Farm Production & Practice

Ministry of Agriculture and Fisheries

Brood Diseases In Honey Bees

Significance and Control

Other Keywords: American foulbrood; sacbrood; chalkbrood; beekeeping.

Three significant brood diseases are found in honey bees in New Zealand. American foulbrood is the most serious, and infected colonies must be destroyed to prevent its spread. Sacbrood has similar symptoms but its effects are relatively minor. Chalkbrood has only recently been confirmed in New Zealand (January 1984). Its symptoms are quite distinct from those of American foulbrood, and its effects on honey bee colonies are normally slight.

AMERICAN FOULBROOD

Cause

American foulbrood (AFB), also known as American brood disease, is caused by the spore-forming bacterium *Bacillus larvae* (BL). The disease itself is often referred to as BL.

Honey bee larvae are infected by eating *Bacillus larvae* spores with the brood food given to them by nurse bees in the hive. They are most susceptible to infection at 24–36 hours old.

The ingested spores germinate within the larval gut. The active stages (vegetative rods) penetrate the gut wall and enter the haemolymph or 'blood' of the larva, where they multiply rapidly. Millions of spores are formed, and the developing bee usually dies either at the prepupal stage or immediately after pupation.

As few as 10 *Bacillus larvae* spores can prove fatal when eaten by a day-old larva. When the larva dies its body will contain up to 2500 million spores, which are then available to infect another host and repeat the disease cycle.

Symptoms

Beekeepers must be familiar with the appearance of healthy brood and its development (fig. 1), so that any brood abnormality can be recognised immediately. AFB is usually simple to diagnose in the field.

Patchy brood pattern: Brood combs in an infected hive develop a patchy pattern: diseased brood collapse and die, contrasting with the healthy brood alongside. There are other causes of a patchy brood pattern—such as laying workers or a failing or inbred queen—but as it is a characteristic of AFB it should be treated with suspicion.

Appearance of cappings: The cell cappings covering diseased larvae and pupae appear moist, dark, and sunken. Adult bees begin to chew open the cappings to remove some of the decaying remains, giving the brood cappings a perforated appearance.

Colour of brood: Infected worker larvae turn a coffee-brown colour (fig. 2). They then collapse and die (fig. 3). After about a month the dead larvae form scales, which adhere tightly to the lower wall of the cells. If brood dies at the pupal stage the tongues may remain upstanding (fig. 4, and 5). This sign, if found, is conclusive proof of AFB, but it occurs only in a minority of cases.

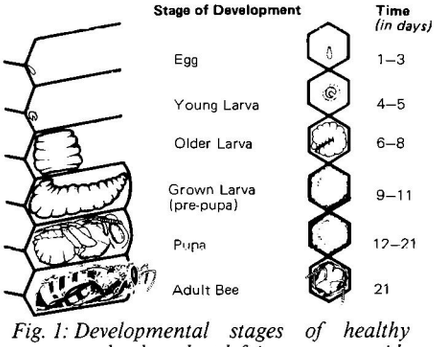

Fig. 1: Developmental stages of healthy worker brood: at left is a cut-away side view; at right is a view from the front of the cells.

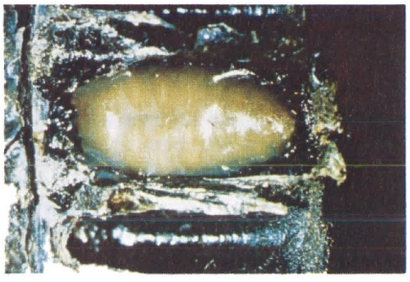

Fig. 2: Larvae infected with American foulbrood prior to dehydration. Note the relative lack of segmentation compared with sacbrood (fig. 8).

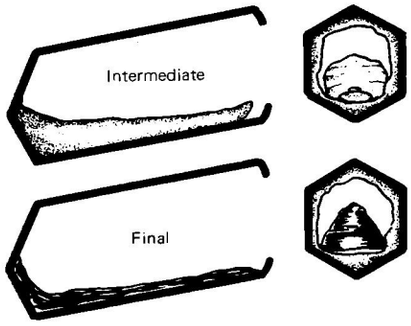

Fig. 3: Intermediate and final positions of decaying remains of a larva infected with American foulbrood.

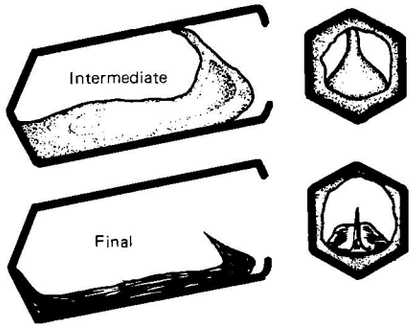

Fig. 4: Intermediate and final positions of decaying remains of a pupa infected with American foulbrood.

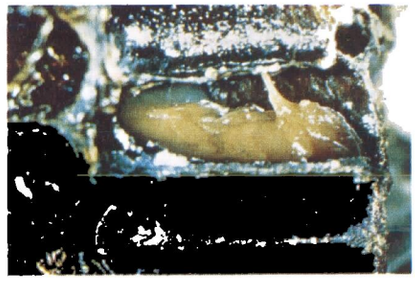

Fig. 5: Pupa infected with American foulbrood, showing collapse of the body but with the tongue remaining prominent.

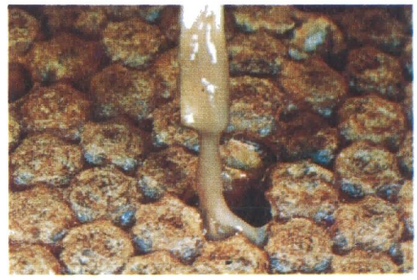

Fig. 6: The 'ropiness' test for American foulbrood. If a match is inserted into an infected larva before dehydration the contents can be withdrawn as a brown ropy thread.

Texture of brood: If a matchstick is inserted into an infected larva prior to its dehydration, the contents can be slowly withdrawn in a brown ropy thread 10–30 mm long. This is known as the 'ropiness' test (fig. 6). The match should be left in the comb or burnt in the smoker, as it will be contaminated with *Bacillus larvae* spores.

Smell: Large amounts of infected brood can have a characteristically foul or "fishy" odour. As people differ in their ability to detect odours, smell is not a reliable test.

Spread and Control

Bacillus larvae is infectious. Also, its spores are resistant to boiling water, desiccation, drugs, and other chemicals. They can remain viable outside the hive for at least 35 years.

In New Zealand about 4 percent of apiaries and 0.7 percent of hives are infected by AFB each year. The disease can be contained and controlled by regular hive inspection, adoption of preventative measures, and the burning of infected hives.

AFB is spread by:

- Beekeepers transferring frames of brood or stores from diseased hives to disease-free hives.
- Beekeepers using hive equipment which at some time has been contaminated with BL spores.
- Beekeepers extracting diseased honey and returning the contaminated extracting supers to disease-free hives.
- Beekeepers feeding diseased honey, whether in the comb or extracted.
- Beekeepers feeding pollen which has been trapped from diseased hives.
- Bees robbing honey from diseased hives or feral colonies which are weak or dead.
- Adult bees carrying BL spores on their bodies and drifting into neighbouring hives.
- Swarms issuing from diseased hives.

Destroying Infected Hives

Because of the highly infective nature of *Bacillus larvae,* diseased hives, bees, and honey must be destroyed by burning.

Killing the bees: Diseased hives should be destroyed at dusk, or on a cold wet day, when no bees are flying. To begin, carefully block the hive entrance after first ensuring the hive is otherwise bee-tight. Next, raise the lid and hive mat and pour about half a litre of petrol or diesel over the bees and combs. Finally, close the hive and leave it undisturbed for 10–15 minutes until all the bees have been killed by the fumes.

Burning the bees and combs: Dig a hole about 1 metre in diameter (according to the amount of material to be dealt with) and at least ½ metre deep, close to the affected hives. The hole should be deep enough to take any liquid honey that may escape the fire, and to avoid subsequent disturbance or exposure.

Light a fire in the hole, using paper, small sticks, and honey-free combs, which will burn easily. *Take care with the petrol-soaked combs, which may explode.* Build up a good fire and add the hive boxes, floorboard, dead bees, combs of honey and brood, and hive lid or mat. Any unburnt honey will seep to the bottom. When the fire has completely burnt out, fill in the hole.

If local fire restrictions prevent the burning of hives on site, specific permission is required from MAF for their removal to another location.

Sterilisation of protective clothing and hive parts: The hive tool used in the operation should be scorched by fire, and smoker bellows and gloves or hands washed with a strong disinfectant, mixed 50:50 with water. Gloves and overalls should be washed later in hot soapy water.

A MAF inspector may approve the salvaging of relatively new hive boxes, bottom boards, lids, and queen excluders by the paraffin wax sterilisation method. This involves immersing the equipment for at least 10 minutes in paraffin wax heated to 160°C. Further information can be obtained from MAF apicultural advisory officers.

Legal Requirements

The Apiaries Act 1969 and its amendments include a number of provisions relating to the control of AFB:

- Beekeepers must register with MAF all apiaries where bees are kept for more than 14 days.
- Each spring every beekeeper is required to inspect all hives for AFB, and must complete a hive inspection statement (provided by MAF) and return it by 7 December.
- A MAF inspector must be notified immediately if AFB is discovered, and the beekeeper must take proper measures to control the disease.
- The use of drugs for treatment or control of brood diseases is prohibited.
- If AFB is found in an apiary, no honey or hives may be removed for a period of 28 days unless MAF approval is obtained.

Although apiaries may be examined by MAF inspectors as part of an inspection programme, the onus is on the beekeeper to inspect hives, to report disease, and to take the necessary action if disease is found.

SACBROOD

AFB can sometimes be confused with sacbrood, a viral disease of honey bee brood. If a beekeeper is uncertain about identifying a brood disease, confirmation should be obtained from an experienced beekeeper or MAF apicultural adviser.

Symptoms

Colonies infected with sacbrood may have a patchy brood pattern, with sunken and perforated cappings.

Brood dies from sacbrood infection at the late larval (prepupal) stage, never as a pupa. The decaying larvae turn yellow, then brown, grey, and later black. The head is always darker than the rest of the body and is often characteristically raised (fig. 7).

The larval skin becomes tough and plastic-like (fig. 8), and keeps the segmented appearance of healthy brood. Diseased larvae can often be removed from the cell intact, but if the skin is punctured the watery body contents run out.

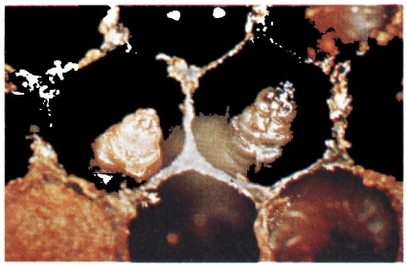

Fig. 7: Two larvae dead from sacbrood (cappings removed). Body segmentation is still visible. Note the darkened raised head.

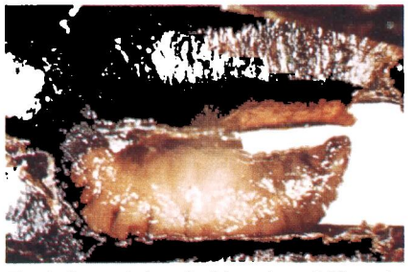

Fig. 8: Larva infected with sacbrood. Note the darkened head and plastic body skin.

Spread and Control

Sacbrood is an endemic disease, present in many colonies without usually becoming serious. The disease is only obvious in some circumstances, particularly in spring. Colonies that show symptoms in spring usually recover of their own accord, and it is uncommon to see sacbrood persisting during the honey flow.

Colonies which suffer badly from sacbrood usually recover if they are requeened. If the colony has become weak this is best done by killing the old queen and uniting on a nucleus.

It is most important that sacbrood is not confused with AFB. Both diseases can be present in a hive at the same time.

CHALKBROOD

Chalkbrood is found in many important beekeeping areas of the world, including North America, Western Europe (including Britain), and the USSR. In these areas the disease is seldom regarded as anything more than a nuisance with little or no economic effect.

In 1957 a honey bee colony in Southland was tentatively diagnosed as having chalkbrood, but there was no evidence of the disease having become established.

In late 1983 chalkbrood was diagnosed in a brood sample from Kerikeri, and a survey by MAF in January 1984 showed the disease was widespread north of Whangarei. Chalkbrood has also been reported in South Auckland and in the South Island.

Cause

Chalkbrood is caused by a fungus called *Ascosphaera apis*. This fungus has two phases in its life cycle—a spore stage and an active or vegetative stage. Active growth is by means of white filaments or hyphae, which form a large mass called the mycelium.

There are no males and females with *Ascosphaera apis,* but when two different strains of the fungus come into contact sexual reproduction occurs, and dark fruiting bodies are formed which contain the spores.

Life Cycle of Chalkbrood in Colony

The chalkbrood infection begins in honey bee larvae when they are fed brood food which is contaminated with *Ascosphaera apis* spores. Larvae 3–4 days old are most susceptible, especially if they are chilled slightly about 2 days after infection.

The spores germinate in the larval gut, and the fungus grows there as filaments or hyphae. The mass of hyphae (or the mycelium) breaks through the gut wall and invades the larva's body, though the head is often left intact.

Spore formation is always on the outside of the infected larva.

Symptoms

Larvae almost always die at the elongated stage, and only rarely when still coiled in the bottom of the cell. Both capped and uncapped cells can contain diseased larvae, so it is necessary to pick the cappings off any sunken or discoloured cells to diagnose the disease, in the same way as when checking for AFB.

Diseased larvae first turn vivid white, much whiter than the normal pearly-white of healthy brood, and can be quite obvious in a brood comb (fig. 9 and 10). At this stage the body has a furry surface because of the fungal mycelium, especially towards the rear of the cell.

If removed from the cell the larva is moist, hexagonal-shaped, and swollen.

Fig. 9: Brood comb with a fairly heavy chalkbrood infection. Note the white cells and darkened cappings.

In most cases the larval head appears clearly as a dark spot in these remains.

The larval body later dries out and becomes a hard chalky lump, and at this stage the remains are termed "mummies" (fig. 11). They are mostly white, though some are partly or completely grey to black because of the growth of fruiting bodies or spores on the mummy surface. A comb with a lot of mummies in it will rattle when shaken.

Larvae in the cells which are infected with chalkbrood can be mistaken for mouldy or white pollen. Examination of the cell contents shows the difference: pollen is packed in the cell as a solid mass, whereas a soft chalkbrood larva retains some of the shape of a honey bee larva. Infected larvae can be easily removed from the cell.

In light chalkbrood infections adult bees generally uncap diseased cells, and the larval remains can be easily seen. Bees may actually chew at the remains before they become dried out, and once mummies are formed they are often removed.

Discarded mummies can be found deposited on the hive bottom board or on the ground outside the entrance. In these situations chalkbrood mummies can be confused with mouldy pollen. Mouldy pollen, however, is cylindrical in shape and is easily pulverised between the fingers, whereas mummies are elongated and much flatter than pollen and are not readily crushed.

Spread

The spores produced in the fruiting bodies are the means by which chalkbrood is spread. The disease has a fairly low ability to spread naturally, and most disease transfer is by the beekeeper.

Common means of spreading chalkbrood are by exchanging equipment and bees between colonies, feeding contaminated honey or pollen, and using contaminated hive tools and gloves. The other main cause of disease spread in apiaries is through drifting of adult bees between hives.

As chalkbrood is a fungus, it is thought that its spores may be windborne and able to survive in the soil. It is known that chalkbrood spores can remain viable for at least several years, and possibly as long as 15 years.

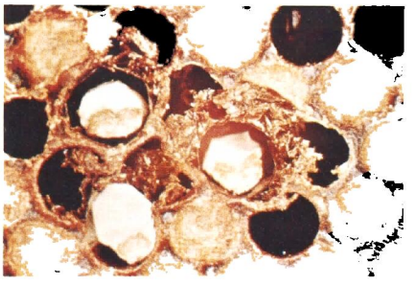

Fig. 10: Larvae dead from chalkbrood before drying out to the mummy stage. The bodies are vivid white with darkened heads.

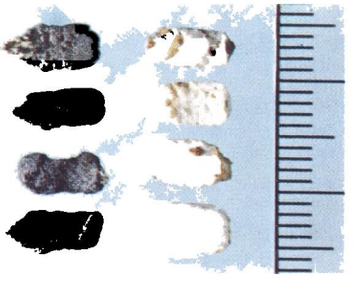

Fig. 11: Chalkbrood mummies removed from the comb. The dark mummies are covered with fruiting bodies. (Scale in millimetres.)

Occurrence of Chalkbrood

In areas where chalkbrood is present there is often a low level of the disease present in many apiaries. As chalkbrood is caused by a fungus, it is most apparent in damp, cool conditions. Because of this, most infections appear in colonies during the spring or early summer period. At this time of year colonies have high ratios of brood to bees and are most susceptible to temperature changes and chilling. Chalkbrood is often found on the periphery of the brood nests and in drone brood, where such chilling is most likely to occur.

Chalkbrood is usually most severe when a colony is put under stress, which often happens because of beekeeper negligence. Excessive damp in the hive, lack of re-queening, and shortage of stores are common causes of stress.

Control

No chemicals are registered for the control of chalkbrood, either in New Zealand or overseas. A few substances have shown an effect on chalkbrood, but the disease has never proved serious enough to justify the research needed to find a reliable cure.

Because chalkbrood mummies can be removed easily by housecleaning bees, the disease can often disappear from a hive without assistance from the beekeeper. As with sacbrood, a chalkbrood infection usually vanishes at the beginning of the honey flow.

Control is rarely necessary, although heavily infected combs are sometimes

removed from the colonies and destroyed or melted down.

Prevention

Sound management practices can reduce the impact of chalkbrood in an apiary.

Apiary site: Damp and cold conditions favour the onset of the disease. Make sure that sites are sheltered, sunny, and have adequate air drainage.

Drifting is a prime cause of spread between hives. Position hives in a low-drift layout. (See Aglink FPP 535.)

Hives: Top ventilation is a must to ensure that hive interiors do not become excessively damp in winter and spring.

Bee stock: Increased disease resistance can be gained by breeding queens from colonies which show a low degree of chalkbrood infection. Drone mothers should also be bred with chalkbrood resistance in mind.

Italian bees, with their greater housekeeping ability, have proved to be more resistant to chalkbrood than darker races.

Bee colonies: Keep colonies strong at all times to reduce the risk of brood being chilled, which leads to greater fungal development in larvae.

Other AgLinks of Relevance

FPP 428: Beekeeping; Overseas Diseases and Pests.
FPP 535: Beekeeping; Apiary Sites; How to Prevent Drifting.

TABLE 1: CHARACTERISTICS OF AMERICAN FOULBROOD, SACBROOD, AND CHALKBROOD

	AFB	*Sacbrood*	*Chalkbrood*
Brood pattern	Patchy.	Patchy.	Not changed in light infections. May become patchy.
Cappings	Sunken, darker in colour, perforated.	Perforated or completely removed, sometimes sunken.	Become dark and sunken in heavy infections.
Age of dead brood	Older larvae or young pupae.	Older larvae.	Larvae, before or after capping.
Colour of dead brood	Off-white or yellow, then light brown, then dark brown to black; colouration even.	Yellow, then brown to grey. Head end usually darkest.	Soft larvae are vivid white, with a conspicuous yellow or dark head. Hard mummies are either creamy-white or grey-black.
Consistency of dead brood	Smooth rope 10–30 mm long when at brown stage; later tacky.	Plastic sac, watery contents (often lumpy).	Initially soft, with a furry surface swollen to a hexagonal shape, filling the cell. Later shrinking to a hard chalky mummy.
Tongue	Prominent in dead pupae but not dead larvae; may be attached to opposite wall of cell.	Rarely prominent; never reaches opposite wall of cell.	Not noticeable, but head is a conspicuous dark spot in soft larvae.
Brood remains	Dark scales, sometimes tacky, which adhere tightly to the bottom of the cell.	Dark scales, easily removed from cell.	Creamy-white or grey-black mummies, easily removed from cell. Also found on floorboard or at hive entrance.
Smell	May smell putrid in advanced cases.	Occasionally sour smell present.	Not noticeable.

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