even young larvae can survive for several hours at temperatures well below the brood nest heat of 35° C. It is probable, therefore, that 'chilling' of brood is the result of brood becoming isolated from the adult bees and being neglected by them. As a result the brood dies from a combination of starvation and prolonged low temperatures. No pathogenic organism is responsible.

Examining colonies in cold weather should not cause chilled brood. Keeping colonies in thriving condition with ample bees to cover and nurture the brood can prevent chilled brood.

Diseases of uncertain origin

Eggs, larvae and pupae sometimes die for reasons unconnected with infectious disease, and the cause of the death is often difficult to establish. A patchy brood pattern might be the result of poor egg-laying by the queen, or caused by a genetic defect in some of her eggs, preventing them from hatching or developing from larvae into adults. Usually the workers quickly remove the dead brood. Brood death of this kind may happen in many colonies, however, the numbers of abnormal eggs or larvae are probably so low that they are removed by the bees before the beekeeper even notices.

If a genetic defect or a faulty queen appears to be the cause of a brood disorder then replacing the queen with another is the most effective course of action.

SUMMARY OF BROOD DISEASE SIGNS, CAUSES AND CONTROL

	SIGNS OF DISEASE	CONTROL
Normal brood	Uncapped: Pearly white, 'C' shaped larvae. Capped: Uniform brown colour, domed cappings.	None required.
American foul brood <i>(Paenibacillus larvae larvae)</i>	Affects only sealed brood sunken concave cappings, uneven brood pattern, 'pepper pot' or mosaic pattern, scales on bottom walls of open cells, brown decomposing larvae that 'rope' using matchstick test, moist dark perforated cappings.	Notifiable disease A CSL Bee Inspector burns infected colonies and the hives are sterilised by scorching.
European foul brood, <i>(Melissococcus plutonius)</i>	Affects mainly unsealed brood. Infected larvae discoloured yellow-brown lying in abnormal positions in cell with 'melted' appearance. Some dark sunken cappings may be present, but cell contents will not form a 'rope'.	Notifiable disease Lightly infected colonies are treated by a CSL Bee Inspector with antibiotic. Severe cases of EFB are destroyed as with AFB.
Chalkbrood <i>(Ascosphaera apis)</i>	Affects only sealed brood. Perforated cappings over cells containing hard white or mottled grey chalk like remains ('mummies').	No specific treatment. Keep strong colonies. Requeen severely affected colonies.
Sacbrood <i>(sacbrood virus)</i>	Affects only sealed brood. Perforated cappings. Larvae become yellow-brown fluid filled sacs ('Chinese slipper'). Watery contents will not form 'rope'.	No specific treatment. Requeen severely affected colonies.
Bald brood	Abnormal cell cappings over sealed brood. Affected cells have round hole in capping sometimes with a slight protrusion. Pupae have normal appearance. Signs of wax moth larvae may be visible in comb.	No specific treatment. Control wax moth infestation.
Drone laying queen or laying workers	Domed drone cappings over worker cells. Abnormally small drone pupae within cells. May be multiple eggs per cell. Unsealed brood may be neglected and dying.	Replace drone laying queen. Unite colony with laying workers to another colony.
Chilled brood	Dead brood usually present in all stages. Unsealed brood turns very dark brown or black in colour.	Avoid conditions that prevent bees being able to care for brood.
Varroa infestation	Signs vary. Sealed brood may be partially uncapped, dead pupae discoloured brown or black, watery or firm, but never ropy.	Control varroa infestation to low levels using appropriate treatment.

FURTHER INFORMATION

What to do if you suspect foul brood

1. Close the hive
2. Reduce the size of the entrance and take any other steps necessary to prevent the hive being robbed by other colonies
3. Disinfect gloves and beekeeping equipment before examining other colonies

Either:

- a) Contact the NBU to arrange a visit by your local bee inspector
 - b) Send a whole comb containing diseased brood wrapped in several layers of paper and sealed in a cardboard box **so that it can not leak honey** in transit to the NBU, with a note stating your name and address, the location of the apiary and the identity of the affected hive.
4. You must not remove any hives, bees, or equipment from the apiary until the disease, if present, has been controlled.

Sterilising hives and equipment

It is very good practice to sterilise spare and empty hives routinely before re-use. This applies particularly to second-hand equipment and that which might have been associated with foul brood infection, but also will help to reduce the likelihood of transmitting foul brood or other diseases between colonies, if applied as part of normal apiary management.

Heat

Wooden hive parts can be sterilised by first scraping off brace comb and propolis, and then scorching with a blowlamp until the wood reaches a uniform coffee-brown colour. Particular attention needs to be paid to the corners and any cracks or crevices. Such treatment will destroy the infective stages of all the bee diseases. Alternatively, empty hive boxes and frames can be sterilised by immersion in molten paraffin wax heated to 150°C for 10 minutes.

Chemical sterilisation

There are no chemicals that have been shown to be suitable for the sterilisation of stored combs against foul brood. The spores of AFB in particular are strongly resistant to virtually all sterilising agents. Combs can, however, be sterilised to

destroy the spores of chalkbrood (and Nosema disease of adult bees), using acetic acid vapour. In general it is better practice to melt down or burn old combs and replace them with new frames fitted with foundation.

Irradiation of equipment

Equipment such as stored supers and empty combs which may have been associated with colonies infected with foul brood, but do not show any disease signs, can be sterilised by gamma rays from a radioisotope of cobalt. This will kill the spores of the bacteria that cause disease without damage to equipment. Infected combs must not be irradiated if scales or other disease signs are present as these would remain indistinguishable visually from infectious untreated disease signs.

Firms specialising in irradiation use 25 kiloGrays (kGy) to kill *Paenibacillus larvae* (AFB) and its spores on combs and hive equipment. Currently there is no recommendation for the treatment with irradiation for *Melissococcus plutonius* (EFB), but it is likely that 25 kGy is sufficient to kill *M. plutonius*.

The National Bee Unit

The Central Science Laboratory National Bee Unit provides a statutory and advisory service to beekeepers in England and Wales. It provides diagnostic, constancy and research services to MAFF, NAW, commerce and beekeepers. The Unit laboratories are fully compliant with the international Good Laboratory Practice (GLP) quality scheme to ensure a high professional standard. All staff are trained practical beekeepers as well as scientists, and are supported by teams of analytical chemists and agricultural specialists in the rest of CSL. (website address <http://www.csl.gov.uk>)

Fig 30 Central Science Laboratory, Sand Hutton, York



Fig 31 Disease control co-ordination from the NBU



Further help and advice

The NBU has a bee health support service, operating in England and Wales, comprising a regional network of Regional Bee Inspectors (RBIs) managing teams of Seasonal Bee Inspectors (SBIs). As well as the control of foul brood through a programme of apiary inspections, the bee inspectors provide advice and assistance to beekeepers on a range of bee health issues and run training courses for beekeepers on disease recognition and control, usually in conjunction with local beekeeping associations. For further information see contacts information on this website.

In many areas, beekeeping associations operate local disease control schemes, and provide practical help and advice to members on bee disease recognition and control. Contact your local beekeeping association for details.

Bee Diseases Insurance Ltd

An insurance scheme to compensate against losses incurred through destruction of foul brood infected colonies is organised by Bee Diseases Insurance Ltd, a specialist insurance company operating with the aim of reducing the incidence of the foul brood diseases. Beekeepers can take out insurance either individually or through their local beekeeping association.

Acknowledgements

Leaflet written by James Morton and Michael Brown, Central Science Laboratory National Bee Unit on behalf of MAFF Horticulture and Potatoes Division.