insects

Microplitis demolitor and ascovirus: Important natural enemies of helicoverpa

Helicoverpa (often called heliothis) is a serious pest of southern Queensland crops, particularly grain legumes, summer grains and cotton. There are two pest species of helicoverpa in Australia that this publication refers to as 'helicoverpa': the native budworm, *Helicoverpa punctigera*; and the cotton bollworm or corn earworm, *H. armigera*. The wasp *Microplitis* and the disease ascovirus kill the caterpillars of both *H. armigera* and *H. punctigera*.

About *Microplitis* and ascovirus

What is *Microplitis?*

Microplitis demolitor is a small native wasp. It is one of the key beneficial insect species that attack helicoverpa caterpillars in Australia. Female wasps also play an important role in spreading ascovirus, a lethal disease of helicoverpa caterpillars.

Microplitis is a parasitoid

A parasitoid is an insect that kills its host to complete its life cycle. Parasitoids are usually described according to the life stage of the host that they attack. *Microplitis* wasps are called larval parasitoids because they lay their eggs in (parasitise) small helicoverpa caterpillars (Figure 1).

Figure 1. Microplitis *cocoon attached to a dying helicoverpa caterpillar on a sorghum leaf. Finding these distinctive fawn cocoons next to dead or dying caterpillars is a key indicator that* Microplitis *wasps are active in a crop. (Photo: B. Scholz, DPI&F)*

Queensland Government
Department of Primary Industries and Fisheries

What is ascovirus and what is its link with *Microplitis?*

Ascovirus lethally infects a range of caterpillar species. The ascovirus that infects helicoverpa is transmitted from caterpillar to caterpillar by female *Microplitis*, *Heteropelma* and *Netelia* parasitoid wasps. When a female wasp lays an egg (stings) inside an ascovirus-infected caterpillar she picks up the disease on her ovipositor (stinger). When she stings subsequent caterpillars, her contaminated ovipositor infects those caterpillars. The ascovirus prevents the wasp's offspring developing inside the caterpillar host. However, as the virus on the wasp's ovipositor wears off and decreases over time, the wasp can then produce viable offspring in uncontaminated caterpillars.

How important are *Microplitis* and ascovirus to helicoverpa control?

A female wasp can parasitise approximately 70 helicoverpa caterpillars in her lifetime. Together *Microplitis* and ascovirus can have a significant impact on helicoverpa populations, especially when these populations are low and/or close to the economic threshold. The percentage of helicoverpa caterpillars killed by *Microplitis* parasitism and resulting ascovirus infection can exceed 75 per cent, though 30–50 per cent is more typical.

How is ascovirus different from the other helicoverpa virus — NPV?

Helicoverpa NPV only kills helicoverpa spp. Ascovirus, on the other hand, infects other moth caterpillars in the Noctuid family (the same family to which helicoverpa belongs). Some of these noctuids killed by ascovirus include pests such as armyworms (*Spodoptera* spp.).

Ascoviruses are not related to the commercially available NPVs (Vivus Gold®, Gemstar®). They belong to a separate virus family. A caterpillar infected with NPV will turn black, liquidise and splatter. A caterpillar infected with ascovirus is much harder to detect as being infected.

Interpreting mortality data

Some of the helicoverpa mortality caused by *Microplitis* is as a direct result of parasitism. However, direct parasitism is not the only way that *Microplitis* impacts on helicoverpa populations. As discussed, *Microplitis* is also the main carrier (vector) of an ascovirus disease that kills helicoverpa caterpillars. Understanding this important link between *Microplitis* and ascovirus is essential for interpreting the overall impact of *Microplitis* on helicoverpa in a crop.

Figure 2. shows the overall impact of *Microplitis* against helicoverpa caterpillars in three unsprayed cotton fields at Warra, in southern Queensland, during the 1996–97 season. This graph shows that *Microplitis* was directly killing only up to 32 per cent of the helicoverpa caterpillars collected. However, taking into account the caterpillars infected with ascovirus and *Microplitis* is shown as responsible for killing up to 75 per cent of the second and third instar helicoverpa caterpillars in these unsprayed cotton crops —a significant contribution to the control of helicoverpa.

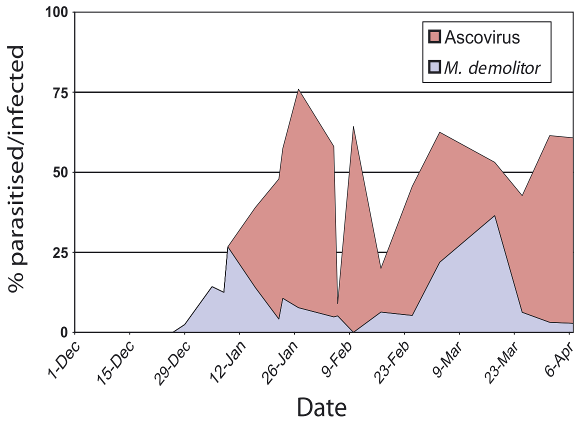


Figure 2*. Percentage of helicoverpa larvae killed by* Microplitis *and ascovirus. Estimate the overall impact of parasitism and disease by adding the mortality caused by each. Data collected from unsprayed cotton at Warra, south-east Queensland during the 1996-97 season.*

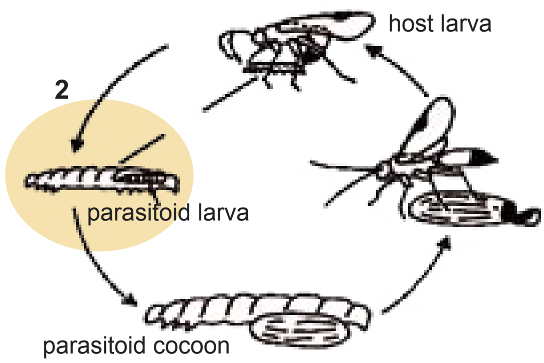
Microplitis lifecycle

Understanding the lifecycle of the *Microplitis* wasp is the key to understanding its role in helicoverpa control.

From egg to adult, the *Microplitis* lifecycle takes about 12 days. This is made up of 7 days from egg laying to forming a pupa (pupation), and then 5 days for pupal development.

1. After finding a helicoverpa caterpillar, the female Microplitis *wasp uses her ovipositor to insert an egg into the caterpillar's body. (Photo: M. Shepard, UQ)*

2. The Microplitis *larva hatches from the egg placed inside the helicoverpa caterpillar. It stays inside the caterpillar and grows, feeding on the internal tissues of its host (the helicoverpa caterpillar).*



Life cycle of Microplitis demolitor. *(D. Murray, DPI&F).*

3. About 7 days after the caterpillar was first parasitised, the Microplitis *larva chews a hole in the side of the caterpillar and emerges. (Photo: B. Scholz, DPI&F)*

4. Still attached to the side of its now dying host, the Microplitis *larva quickly spins a fawn-coloured cocoon around itself. Once inside the cocoon, the* Microplitis *larva turns into a pupa. (Photo: B. Scholz, DPI&F)*

5. After about 5 days as a pupa, the now fully developed adult wasp is ready to emerge from the cocoon. It chews a lid off the cocoon and crawls out. The caterpillar that was parasitised may still be alive, but its internal tissues are damaged and a hole has been chewed in its side, so it will soon dehydrate and die. (Photo: B. Scholz, DPI&F)

6. Emerged adult wasps will mate and females will seek out helicoverpa caterpillars to parasitise. (Photo: B. Scholz, DPI&F)

Identifying *Microplitis* in the crop

Detecting and recognising the signs of *Microplitis* activity in a crop is important so that they can be monitored, and the impact of their parasitism factored into decision making.

Identifying adult wasps

Microplitis adults are small (3 mm) black–brown wasps. They are often seen flying slowly above the crop canopy in search of caterpillars (hosts). *Microplitis* wasps are active throughout the day, from shortly after sunrise until just after sunset. If *Microplitis* is active in a crop, sweep netting will often capture wasps that are in the plants (Figure 4).

Figure 4. *Using a sweep net to monitor* Microplitis *activity in a crop. (Photo: H. Brier, DPI&F)*

What caterpillar stage does *Microplitis* attack?

Wasps have a preference for second instar helicoverpa caterpillars (4–7 mm). This is important for pest management because, in the absence of *Microplitis* or other natural enemies, most helicoverpa caterpillars that reach this age have a good survival rate and go on to cause crop damage.

Third and fourth instar caterpillars are also suitable as *Microplitis* hosts, but are parasitised less frequently because they vigorously defend themselves, sometimes injuring or killing the wasp.

Occasionally, twin parasitoids emerge from a single host and rarely (in about 1 per cent of cases) the host caterpillar survives and pupates normally after the wasp has emerged.

Identifying parasitised caterpillars

In the field, you can identify parasitised helicoverpa caterpillars by performing a simple split test. Parasitised caterpillars will only grow to about 15 mm, so caterpillars smaller than this are potentially *Microplitis* hosts. To identify whether a caterpillar is parasitised, hold it across a forefinger with one thumb on the rear end of the caterpillar, and with the other thumb on the head. Gently stretch the caterpillar until the skin ruptures. A *Microplitis* larva developing within the caterpillar looks like a white maggot up to 4 mm long (more mature *Microplitis* larvae are browner in colour; see Figure 5).

Figure 5. *Split helicoverpa caterpillar showing* Microplitis *larva. (Photo: B. Scholz, DPI&F)*

Clues to *Microplitis* activity levels

To determine whether *Microplitis* is active and present in significant numbers:

- Look for adult wasps flying above the crop or use a sweep net to check in the crop.
- Collect caterpillars shorter that 15 mm and perform the split test on a number to estimate percentage parasitism.
- Look for visible signs of parasitoid activity, that is, the distinctive fawn cocoons (often next to a dead or dying caterpillar) and/or small pale caterpillars that might be infected with ascovirus (see *Ascovirus symptoms, page 6*).
- Crop scouting data can also be an important trigger to check for *Microplitis*. Remember that *Microplitis* parasitises second instar caterpillars (4–7 mm). Therefore *Microplitis* activity should be suspected in situations when previous counts have shown the presence of eggs and very small caterpillars, but these do not seem to be developing through to third instar caterpillars and larger (that is, longer than 15 mm). Although this situation might also be due to other natural enemies, combined with the previous observations, it is a good indication that *Microplitis* is exerting some control on the helicoverpa population.

Parasitised helicoverpa caterpillars cause much less crop damage before they die compared to unparasitised caterpillars. Experiments have shown that a caterpillar parasitised by *Microplitis* consumes about 90 per cent less than a healthy caterpillar. This demonstrates the importance of parasitism on helicoverpa feeding behaviour. Because they do so little damage, do not include parasitised caterpillars in counts during crop scouting.

Figure 9. *Ascovirus vector* Microplitis demolitor *about to sting a helicoverpa caterpillar. (Photo: R. Lloyd, DPI&F)*

Ascovirus: Good for helicoverpa management, not so good for *Microplitis*

Microplitis is the main vector of ascovirus and so plays a key role in increasing the percentage of caterpillars affected by this disease. However, high ascovirus levels can eventually cause *Microplitis* numbers to decline. How does this happen?

As ascovirus becomes more widespread in a helicoverpa population, female wasps become infected with ascovirus and pass the infection on to caterpillars that it parasitises. Unfortunately for *Microplitis*, when a parasitised caterpillar is killed by ascovirus, so is the *Microplitis* larva developing inside. As a result, high levels of ascovirus may lead to a decline in *Microplitis* wasp populations.

Ascovirus lifecycle

Ascovirus establishes in the *helicoverpa* population through spring-summer. The disease is transmitted from caterpillar to caterpillar by wasps (such as *Microplitis*). Ascovirus could be transmitted directly from one caterpillar to another by spitting – for example, when caterpillars encounter each other on the plant. Laboratory studies have also shown that ascovirus can be transmitted by cannibalism.

The way in which ascovirus survives winter is not clear. It could persist in low numbers of helicoverpa, or use alternative hosts such as *Spodoptera* larvae (e.g. cluster caterpillars and armyworms).

When ascovirus particles enter the caterpillar's body they multiply in tissue cells, eventually infecting the haemolymph (blood). This causes the haemolymph to change from clear to milky. The caterpillar stops eating, but may not die for several days or weeks, surviving in a lethargic state.

Figure 6. *Some ascovirus-infected caterpillars stay in exposed situations and look as though they have been grazing lightly in the one place. Small 'windows' in the leaves next to infected caterpillars are a typical symptom. (Photo: M. Miles, DPI&F)*

Ascovirus symptoms

In cases where a *Microplitis* wasp has both parasitised a caterpillar and infected it with ascovirus, the symptoms seen are those of the disease rather than of the parasitoid. When ascovirus kills the caterpillar, it also kills the developing *Microplitis* larva. Caterpillars infected with ascovirus will generally stop eating within two days. They stop growing, but can live for weeks in a lethargic state before they die (Figures 6 & 7). Be aware that although ascovirus-infected caterpillars are smaller than similarly aged non-infected caterpillars, they may look otherwise healthy.

Some other signs to look for:

- The blood of an ascovirus-infected caterpillar is white and creamy, whereas the blood of a healthy caterpillar is clear. Blood colour gives the best diagnosis in the laboratory and can be tested by splitting or pricking the caterpillar (Figure 8).
- Small pale caterpillars in unusually exposed situations (e.g. on a leaf) that look as though they have been feeding in the same place for some time, making a window in the leaf, are probably infected with ascovirus.
- Because infected caterpillars can take a long time to die, ascovirus infection in the population can show up in crop scouting data over a series of checks as a number of small caterpillars (shorter than 8 mm) in the crop, with very few medium-large caterpillars coming through. Photo: M. Miles (DPI&F)

Figure 7. *The two caterpillars in the photo are the same age. The caterpillar infected with ascovirus (on right) will stop eating and growing, and may be paler in colour, but can appear otherwise healthy. (Photo: R. Lloyd, DPI&F)*

Figure 8.The white and creamy blood of an ascovirus-infected Spodoptera litura *caterpillar (left) and the clear blood of an uninfected caterpillar (right). The symptoms are the same in helicoverpa caterpillars. (Photo: I. Newton)*

Can *Microplitis* be effective against large populations of helicoverpa?

As a general rule, *Microplitis* has greater impact on near-threshold helicoverpa populations than against populations in excess of the economic spray threshold for that crop. If we consider the example of a crop where the economic threshold is 2 caterpillars/m^2, 50 per cent parasitism by *Microplitis* will reduce a population of 3 caterpillars/m^2 to below threshold, but will not be effective on its own against a population of 10 caterpillars/m^2.

When is *Microplitis* most effective?

The overall effectiveness of *Microplitis* is related to the abundance of the wasp in the farming system. *Microplitis* is active in all crops attacked by helicoverpa, except chickpea where the plant's acid secretions deter predators and parasitoids. *Microplitis* numbers generally start off low in the spring, before building up and eventually peaking by late summer. In early spring, even low numbers of *Microplitis* can parasitise a significant proportion of the helicoverpa population because the helicoverpa numbers are also low (e.g. in spring mungbeans, sunflowers and sorghum).

Microplitis populations will increase during the season provided there are hosts to breed up on, and are not disrupted by insecticides.

Minimising insecticide disruption of *Microplitis*

Insecticide selection

Broad-spectrum insecticides will kill *Microplitis*. The cotton industry's IPM guidelines contain a table with information on the impact of different insecticides on wasps (including *Microplitis*). Find this table at www.cotton.crc.org.au/publications.

Spray timing

Even a biological insecticide, like NPV and Bt, can kill *Microplitis* larvae if the host caterpillar is killed before the parasitoid can complete its development. The cocoon (pupal stage) of *Microplitis* is less susceptible to insecticides than the adult and larval stages. It is not practical to try and time sprays to preserve *Microplitis* in crops where there is a range of life-stages present.

In sorghum, it is possible to time NPV sprays to conserve *Microplitis* because helicoverpa egg lay occurs over a relatively short period around flowering (10 days). To conserve *Microplitis*, NPV sprays should be applied at 3 days after 50 per cent of heads in the field have completed flowering (that is, brown anthers to the base of the head). This timing allows most of the *Microplitis* larvae time to emerge before their caterpillar hosts are killed by the NPV infection.

Further information

DPI&F information

To obtain copies of DPI&F publications, contact the DPI&F Call Centre on 13 25 23 or via the DPI&F website www.dpi.qld.gov.au.

Understanding helicoverpa ecology and biology in southern Queensland: Know the enemy to manage it better. DPI&F Brochure. 2005. QI07078.

Parasitoids: Natural enemies of helicoverpa. DPI&F Brochure. 2005. QI04081.

Using NPV to manage helicoverpa in field crops. DPI&F Brochure. 2005. QI04080.

Crop insects: The Ute Guide. Northern Grain Belt Edition. 2000. ISSN 0727–6273

DPI&F Summer and Winter Crop Management Notes on CD-ROM

Infopest – a DPI&F national database on CD-ROM, containing up-to-date information on all registered agricultural and veterinary chemicals.

Heliothis Stateline, DPI&F Newsletter. ISSN 1441–4244.

Other publications

Cotton Pest Management Guide (annual publication). NSW Department of Primary Industries, Australian Cotton CRC. ISSN 1442–8792.

The Cotton Pest and Beneficial Guide, Cotton Research & Development Corporation. ISBN 0 7242 6633 X.

ENTOpak – A compendium of information on insects in cotton. Available from the Technical Resource Centre at the Australian Cotton Research Institute, Narrabri. Phone (02) 67991534.

Online Information

The DPI&F website www.dpi.qld.gov.au/ fieldcrops is constantly updated with the latest pest management information.

Information on up-to-date pesticide registrations is on the Australian Pesticides and Veterinary Medicines Authority (APVMA) website www.apvma.gov.au.

The Australian Cotton CRC website www.cotton.crc.org.au has a variety of information related to integrated pest management including:

Impact of insecticides and miticides on predators in cotton

Current Insecticide Resistance Management Strategy

Integrated Pest Management Guidelines for Cotton Production Systems in Australia

Online version of *The Cotton Pest & Beneficial Guide*

Acknowledgements

The authors thank Dr Rob Annetts and Dr Ian Newton for technical input.

About the authors

The DPI&F Entomology team is a leader in the science of managing insect pests and their natural enemies in broadacre farming systems.

Information series ISSN 0727-6273 QI04079
Agdex No. 624 2005

This work has been supported by these organisations

Grains Research & Development Corporation

Cotton CRC

Australian Government
Cotton Research and Development Corporation