Animal & Plant Health Agency

The National Bee Unit

Foulbrood Disease of Honey Bees

and other common brood disorders

Pollination

Pollinating insects 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 directly on pollinators. 70% of the 124 main crops used directly for human consumption in the world are dependent on pollinators.

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

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About this leaflet

Foulbrood disease of honey bees and other common brood disorders

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 foulbrood and European foulbrood (which are subject to statutory control) along with other common but less serious brood disorders.

Acronyms

AFB	American Foulbrood
APHA	Animal and Plant Health Agency
BBKA	British Beekeepers' Association
BBSRC	Biotechnology and Biological Sciences Research Council
BDI	Bee Diseases Insurance Ltd
Defra	Department for Environment Food and Rural Affairs
DWV	Deformed Wing Virus
€	Euros
EFB	European Foulbrood
EU	European Union
IBRA	International Bee Research Association
IPI	Insect Pollinators Initiative
IPM	Integrated Pest Management
ISO	International Organisation for Standardisation
kGy	kiloGrays
LFD	Lateral Flow Device
NBU	National Bee Unit
OIE	World Organisation for Animal Health
PCR	Polymerase Chain Reaction
SASA	Science and Advice for Scottish Agriculture
SS	Shook Swarm
UK	United Kingdom
VMD	Veterinary Medicines Directorate
WBKA	Welsh Beekeepers' Association
WG	Welsh Government

Contents

Help and advice

The National Bee Unit

The National Bee Unit (NBU) provides an integrated statutory and advisory service to beekeepers in England and Wales. It provides diagnostic, consultancy and research services to Defra, Welsh Government, Scottish Government, to commerce and to beekeepers. The NBU is a recognised centre of excellence in the provision of advice and research in bee health. The Unit's laboratories are fully compliant with ISO 9001 quality schemes to ensure a high professional standard and use as a base the Office International des Epizooties (OIE) Manuals of Standard Diagnostic tests for laboratory diagnosis. Many NBU staff are trained practical beekeepers and are supported by teams of specialists across The Animal and Plant Health Agency (APHA) and the rest of Fera Science Limited.

The Unit has modern facilities, including laboratories with computer support through BeeBase, as well as 150 honey bee colonies and the apiary buildings to support them.

The NBU has a bee health inspection and advisory service, operating in England and Wales, comprising a regional network of inspectors. The head of the field inspection services is the National Bee Inspector (NBI). Regional Bee Inspectors (RBIs) reporting to the NBI manage teams of Seasonal Bee Inspectors (SBIs) throughout England and Wales. As well as the statutory inspection and apiary surveillance programme which includes the control of foulbrood, Bee Inspectors provide free advice and assistance to beekeepers on a range of bee health issues. Inspectors run training courses for beekeepers on disease recognition and control, and good husbandry, often in conjunction with local beekeeping associations. NBU staff deliver 500-800 training events per year. Bee Inspectors also assist with field trials within the NBU's experimental programmes.

For further information contact the NBU, who will put you in touch with the appropriate Bee Inspector for your area, or visit the NBU website key contacts pages (www.nationalbeeunit.com)

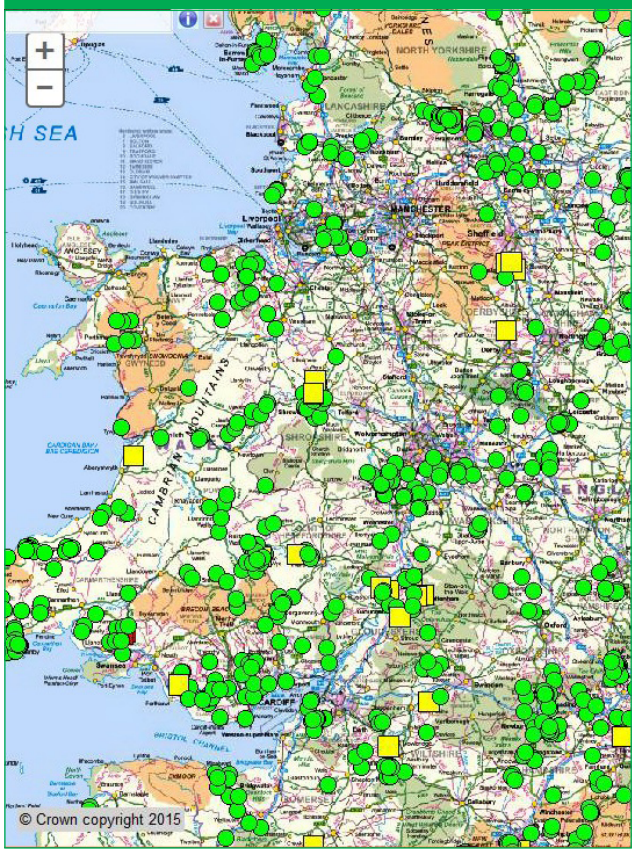
The NBU has broad research and development interests (current list outlined on BeeBase (www.nationalbeeunit.com)). Our portfolio covers Varroacide development, EU-wide colony loss surveillance, risk assessment and novel control methods for exotic pest threats, the economics and biology of pollination, as well as several foulbrood- centred projects: The NBU is a contributor within the Insect Pollinators Initiative (IPI) (www.bbsrc.ac.uk/pollinators), leading research into systems that model the epidemiology of EFB to enable improved disease management in the future. We are also using advanced molecular techniques to identify specific strain types for both AFB and EFB, which will further add to our understanding of the spread of these serious brood diseases. The NBU works in partnership with many Universities and Organisations to achieve these shared research goals. (see BeeBase (www.nationalbeeunit.com).

Figure 1: The National Agri-Food Innovation Campus, Sand Hutton, York

BeeBase

BeeBase is the NBU's award winning website. BeeBase contains all the apicultural information relating to the statutory bee health programme in England and Wales. BeeBase contains a wide range of beekeeping information such as the activities of the NBU, the bee-related legislation, pests and diseases information including their recognition and control, interactive maps, current research areas, publications, advisory leaflets and key contacts. To access this information visit the NBU website www.nationalbeeunit.com. Many beekeepers find this website to be a very useful source of information and advice. In addition to the public pages of the BeeBase website, registered users can view their own apiary records, diagnostic histories and details.

Figure 2: An example Foulbrood disease Incidence map confirmed in tested apiaries



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 honey bee pests and diseases. Where the statutory diseases AFB and EFB are confirmed we use BeeBase to identify apiaries at risk in the local area and, as a result, target control measures effectively. By knowing where colonies are we can help you manage disease risks in your apiaries. Such risks also include the incursion of exotic pests Small hive beetle, *Tropilaelaps* mites or Asian hornets. The more beekeepers who are registered, the more rigorous our bee health surveillance can be 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 at: www.nationalbeeunit.com. Otherwise get in touch with the NBU office team who will be happy to help (The National Bee Unit, The National Agri-Food Innovation Campus, Sand Hutton, York, YO41 1LZ. Email: nbu@apha.gsi.gov.uk. Telephone: 0300 303 0094). By telling us who you are you'll be playing a very important part in helping to maintain and sustain honey bees for the future.

How do I know that my details will be secure?

All of the information that you provide for the purposes of registration on BeeBase is covered by the Public Service Guarantee on Data Handling (see Confidentiality page of BeeBase). In addition, all data will be handled according to rules stated in the Data Protection Act, 1998. 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 check your own record on BeeBase. If you wish, you can make use of the apiary records system if you want to record your apiary visits. Your Seasonal Bee Inspector, Regional Bee Inspector, National Bee Inspector and NBU staff at York will have

access to your records, but no Inspector or the NBU will ever disclose to others that you have been inspected or any details about your bees or beekeeping without your consent. Although BeeBase includes public pages containing information such as disease, colony losses, leaflets, useful links and much more of general information, the public has no access to your or other beekeepers' details.

Beekeeping Associations

In many areas, Beekeeping Associations operate disease control schemes and provide practical advice to members on disease recognition and management. You can contact your local Beekeeping Association or bee health advisor for details (England – www.bbka.org.uk; Wales – www.wbka.com and the Bee Farmers Association – http://beefarmers.co.uk/).

Bee Disease Insurances Ltd

An insurance scheme to compensate against losses incurred through destruction of foulbrood infected colonies is organised by Bee Disease Insurance Ltd (BDI), a specialist insurance company operating with the aim of reducing the incidence of the foulbrood diseases. Beekeepers can take out insurance either individually or through their local Beekeeping Associations.

Figure 3: Mini nucs in the snow. Winter 2010 at the NBU

Honey bees and disease

Honey bees, as they forage for nectar and pollen, play vital roles as pollinators of agricultural crops and also many wild flowers. The total economic value of pollination worldwide is in excess of €1.5 billion every year – a figure that corresponds to almost 10% of the value of world agricultural production. The economic value of insect crop pollination (including honey bees) in the UK is estimated at £500m annually; and this is in addition to the income from honey, beeswax and other hive products. The contributions of pollinating honey bees to biodiversity and the sustainability of myriad natural landscapes are unmeasured, but are very significant. These essential and profitable activities depend upon beekeepers maintaining a healthy population of honey bees.

Figure 4: Honey bees are important pollinators of orchard fruit and certain field crops

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). The latter 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 foulbrood diseases, which are subject to statutory control, together with a range of common and less harmful disorders.

Foulbrood

The term 'foulbrood' covers two diseases of honey bee larvae, one known as American foulbrood (AFB) and the other European foulbrood (EFB). The names bear no relation to the geographical distribution of the diseases: both occur in Great Britain and the economic damage done by them annually to our beekeeping industry is considerable. American foulbrood is considered the most destructive brood disease in Great Britain. However, European foulbrood 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 foulbrood, are extremely widespread.

It is essential that beekeepers are able to recognise these and distinguish them from foulbrood.

Varroosis and exotic pests

Infestation of honey bee colonies by the parasitic mite *Varroa destructor*, the exotic mite *Tropilaelaps ssp.* and the exotic Small hive beetle *Aethina tumida* are subjects of separate leaflets. Identification sheets and further information on monitoring for the Asian hornet *Vespa velutina* are also available.

The aforementioned information can be obtained online, through the National Bee Unit's (NBU's) BeeBase website (www.nationalbeeunit.com). You can also ask your local Bee Inspector for copies or contact the NBU main office:

The National Bee Unit
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UK bee disease legislation

Both AFB and EFB are subject to statutory controls in the UK. The Bee Diseases and Pests Control (England) Order 2006 (SI 2006 No 342), empowers the Department for Environment, Food and Rural Affairs (Defra) to take measures to control both diseases in England. There are separate Orders in Wales, Scotland and Northern Ireland. Beekeepers should be familiar with the provisions of the Order. Copies are available online from the Office of Public Sector Information (OPSI) (www.opsi.gov.uk).

The NBU operates a statutory apiary inspection and surveillance programme in England and Wales. Inspectors examine bee colonies for foulbrood, free of charge. When foulbrood disease is suspected, a sample (a symptomatic larva) is tested using a rapid diagnostic field test kit known as a Lateral Flow Device (LFD) (see pages 17-18 and 34-35). Sometimes samples are taken for laboratory analysis. If disease is confirmed a Standstill Notice is issued, prohibiting the removal of bees and equipment from the apiary. The inspector will then carry out the necessary disease control measures. Further details about the NBU and its advisory and training services are given at the end of this leaflet.

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 Animal and Plant Health Agency's NBU in order to have the colony officially examined by an APHA Bee Inspector, or to submit a suspect disease sample for analysis to the Laboratory at York.

Beekeepers should also place the apiary from which the sample is taken under 'self-imposed' standstill. Beekeepers elsewhere in the UK who suspect the presence of AFB or EFB should contact the National Bee Unit.

Figure 5: APHA Bee Inspectors at work

Statutory inspection of colonies for pests and diseases

Beekeeper's responsibilities

- All colonies in the UK are at risk of contracting foulbrood. 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 and action is taken to tackle it, no further or only limited spread should occur.
- Good husbandry must be the beekeeper's starting point for control of foulbrood. Keep a close eye on the health of your bees and, in particular, make sure you can recognise the signs of foulbrood infection and any abnormalities in the brood.
- Maintain apiaries to minimise the effects of robbing and drifting.
- Aim to keep strong, vigorous colonies and try to select hygienic strains of bees that do not suffer from disease.
- As part of routine good husbandry practice aim to regularly replace old comb. Many beekeepers replace a minimum of one third to half of the combs per brood box each year. Others replace all the combs in the brood chambers each year as the colony expands in the spring.
- Beekeepers, as keepers of livestock that contribute enormously to agriculture and the environment, 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 foulbrood is suspected and the measures you should take to help keep your colonies healthy and productive.
- 'Caveat Emptor'. Be careful what used equipment and bees you buy. Make sure that equipment is clean and bees are healthy before parting with your money.
- The Healthy Bees Plan has produced useful advice notes about obtaining honey bees and also the sale of honey bee nuclei. You can find both of these on BeeBase (see References at the end of this leaflet).
- Old, used equipment must be thoroughly sterilised before reuse.
- Be aware of the risk of spreading infection when you visit other apiaries or when other beekeepers visit you.
- NBU Bee Inspectors cannot examine all colonies each year, so it is therefore essential you regularly inspect your colonies for signs of brood disease. Vigilance is the key; you must spot the signs of infection **early**.
- If you suspect foulbrood, 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 quickly check for signs of disease in their own bees.

Figure 6: Migratory beekeeping can spread pests and diseases over long distances. Before moving your colonies it is essential to check that they are healthy

10 Rules for foulbrood control

1. Make sure you are familiar with the signs and causes of foulbrood and other brood disorders.
2. Inspect your colonies at the very least 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 them 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 why is unknown, examine the brood for signs of disease.
9. Be suspicious of stray swarms. Hive them on foundation rather than drawn comb, keep them 'isolated' from the rest of the apiary as the colony expands 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.

Figure 7: Bee disease recognition training in the field

Figure 8: Bee disease recognition training in the field

Figure 9: Bee disease recognition training in the laboratory

Healthy brood

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

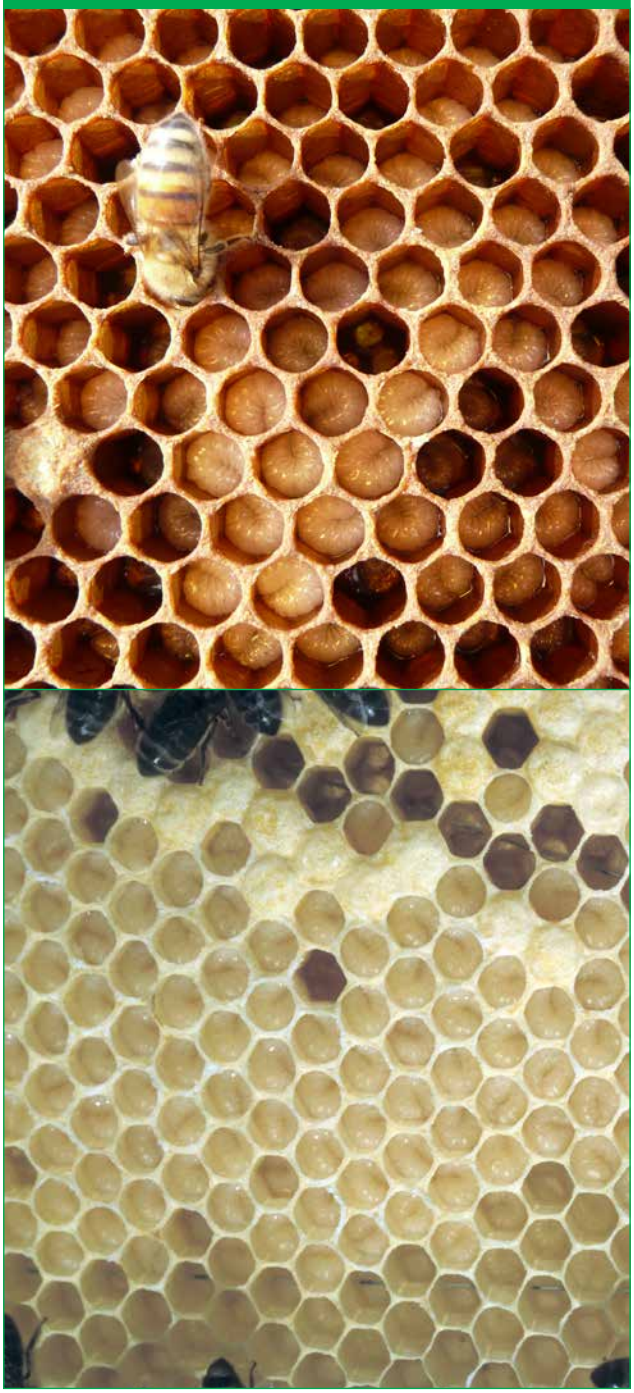
The queen lays eggs at the base of cells in the brood nest. These hatch after three days and develop into tiny translucent larvae, each lying at the base of the cell in a bed of milky brood food.

Figure 10: An even pattern of eggs

Figure 11: Young healthy worker bee larvae and eggs

After six further days of development, the larvae have increased in size to almost fill the base of their individual cells. 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 each larva is divided into a series of segments along its length.

Figure 12: Healthy larvae shortly before sealing



When the larvae are nine days old, adult bees seal the opening of each cell with a cap of wax and development into an adult bee occurs inside the sealed cell, completing metamorphosis. The wax cappings on healthy worker brood vary in colour from very light to dark brown (often referred to as digestive biscuit colour), they are dry-looking and slightly convex. Drone brood can be distinguished from worker brood by its larger cells and domed cappings.

A good, even brood pattern (refered to by beekeepers as ‘wall-to-wall’) with very few empty cells within patches of brood, suggests that the queen is laying well and that 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.

Figure 13: Sealed healthy brood

Figure 14: Healthy capped brood produced in a productive healthy colony. Note the drone brood at the bottom left of the picture

Sources of spread of foulbrood	
Sources of infection	**Means of spread**
Infected combs, brood combs	Transfer of combs between colonies
Super combs	Robbing
Honey (e.g. in exposed combs or drums)	Drifting
Beekeeping equipment	Swarming
Beekeepers (e.g. dirty bee suits)	The beekeeper through management practices
	Purchase of infected stocks of bees

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 (to the side of the hive or behind away from the hive entrance).
- 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. Place the excluder on the ground next to the roof.

Figure 15: Opening the hive for disease inspection

- 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.
- Any bees on a comb may be concealing infected brood from the beekeeper's view. On combs free from bees, any abnormality is easily spotted.

Figure 16: With the adult bees on the comb you can not clearly see the brood

Figure 17: Shaking adult bees from the comb into the hive

- 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 onto the bottom of the hive without harming them, the queen or brood.
- 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 16 – Fig 26) by holding the combs towards the light and scanning the bottom walls of any open cells.

Figure 18: With the bees removed the brood is clearly visible

- Using a suitable implement (a matchstick) open any sealed cells that have abnormal looking cappings – look inside.
- 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 carefully reassemble the hive.
- If you use a hive tool remember to flame it.
- **If you suspect EFB or AFB may be present in any colony you must report this immediately: notify your local Bee Inspector. This is a legal requirement under the bee legislation.** If you are in doubt who this is, please visit the contact pages of NBU's BeeBase website (www.nationalbeeunit.com).
- If you wish, you may also send in a sample of diseased brood to the NBU for examination (The National Bee Unit, The National Agri-Food Innovation Campus, Sand Hutton, York, YO41 1LZ).
- Your Bee Inspector will arrange to visit your apiary and inspect the colony(ies). In most cases he/she will be able to confirm or discount presence of foulbrood at the time of inspection. However, sometimes laboratory confirmation of diseased samples will also be necessary.
- If foulbrood is confirmed your Inspector will make recommendations for management. Various treatment options are available for EFB. For AFB the only option in the UK is destruction (see later sections).
- Read more about 'What to do if you suspect foulbrood' on page 33.

Figure 19: When examining comb for scales it helps to stand so that the light comes over your shoulder

American foulbrood

Cause

American foulbrood is caused by a spore-forming bacterium *Paenibacillus 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 gut tissues, where they multiply enormously in number. Infected larvae normally die after their cells are sealed. Millions of infective spores are formed in their remains, which dry to form 'scales' that 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. If the scales go unnoticed and infected combs are subsequently used or moved from colony to colony during routine beekeeping management, then infection has the potential to spread quickly.

The spores are very resistant to disinfectant and to extremes of heat and cold. 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 usually 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. 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 and Pests Control Orders (for England and Wales) and is subject to official control by a programme of apiary inspections carried out by the NBU. Control of the disease is through compulsory destruction of infected colonies, which is a very effective measure. This eradication policy has been highly effective since first introduced in the 1940s, bringing the incidence of AFB down from several thousand infected colonies per year to less than 100 nowadays. In recent years disease incidence has been characterised by sporadic but large outbreaks, which have been rapidly brought under control by the Inspectors and beekeepers working together. Methods of control for AFB using antibiotics, which are used in some overseas countries, are not effective – they only serve to suppress signs of the disease without eradicating it and, through frequent use, allow the development of resistant bacterial strains.

The use of antibiotics to control AFB is not permitted in the UK.

Diagnosis

For confirmation of AFB a suspect sample is tested using an LFD field kit. Sometimes brood combs (or suspect larvae) are sent to the NBU laboratory where larval remains are examined for the presence of 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 safely burned in a deep pit (Fig 20).

Hives and appliances can be sterilised by thoroughly scorching them with a blow lamp (Fig 21). Gloves, overalls, footwear and the smoker are then washed thoroughly in washing soda or hot soapy water.

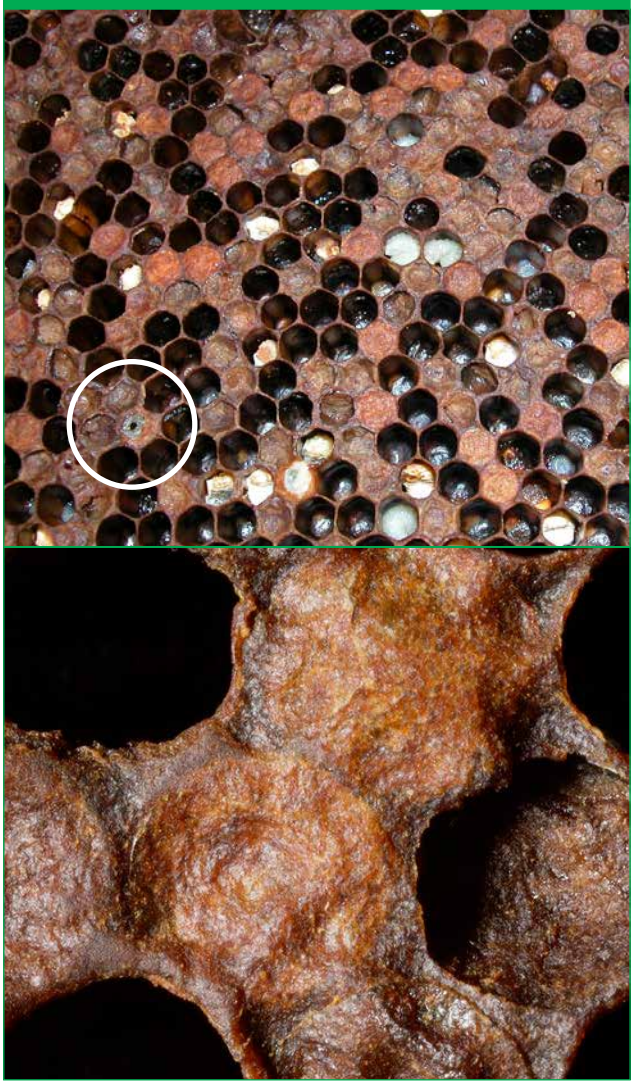
Figure 20: Destruction of an AFB infected colony

Figure 21: Sterilisation of hive boxes with a powerful blow lamp

Signs of American foulbrood

- AFB generally affects only sealed brood. When infected larvae die within the sealed cells, the appearance of the cell cappings changes. A good way of remembering this is: AFB = ***A*** (**A**fter sealing of the cell).
- Wax cappings become sunken and perforated when adult bees nibble holes in them to try to remove the infected larvae underneath. 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.

Figure 22: AFB – perforated (circled) and sunken cappings (lower image)



- 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 associated with decomposition.
- At the sunken capping stage the dead larval remains are light to dark brown in colour and have a slimy consistency.

Figure 23: AFB-’pepper pot’ brood

- 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 the presence of 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 tongue-like proboscis of dead pupae may sometimes remain intact, protruding upwards from the bottom edge of the cell (Fig 25).

Figure 24: AFB-ropiness test

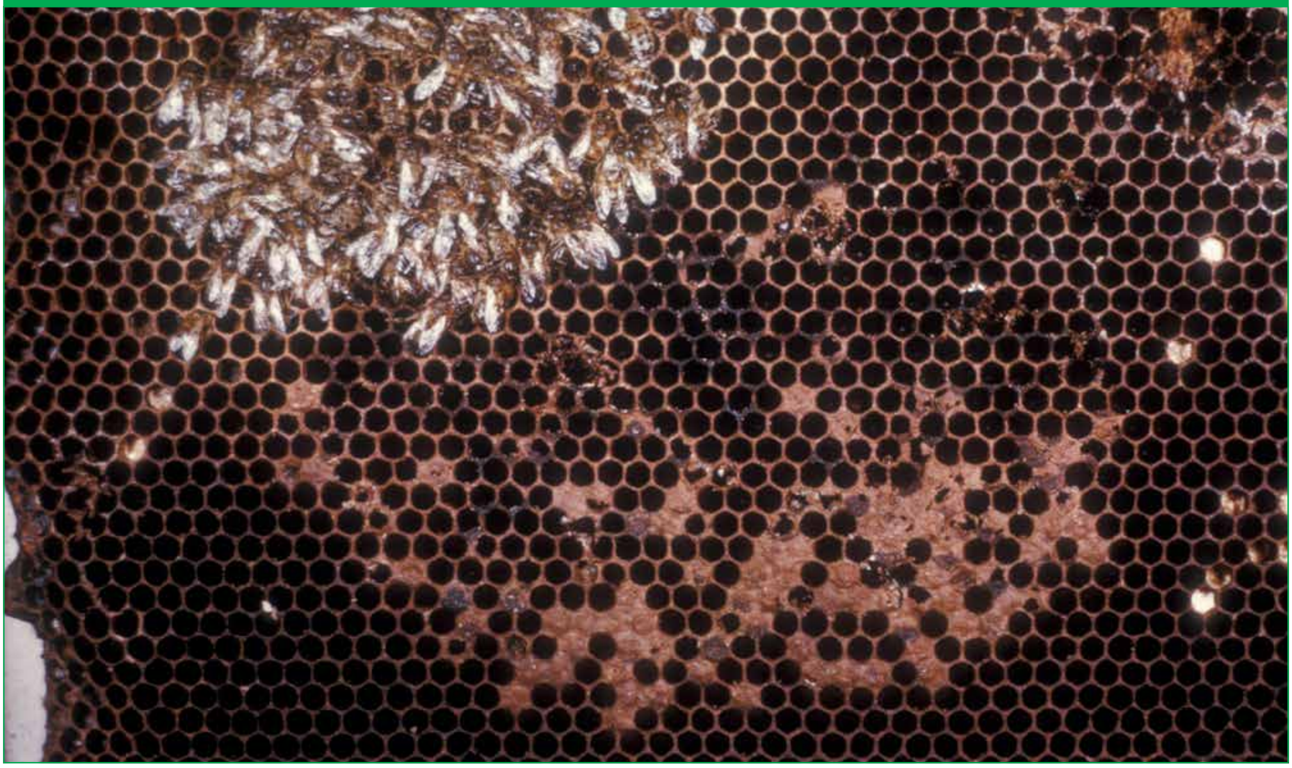
- Further drying leads to the final stage, which is a very dark brown, rather rough scale lying on the lower side of the cell and extending from just behind the mouth of the cell right back to the base (Fig 26).
- The scales can be detected if the comb is held facing the light: they reflect the light from their rough surfaces and can easily be seen, even when their colour is almost the same as the comb itself.

Figure 25: AFB - pupal tongue stage

Figure 26: AFB – scales in the bottom of the cells

Figure 27: Can you spot the abnormality?

Figure 28: What happened to this colony?



Answers

Figure 27: If you look carefully AFB scales are visible towards the top of the cells.

Figure 28: This colony died of starvation and a heavy infection of American foulbrood. Note sunken cappings and other signs.

European foulbrood

Cause

European foulbrood is caused by the bacterium *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. Such 'secondary invaders' include *Paenibacillus alvei, Enterococcus faecalis, Brevibacillus laterosporus* and *Lactobacillus eurydice.*

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, often 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 foulbrood disease. If a healthy colony receives combs, honey or hive equipment from an EFB-infected colony it is likely to become infected. Bees robbing honey from infected colonies also transmit the disease (EFB can remain infectious in honey for more than a year). Swarms from infected colonies may also carry infection with them and become diseased after they are hived.

Migratory beekeeping – moving infected or healthy colonies into close proximity of infected apiaries – can also spread disease, as can the purchase of infected bees (e.g. nuclei).

Diagnosis

European foulbrood cannot be reliably identified visually, as the disease signs can easily be confused with various other brood abnormalities. Suspect infections are confirmed in the field by APHA Bee Inspectors using LFDs (Figs 29, 51 and 52). Occasionally sample brood combs (or suspect larvae) are sent to the NBU laboratory where larval gut contents are examined for the presence of the causative bacterium.

Control

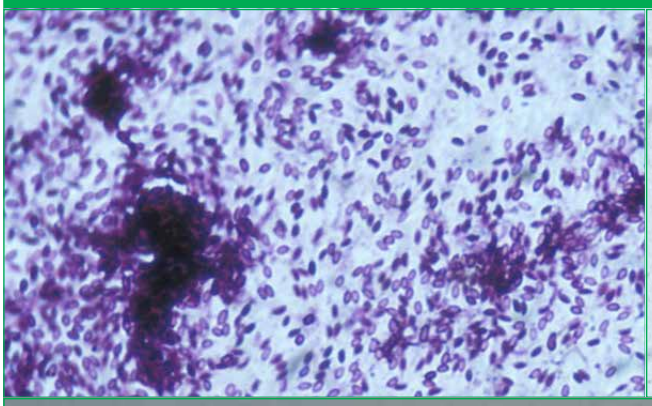
European foulbrood is a notifiable disease under the Bee Diseases and Pests Control Order (for England and Wales) and is subject to official control by the examination of colonies for signs of disease and compulsory treatment or destruction of diseased colonies. Weak colonies and colonies with a high proportion of diseased brood are destroyed, as with AFB, but lightly diseased colonies may in certain circumstances be treated with an antibiotic. However, this is not the control method of choice. Treatment must be carried out only by an Appointed Officer under the Order, using drugs officially dispensed following confirmation of EFB in a disease sample submitted for diagnosis at an approved laboratory or by LFD. Treatment is prescribed by the Veterinary Medicines Directorate (VMD).

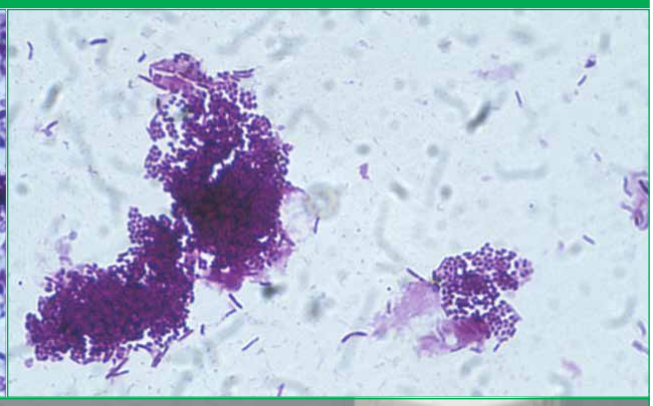
Control of the disease by a husbandry method known as 'Shook Swarm' has also been shown to be effective and is an option available to beekeepers (see pages 22-26).

Figure 29: Some of the options for laboratory diagnosis of foulbrood

Real-time TaqMan® PCR (molecular diagnosis)

Microbiological identification





A Lateral Flow Device (LFD) kit as used for diagnosis of foulbrood in the field and in the laboratory

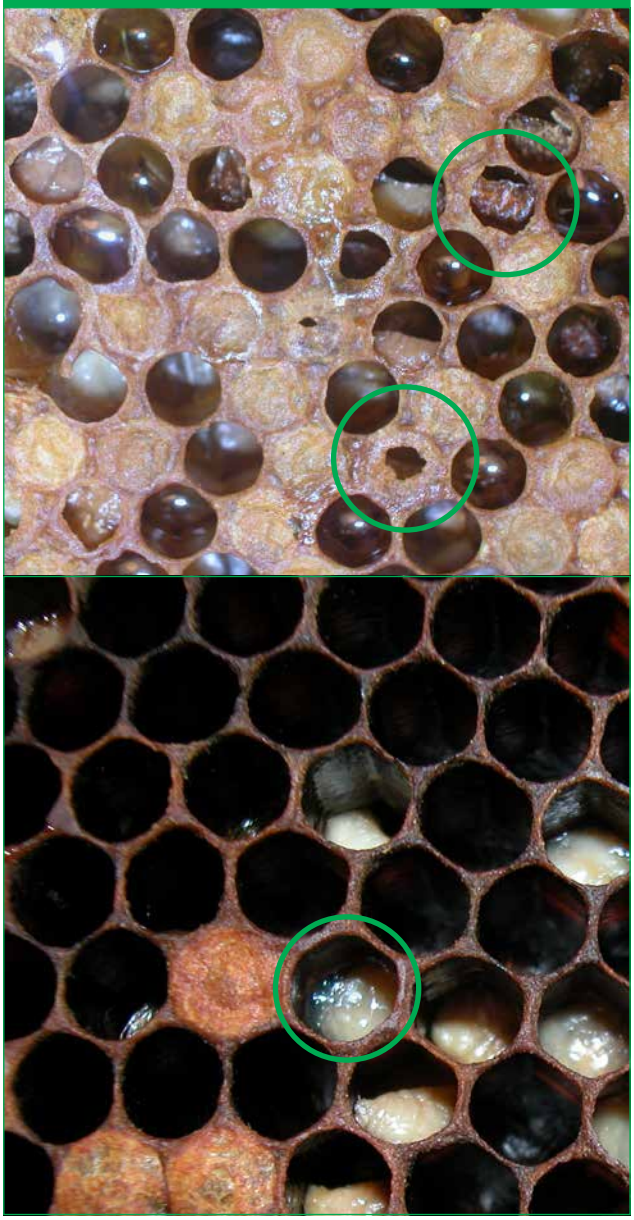
Signs of European foulbrood

- EFB mainly affects unsealed brood, killing larvae before they are sealed in their cells.
- An easy way to remember this is: EFB = ***E*** (**E**arly infection before sealing of the cell).
- 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.

Figure 30: EFB affected unsealed brood (circled)

- The dead larva often collapses, as though melted, turning yellowish-brown and eventually drying up to form a loosely-attached brown scale (Fig 33).
- The gut of an infected larva may be visible through its translucent body wall. It has a creamy white colour caused by the mass of bacteria living within it (Fig 34).

Figure 31: Very heavy clinical infection with EFB-twisted and discoloured larvae (circled: chewed capping – melted larva – scale)



- 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 (Fig 32).
- 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.

Figure 32: EFB – severe infection and patchy brood pattern (example circled)

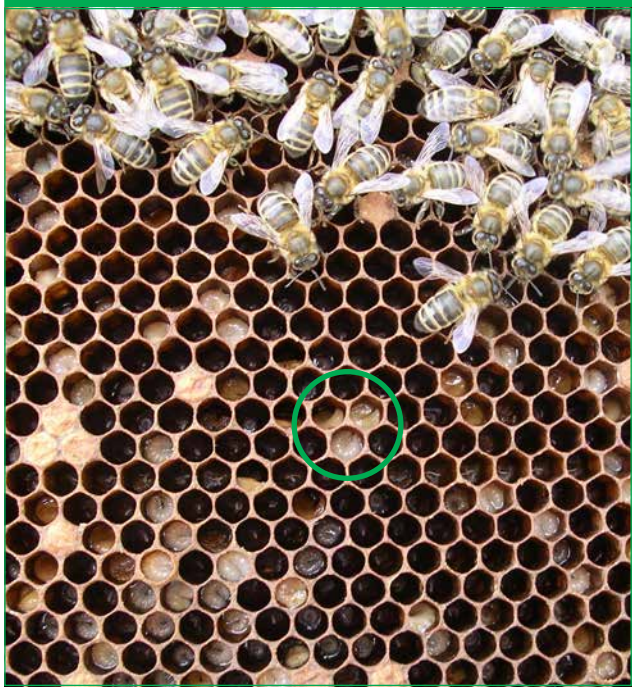


Figure 34: EFB photograph showing yellow/white colour of infected larval gut

- Some infected larvae may die after their cells are sealed. In such cases, there may be sunken perforated cappings resembling AFB infection. However, although brown and sticky, the cells' contents cannot be drawn into a 'rope' as with AFB (Fig 24).
- Where larval remains dry to form scales, these are variable in colour, loose (easily removed) within the cell and somewhat 'rubbery', unlike the hard black firmly attached scales of AFB.

Figure 33: EFB – dead brood with dried scales (circled)

Controlling an outbreak of foulbrood

If you keep bees for long enough, it is likely that someday you will 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, returning later to make sure that there has been no disease recurrence in the apiary.

Bee Inspectors will work closely with you to bring the outbreak under control and provide advice on minimising recurrence. However, you have an equally important role in managing foulbrood disease. 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 and swarming. Despite this, unfortunately in practice the main agent of spread is the beekeeper, as he/she 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 foulbrood affecting many colonies in large beekeeping enterprises can be successfully brought under control so long as cases of foulbrood are found and dealt with faster than new cases are allowed to develop.

Key strategies for controlling an outbreak of foulbrood in your bees

Develop a keen eye: learn to recognise the signs of foulbrood.

This is a skill that takes a little time and practice to acquire. Start by working with your Bee Inspector, as he/she inspects your bees. He/she 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. **You should aim to be able to spot one diseased larva in a comb of several thousand.** You can send individual suspect larvae to the NBU for diagnosis. See page 33 for advice on sending samples to the NBU.

Use quarantine systems to avoid spreading disease

When colonies with signs of foulbrood 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 foulbrood outbreak is brought under 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. You will need 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 particularly at risk – such as those that have been previously treated or those that have had close contact with infected colonies – but involves significant effort to carry out on a large scale. This has worked very successfully to bring large outbreaks under control. **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 to implement on a large scale than colony quarantine and also helps to 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 Inspectors). This minimises any contact between diseased and healthy colonies, making it easier to operate quarantine systems appropriate to the level of risk in each apiary.

Disinfect 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. Irradiating equipment is another option (page 33).

Transfer colonies to new comb

The pathogens responsible for AFB or 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 that have been treated against EFB with an antibiotic. A significant proportion of these colonies may suffer reccurrence of disease within a year or so as a result of live bacteria remaining in the colony after treatment. Any method that removes contaminated comb from colonies and replaces it with new comb will be helpful in reducing the risks of disease. The more rapid and complete the transfer, the more effective it will be.

Shook Swarm

The 'Shook Swarm' method aims to completely remove contaminated comb 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 during the season. The removed combs are then destroyed by burning. Although this method can involve significant labour and expense, recent research at the NBU suggests that it is extremely effective at combating EFB and reducing subsequent recurrence of disease. Many beekeepers have found that colonies, when treated by Shook Swarm, are capable of quickly building up to gather a good crop of honey, and that the reduced risk of reccurrence of EFB makes it a sensible strategy for dealing with EFB-affected colonies, and other colonies thought to be at particular risk. For further details of methods that can be used to help control EFB contact the NBU or your local Bee Inspector.

Integrated Pest Management

All of the above strategies amount to Integrated Pest Management (usually abbreviated to 'IPM'), which is a principle that has been widely used in agriculture, especially where it is desirable to keep chemical or medicinal inputs to a minimum.

Significantly, no attempt is made to completely eradicate the pests or disease. Instead, the aim is to keep them below the level where they cause significant harm by using a combination of controls applied at different times of the year.

More or fewer controls are employed depending on the levels of disease present.

An example of an IPM programme for EFB control can be found on page 24. This is a much more effective approach than the alternative of waiting until pathogen numbers have reached a damaging level before applying controls, or applying the same controls each year regardless. **Remember** once AFB is confirmed in a colony then the only treatment option is destruction. However, many of the colony monitoring and hygiene principles found in a good IPM programme will be equally useful in the prevention of AFB and other honey bee pests and diseases.

Figure 35: Shook Swarm technique. The bees from infected colonies are ‘shaken’ from the combs, a comb at a time, into a prepared sterilised brood chamber containing frames with foundation or with clean drawn comb as an alternative. Make sure that a Queen excluder is placed under the brood box

An IPM programme for foulbrood control (with particular emphasis on EFB)

IPM is a principle that can be readily applied to control of many bee pests and diseases. An IPM approach to EFB control would aim to include:

- A varied mix of controls working in different ways and at different times of year according to the level of risks (see Table 1 below and Figs 36 and 37 as illustrations of the types of intervention possible);
- A mixture of prevention and intervention;
- A graded response depending on level of problem;
- Control at several points of the year makes it harder for the disease/pathogens to reach harmful levels.

Table 1: Management action to take based on risk assessment

Low risk	Medium risk	High risk
Check for signs twice a year Basic apiary hygiene Periodic comb change Shook Swarm/destroy affected infected colonies	Check several times a year Careful apiary hygiene Regular systematic comb replacement Shook Swarm/destroy infected colonies Apiary level quarantine	Check at each inspection Strict apiary hygiene Shook Swarm/destroy infected colonies Shook Swarm contact colonies Colony level quarantine Maintain 'hospital' quarantine apiaries

Figure 36: Foulbrood Control Calendar

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sterilise supers and combs. Replace old wax with foundation	■	■	■								■	■
Routine comb change (3-4 older combs per brood box)			■	■	■	■						■
Mark supers placed on individual hives				■	■	■	■	■				
Monitor for disease signs				■	■	■	■	■	■			
Shook swarm				■	■	■	■	■				
Antibiotic treatment				■	■	■	■	■	■			
Colony destruction	■	■	■	■	■	■	■	■	■	■	■	■
Apiary/colony quarantine (barrier management)	■	■	■	■	■	■	■	■	■	■	■	■
Control robbing	■	■	■	■	■	■	■	■	■			
Extraction hygiene	■	■	■	■	■	■	■	■	■	■		

Figure 37: Control options for foulbrood

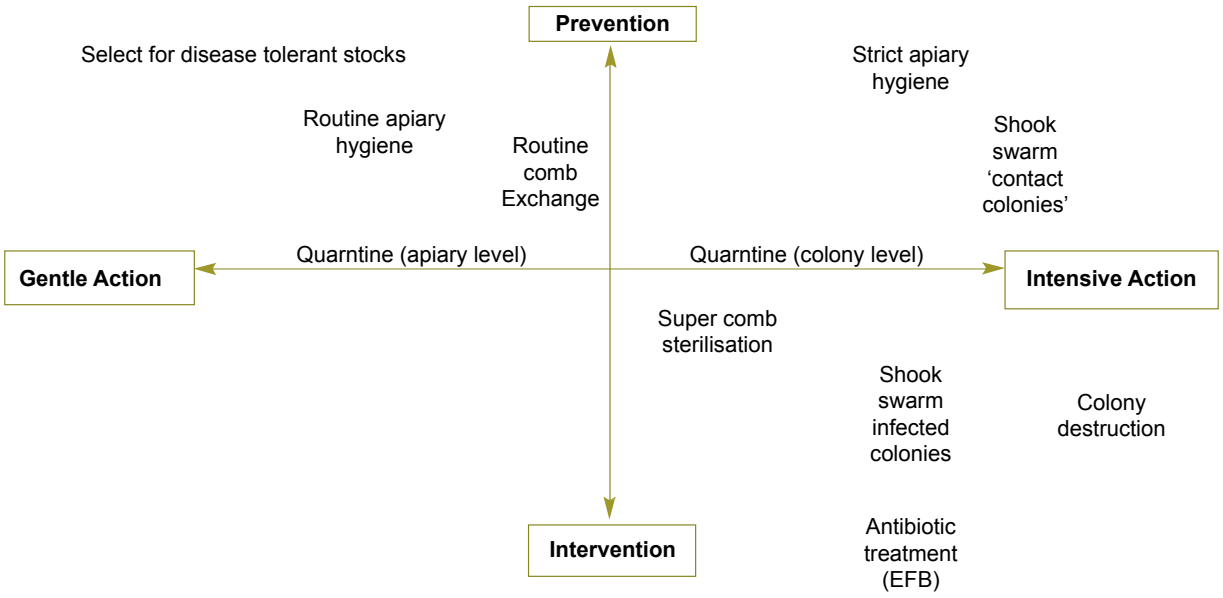
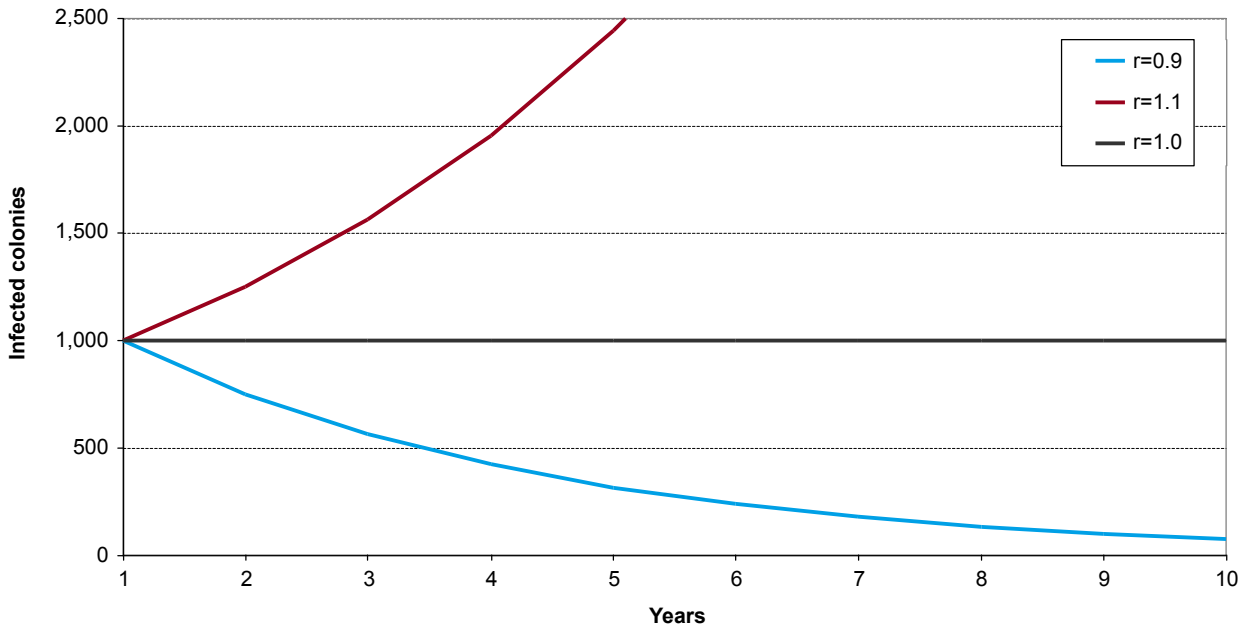


Figure 38: Influence of new infection rate on changes in disease levels

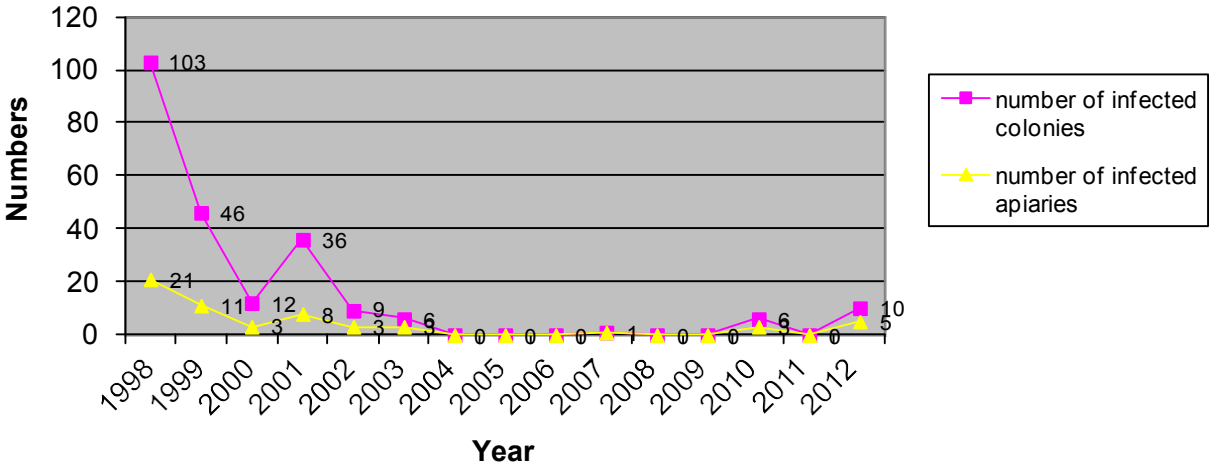


The conceptual graph above shows the big difference that small changes to 'r' the reproductive rate of diseased colonies (i.e. how many diseased colonies end the year compared with those at the beginning) can make to incidence of disease. Just a little below 1 and it dies away; just a little above 1 and it soars out of control.

By implementing the recommended means of control illustrated throughout this leaflet (IPM and good husbandry), r should be < 0.9 – this is illustrated in detail in the case study opposite.

Case Study: Shook Swarm and good husbandry in practice

Figure 39: Reduction in Incidence of European foulbrood 1998-2012



The graph shows a reduction in the incidence of EFB, both in terms on the numbers of infected colonies and infected apiaries from a level of 25% (confirmed clinical cases) to close to zero in five years. This **actual** case involving a bee farm of 400 colonies in the south of England has been followed for 14 years. This success is due to good husbandry, barrier management and an IPM approach.

The beekeeper

- Has learnt to recognise disease;
- Sends off suspect tube samples to the NBU laboaratory frequently;
- Is willing to carry out Shook Swarms (even very early in the year or on small colonies) and will follow up treatment with as much feeding as required to build the colonies into usable units;
- Is happy to shake good colonies into usable units;
- Is happy to Shook Swarm whole apiaries to try to remove any latent EFB in those colonies without clinical signs;
- Does not like to burn colonies to eliminate infection but will do so with poor performing and susceptibe colonies if considered necessary;
- Removes all supers at the end of the season and takes them back to base;
- Fumigates supers with acetic acid routinely, then has the frames/combs refitted and sterilised with acetic acid;
- Sterilises all the boxes with a blowtorch;
- Marks supers and returns them to the same colony and to the same apiary. The supers then stay with those colonies throughout the season.

Generally these practices mean the beekeeper finds and deals with disease faster than it spreads. Therefore there is a general downward trend in disease incidence and low levels are susequently maintained. With improved disease control it has been found that honey production has increased. It is worth mentioning that this case is especially impressive considering that EFB is generally prevalent in the area in which the bees are kept.

Common brood disorders

In addition to the foulbrood diseases, there are other honey bee brood disorders found in the UK, which are generally considered less serious.

Examples include sacbrood, black queen cell virus, varroosis, chalkbrood, bald-brood, laying workers, drone-laying queens and chilled brood. It is important that beekeepers are able to distinguish between these and foulbrood. These disorders will also affect colony productivity and can occassionally be serious problems for susceptible stocks of bees.

Sacbrood

Sacbrood is a very common viral disease affecting brood. In most diseased colonies relatively few larvae are visibly affected and it rarely causes measurable harm. However, the signs of sacbrood can sometimes be mistaken for those of AFB. **Disease signs –** Larvae that have died from sacbrood resemble 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 often referred to as 'Chinese Slippers'. 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 with 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.

Black queen cell virus (BQCV)

This virus primarily attacks developing queens and in rare instances will affect developing worker brood. **Disease signs –** Infected queen cells develop dark brown to black cell walls, hence the name of the virus. In the early stages of infection diseased larvae have a pale yellow appearance and tough sac-like skin, resembling those killed by the sacbrood virus. BQCV is

Figure 40: Sacbrood infected larva (cell mouth enlarged for photograph)

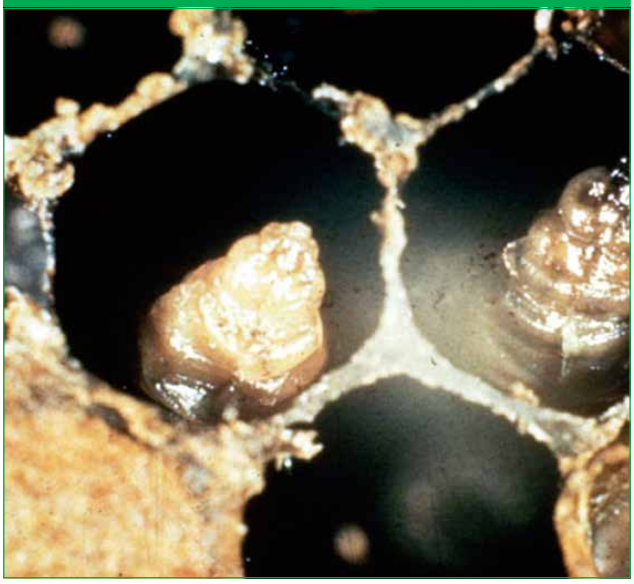


Figure 41: Sacbrood
Top: "Chinese slipper"
Bottom: removed from cell for photograph

closely associated with nosemosis (an adult bee disease caused by the microsporidian fungus *Nosema*) and may also be associated with *Varroa* infestation. It is believed that nurse bees transmit BQCV to queen brood via glandular secretions during feeding. *Varroa* has also been implicated as a vector. (Read more about *Nosema* on the Adult Bee Diseases pages of BeeBase www.nationalbeeunit.com). **Treatment and control –** There is no specific treatment.

Beekeepers can re-queen susceptible colonies with queens from more tolerant stocks. Apply good husbandry practices: strong, well fed, disease-tolerant colonies headed by young, prolific queens are less likely to succumb to BQCV infections.

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. Damage is caused in several ways: by mites themselves feeding on haemolymph and depriving the developing bee of vital nourishment; by viruses that are triggered by the infestation; or, in the case of collapsing colonies, by the bees failing to care adequately for their brood. **Disease signs –** Signs of damage to brood in *Varroa*-infested colonies can be very variable. Usually sealed brood appears to be affected, with dead and discoloured brood in various stages of development visible below perforated cappings. Larval remains may be firm or watery, but never ropy (as with AFB). *Varroa* mites act as vectors for a variety of viral diseases (e.g. DWV) and in heavily infested colonies these become much more widespread. **Treatment and control –** Close examination will reveal numerous *Varroa* mites in floor debris, brood cells and on adult bees. (See Managing *Varroa* leaflet for further details).

Figure 42: Black queen cell virus. Note similarity to signs of EFB. In this case the presence of the virus was confirmed by TaqMan®

Figure 43: *Varroa* infested 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. 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.

Figure 44: Chalkbrood infected brood

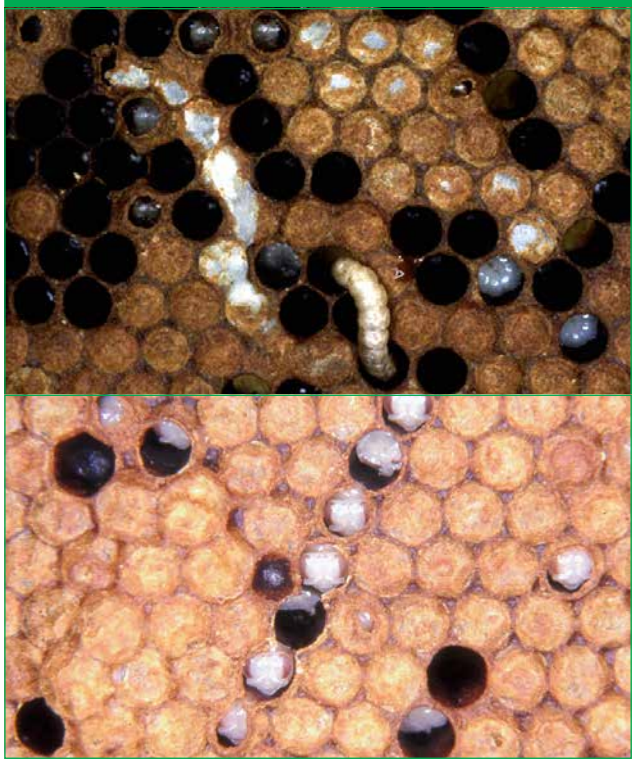
Figure 45: Chalkbrood “mummies” on a hive floor

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 where conditions are cool, damp and hives have inadequate ventilation. It is therefore most prevalent in weak colonies and during early spring. **Treatment and control –** There are no specific treatments available on the market 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. It is reported that Apiguard (a varroacide treatment based on thymol) may assist in the control of this fungal infection.

Bald brood

Normally pupae are sealed in their cells under wax cappings until they are ready to emerge as adults. **Disease signs –** 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.

Figure 46: Wax moth damage (46a) and bald brood (46b)



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. **Treatment and control** – There is no specific treatment for bald brood. Beekeepers should control wax moth infestation. If, during colony management, the beekeeper (re)inserts a frame into the colony too close to neighbouring frames, the bees will make room for themselves between the frames by uncapping brood – resulting in bald brood. It is therefore important that beekeepers always return frames to the hive in the same position from where they were removed. Always try to minimise disruption to the brood nest when working with your colonies.

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.

Signs of drone-laying queens – Worker bees develop from eggs that have been fertilised, before they are laid, by sperm stored in the queen's sperm sac (spermatheca). If the supply of sperm becomes exhausted (e.g. if the queen was poorly mated), 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. **Treatment –** Drone-laying queens should be replaced with queens of proven fertility.

Figure 47: Domed cappings of drone brood in worker cells

Figure 48: Typical comb showing signs of a failed queen or laying workers

Signs of 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. 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, most often on the walls as well as at the bottom of the cell. **Treatment –** 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. Shake out the bees on the ground (on a sheet if wet) so that they return to other colonies in the apiary.

Figure 49: Signs of laying workers

Chilled brood

Signs of 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. **Treatment –** Keeping colonies in thriving condition with ample bees to cover and nurture the brood can prevent chilled brood.

Figure 50: Chilled brood

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 or environmental contamination of some form or another. 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 signs, causes and control

	Signs	Control
Normal brood	Uncapped: Pearly white, 'C' shaped larvae. Capped, uniform brown colour, domed cappings.	None required
American foulbrood *(Paenibacillus larvae)*	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** An APHA Bee Inspector burns infected colonies (bees and combs) and the hives are sterilised by scorching.
European foulbrood *(Melissococcus plutonius)*	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** Several choices are available. Infected colonies can be: 'Shook Swarmed'; an APHA Bee Inspector can treat lightly infected colonies with antibiotic; severe cases of EFB are destroyed as with AFB.
Chalkbrood *(Ascosphaera apis)*	Affects only sealed brood. Perforated cappings over cells containing hard white or mottled grey chalk like remains ('mummies').	No specific treatment. Keep strong colonies. Re-queen severely affected colonies.
Sacbrood (Sacbrood virus SBV)	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. Shake bees out in front of the hive so that they return to other colonies slowly.
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** *(Varroa destructor)*	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. (see Managing *Varroa* leaflet for details).
Black queen cell virus (BQCV)	Primarily attacks developing queens; rarely, affects worker brood. Infected queen cells develop dark brown to black cell walls. In early infection diseased larvae are pale yellow with tough, saclike skin (similar to those affected by sacbrood).	Re-queen susceptible colonies with queens from more tolerant stocks. Apply good husbandry practices: Strong, well fed, disease-tolerant colonies headed by young, prolific queens are less likely to succumb to BQCV infections.

Further information

What to do if you suspect foulbrood

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 other beekeeping equipment with a strong solution of washing soda 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 cannot 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. Alternatively, infected larvae can be sent to the laboratory with all your details in a sample tube (such as an 'Eppendorf' type tube). The NBU can provide samples to local associations and local bee health advisers.

4. You must not remove any hives, bees or equipment from the apiary until the disease, if present, has been controlled. Place the apiary under **Standstill**.

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 which might have been associated with foulbrood infection – this will help to reduce the likelihood of transmitting foulbrood or other diseases between colonies, if applied as part of normal apiary management. Methods include:

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. Great care must be taken when handling paraffin wax at high teperatures. Specialist equipment and protective clothing are required.

Chemical sterilisation – There are no chemicals that have been shown to be fully effective for the sterilisation of stored combs against foulbrood. AFB spores in particular are strongly resistant to virtually all sterilising agents. Super frames that haven't had brood in them can, however, be sterilised to destroy the spores of chalkbrood (and *Nosema* disease of adult bees), using acetic acid vapour. However, there is no evidence that this treatment is effective against AFB or EFB. It is much better practice to melt down or burn old combs and replace them with new frames fitted with foundation. Brood boxes, supers, queen excluders and other bee-keeping equipment, which has been thoroughly cleaned of all wax and propolis can be effectively sterilised by using commercial disinfectants (e.g. bleach). It is important that the manufacturer's instructions are complied with. You can find more information about hive cleaning and sterilisation on BeeBase (www.nationalbeeunit.com). See also Further Reading section at the front of this leaflet.

Irradiation of equipment – Equipment such as stored supers and empty combs, which may have been associated with colonies infected with foulbrood 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 but untreated disease signs. Firms specialising in irradiation use 25 kiloGrays (kGy) to kill *Paenibacillus larvae* (AFB) and its spores on combs and hive equipment. This dose rate is higher than that currently recommended in the OIE Terrestrial Animal Health Code (10 kGy) to destroy both *P. larvae* and *Melissococcus plutonius* and will thus be effective for EFB.

How a Lateral Flow Device works

The routine diagnostic method used by the NBU to confirm the presence of foulbrood is a field kit called a Lateral Flow Device (LFD). The term lateral flow refers to the suspect larval material flowing horizontally across the kit membrane into which specific antibodies have been incorporated. The kits were specifically developed to confirm foulbrood and work on the same principles as a human pregnancy test. They are based on specific monoclonal antibodies to AFB or EFB. There are two kits in use and each is specific for the foulbrood disease in question.

The principle of the LFD relies upon the capture of target bacterium between an immobilised line of target specific (AFB or EFB) antibody on a nitrocellulose membrane (test line) and a blue coloured latex-antibody conjugate to display a visible confirmation of target presence. A line of anti-species antibody is incorporated into the device to provide visual verification of latex flow (Control line), resulting in two lines as an indication of positive detection and a single line for a negative result.

(These kits were developed by the Central Science Laboratory, which became Fera Science Limited on 1st April 2015, on behalf of Vita Europe Ltd. (www.vita-europe.com).

Figure 51: The mechanics of the lateral flow device.

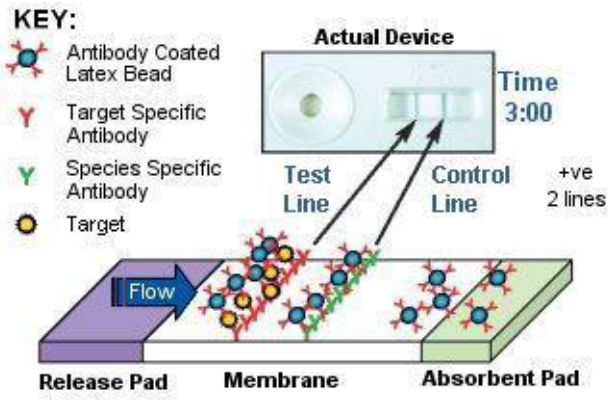


Figure 52: Using a Lateral Flow Device (LFD) These kits were developed by the Central Science Laboratory, which became Fera Science Limited on 1st April 2015, on behalf of Vita Europe Ltd.

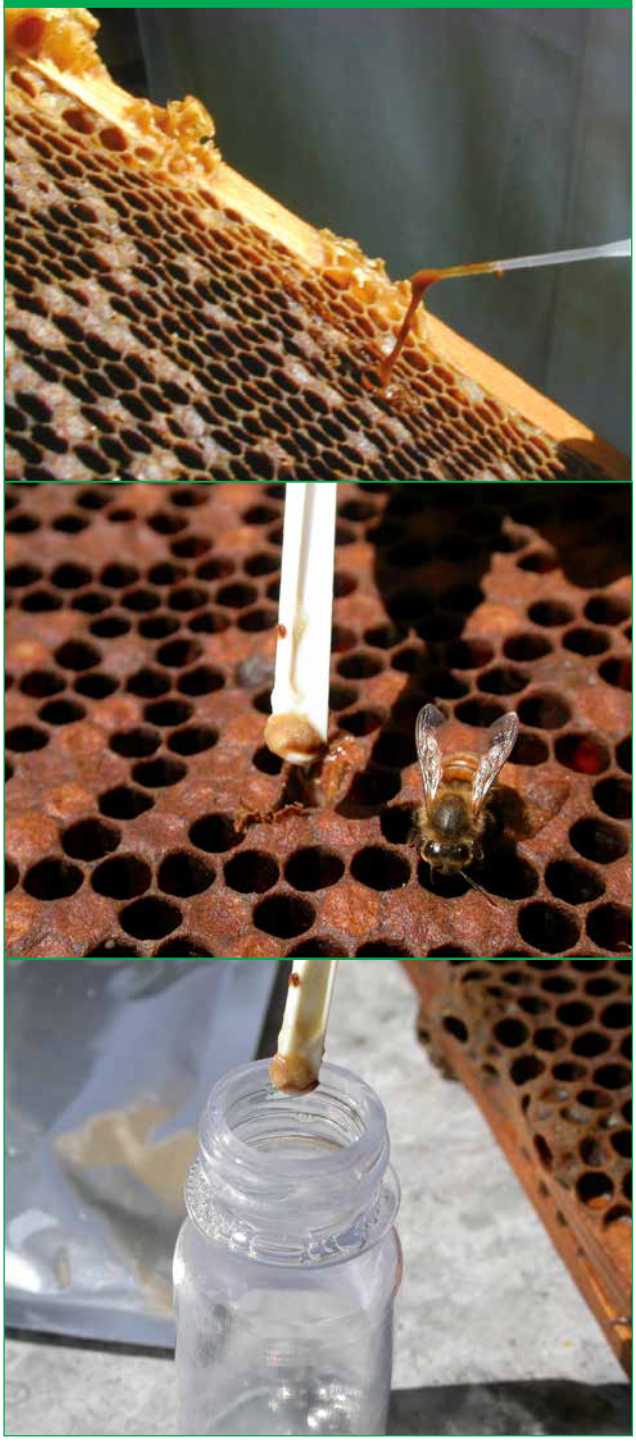
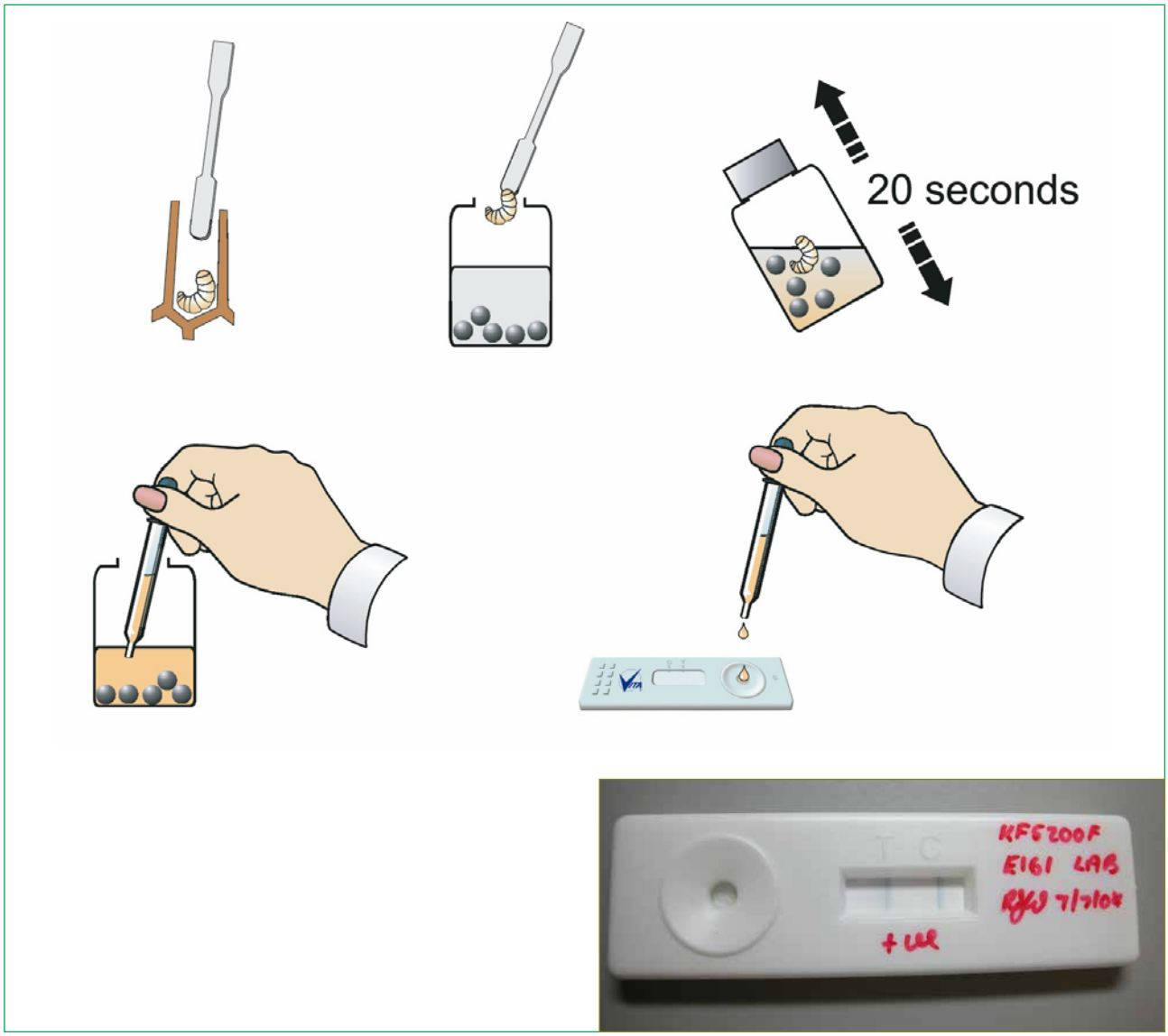


Figure 53: Using a Lateral Flow Device (LFD) A sample of suspect infected larval material is placed in the buffer bottle and shaken for about 20 seconds. 2-3 drops of the resulting suspension are then placed on the lateral flow device. The blue lines at the C (Control) and T (Test) line indicate a positive result for foulbrood infection.



(Diagram courtesy of Vita Europe Ltd)

References and acknowledgements

References

A number of references were used in the development of this advisory leaflet. These key sources are cited below. In addition, this list includes items that may be of interest as further reading.

Budge, G. *et al*. (2010). The occurrence of *Melissococcus plutonius* in healthy colonies of *Apis mellifera* and the efficacy of European foulbrood control measures.
Journal of Invertebrate Pathology 105: 164–170.
www.nationalbeeunit.com/index.cfm?pageid=172

Budge, G. *et al*. (2012). New AFB Research. *BBKA News* 197: 27.

Budge *et al*. (2012). The Random Apiary Survey Findings. BBKA News 202: 21-24.
www.nationalbeeunit.com/index.cfm?pageid=166

Budge, G. (2012). Modelling systems for managing bee disease: the epidemiology of European foulbrood. IPI Bee Disease Newsletter. 1, 5pp
www.beedisease.co.uk

Chen, J. & Siede, R. (2007). Honey bee viruses. Advances in Virus Research 70: 33-80.

Dobbelaere, W. *et al* (2001). Disinfection of wooden structures contaminated with *Paenibacillus larvae* subsp. larvae spores. *J. Applied Microbiology* 91: 212-216.

Forsgren, E. (2010). European foulbrood in honey bees.
Journal of Invertebrate Pathology 103: S5–S9.

Genersch. E. (2010). American Foulbrood in honeybees and its causative agent, *Paenibacillus larvae*. J*ournal of Invertebrate Pathology* 103: S10–S19

Goodwin, M. (2006). Elimination of American foul brood without the use of drugs. A practical manual for beekeepers, revised edition. *National Beekeepers Association of New Zealand*.
nba.org.nz/publications

Haynes, E. (2012). Biology and Spread of European Foul Brood: Some Preliminary Results. BBKA News 201: 19.
www.nationalbeeunit.com/index.cfm?pageid=166

HBP (2011). Advice for Obtaining Honey Bees. Healthy Bees Plan Advice Note number 5.
www.nationalbeeunit.com/index.cfm?pageid=167

HBP (2012) (Guidance for the Sale of Honey Bee Nuclei. Healthy Bees Plan Advice Note number 8.
www.nationalbeeunit.com/index.cfm?pageid=167

I PI (2010). The Insect Pollinator Initiative. *BBKA News* 184: 20-21.

Jones, B. & Marris, G. (2012). Honey bee diagnostics at Fera Part 1. *BeeCraft* 94(7), 7-9.
www.nationalbeeunit.com/index.cfm?pageid=166

Jones, B. & Marris, G. (2012). Honey bee diagnostics at Fera Part 2. *BeeCraft* 94(8), 9-11.
www.nationalbeeunit.com/index.cfm?pageid=166

Klein, A.-M., Vassière, B.E., Cane, J.H., Steffan-Dewenter, I., Cunningham, S.A., Kremen, C., Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. Proc. R. Soc. B 274: 303-313.
http://rspb.royalsocietypublishing.org/content/274/1608/303.full

Marris, G. (2010). BeeBase, A free online resource for beekeepers. *Gwenynwyr Cymru* (The Welsh Beekeeper).

Marris, G. & Ball, R. (2011). Hive Cleaning and Sterilisation. *BBKA News* 194: 15-18.
www.nationalbeeunit.com/index.cfm?pageid=166

OIE (2012). World Organisation for Animal Health - Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. Volume 1, Section 2.2. Apidae.
http://www.oie.int/international-standard-setting/terrestrial-manual/

Roetschi, A. *et al*. (2008). Infection rate based on quantitative real-time PCR of *Melissococcus plutonius*, the causal agent of European foulbrood, in honeybee colonies before and after apiary sanitation. *Apidologie* 39: 362–371

Tomkies, V. *et al*., (2009). Development and validation of a novel field test kit for European foulbrood. *Apidologie* 40: 63-72.

www.nationalbeeunit.com/index.cfm?pageid=172

Waite, R. J., *et al*. (2003). Controlling European foulbrood with the shook swarm method and oxytetracycline in the UK. *Apidologie* 34: 569-575.

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Web: www.sasa.gov.uk

European Union
(website for details of European Community legislation in force)
Web: http://eur-lex.europa.eu/browse/directories/legislation.html?locale=en

Animal and Plant Health Agency
New Haw, Addlestone, Surrey,
KT15 3NB
Email:
corporatecorrespondence@apha.gsi.gov.uk
Web: www.gov.uk/apha

Development, Northern Ireland (DARDNI)
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Tel: 02890 24488
Web: www.dardni.gov.uk

Agri-Food and Biosciences Institute (AFBI)
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Belfast, BT9 5PX
Web: http://www.afbini.gov.uk

Veterinary Medicines Directorate (VMD)
Woodham Lane,
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Tel: 01932 336911
Web: https://www.gov.uk/government/organisations/veterinary-medicines-directorate

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

British Beekeepers' Association
(county and local beekeeping associations)
National Agricultural Centre,
Stoneleigh,
Warwickshire, CV8 2LG
Tel: 08718 112282
Web: www.bbka.org.uk

Welsh Beekeepers' Association
Web: www.wbka.com

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

Bee Farmers' Association of the United Kingdom
Web: www.beefarmers.co.uk

International Bee Research Association
(library and beekeeping information services)
Unit 6, Centre Court,
Main Avenue, Treforest, CF3 5YR
Tel: 02920 372409
Web: www.ibrabee.org.uk

Ulster Beekeepers' Association
Web: www.ubka.org

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

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

Overseas information

NSW Department of Agriculture, Australia
Web: http://www.dpi.nsw.gov.au/agriculture/livestock/honey-bees/pests-diseases#Small-hive-beetle-in-honey-bees

Department of Entomology, University of Georgia, USA
Web: http://www.ent.uga.edu/bees/disorders/small-hive-beetle.html

University of Florida
Small hive beetle fact sheet
Web: http://www.invasive.org/species/subject.cfm?sub=9335

USDA Bee Research Laboratory
Beltsville, Maryland, USA
Web: http://www.ars.usda.gov/main/site_main.htm?modecode=20-22-05-00

Honey bee and pollinator extension website: Bee Health extension
Web: http://www.extension.org/bee_health

Plant Health Australia,
Canberra, Australia.
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Web:
http://www.planthealthaustralia.com.au/sitemap/
Web: http://beeaware.org.au/

Notes

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