

# insects

## Understanding *Helicoverpa* ecology and biology in southern Queensland:

### Know the enemy to manage it better

#### About helicoverpa

*Helicoverpa* (often called *heliiothis*) is a serious pest of southern Queensland crops, particularly grain legumes, summer grains and cotton. Understanding the lifecycle and behaviour of *helicoverpa* improves our chances of managing this pest sustainably.

#### Two pest species

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*. Because *H. armigera* has developed resistance to a wide range of insecticides, it is more difficult to control (Figures 1 & 2).



Figure 1. Large *Helicoverpa armigera* larva on a mungbean pod (Photo: J. Wessels, DPI&F)

#### *Helicoverpa* AWM and IPM

Recent strategies such as area-wide management (AWM) and integrated pest management (IPM) aim to restrict the build-up of *helicoverpa* populations to below damaging levels. Successful AWM and IPM strategies (which combine biological, cultural and chemical control options) require a more sophisticated understanding of *helicoverpa*’s lifecycle and biology than relying on insecticides alone.



Figure 2. Female *helicoverpa* moth (Photo: J. Wessels, DPI&F)



# A tale of two species — The basics of *Helicoverpa* ecology in southern Queensland

To manage *H. armigera* and *H. punctigera* well, it is important to understand the basic differences between the two species. In particular, differences in the timing of annual events that influence their population build-up.

## *Helicoverpa armigera*

Most *H. armigera* moths that appear in spring come from populations that survive locally from year to year. So although there may be low levels of *H. armigera* moths in the migratory population, this is not the major source of *H. armigera*.

In southern Queensland and areas further south, the majority of *H. armigera* moths overwinter as pupae in the soil. These overwintering pupae survive in a state of suspended development (diapause). In most seasons, diapausing pupae can be found under late summer crops such as sorghum, maize and cotton.

Most moths emerge from these diapausing pupae during October. After one or two generations in spring and early summer, *H. armigera* numbers increase to become the dominant species in mid-summer to autumn.

In central Queensland, and further north, winter temperatures are warm enough for *H. armigera* not to enter diapause. As a result, these regions experience year-round *Helicoverpa* activity.

While *H. punctigera* can overwinter in southern cropping regions, pupae numbers are usually low.

For more information on pupae and diapause, see page 6.

There is no simple solution to *Helicoverpa* control in a farming system that provides a wide range of food sources throughout the year (Figure 3).

## *Helicoverpa punctigera*

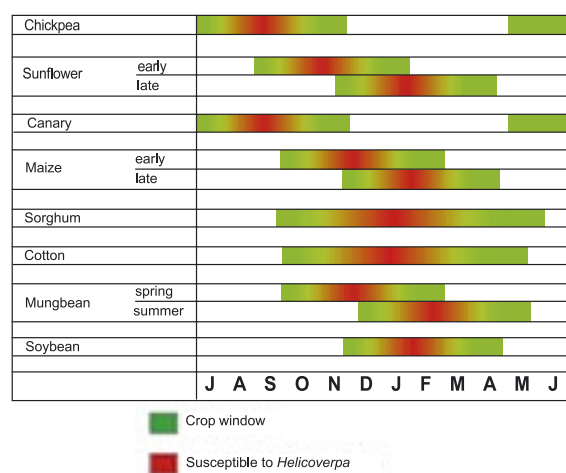
Where do *H. punctigera* moths come from?

Although both species of *Helicoverpa* are capable of travelling hundreds of kilometres on high altitude winds, this characteristic is more typical of *H. punctigera*.

*Helicoverpa punctigera* breeds during winter on flowering plants in inland Australia, when there is sufficient rainfall for broadleaf vegetation to flourish. When this inland vegetation dies off in late winter/spring, the moths move out. Migratory moths reach the cropping areas by flying on the warm winds that precede cold fronts in spring.

When do the moths arrive?

These spring migratory flights make *H. punctigera* an early season pest. The likely magnitude of these influxes of *H. punctigera* can be estimated by monitoring the breeding areas in inland Australia.



**Figure 3.** Shows a typical pattern of *Helicoverpa* host availability in a southern cropping region of Queensland. It is this continuous availability of hosts that potentially allows successive generations of *Helicoverpa* to build up in a cropping region throughout the year.

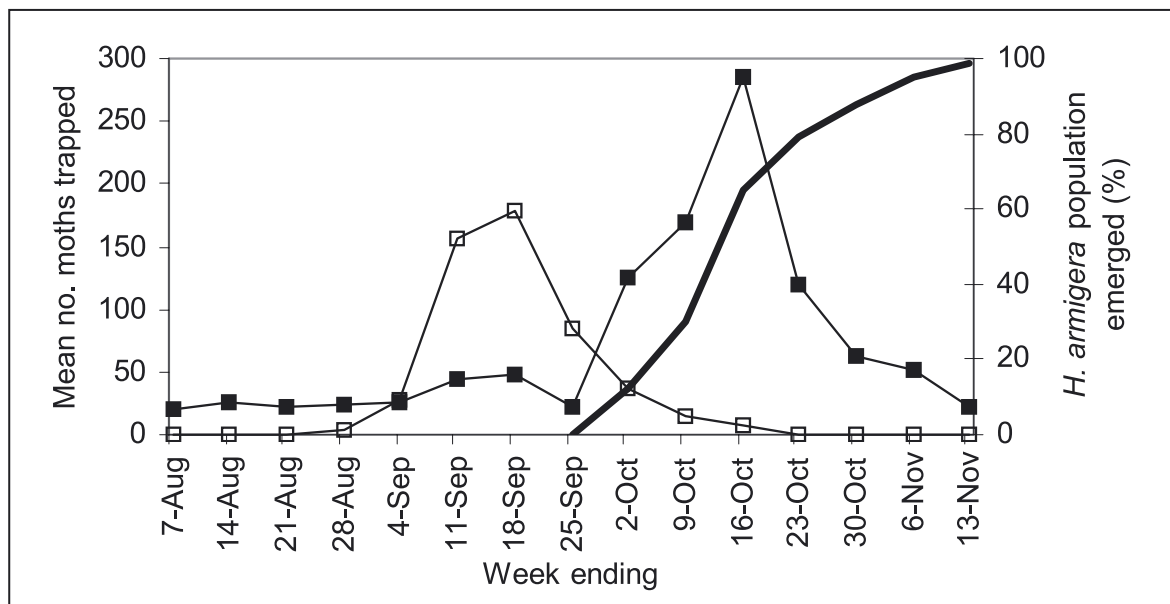
## How do we know when the moths have arrived, or are emerging from diapause?

Pheromone traps and computer modelling are two tools used routinely to monitor the arrival of the first *H. punctigera* moths, and the emergence from diapause of local *H. armigera*.

Pheromone traps attract male moths using the sex pheromone (a chemical attractant) that female moths emit to attract mates. *Helicoverpa armigera* and *H. punctigera* pheromones are different, so each species can be monitored separately. Pheromone traps, baited with synthetic pheromone lures, are used to monitor the arrival of *H. punctigera* moths over spring (Figure 4). The computer model uses current local temperatures to calculate the rate of development of pupae in the soil, and predicts the timing of emergence of moths. Pheromone traps specific to *H. armigera* can confirm the timing of the emergence. Figure 5 illustrates the relative timing of moth immigration, predicted emergence and actual emergence for the two species in 1999, a typical season.



**Figure 4.** A pheromone trap used to monitor *helicoverpa* moths.  
(Photo: M. Miles, DPI&F)



**Figure 5.** Pattern of *H. punctigera* immigration (—□—), predicted *H. armigera* emergence from diapause (—) and observed *H. armigera* emergence (—■—). The graph shows how *H. armigera* activity commences at the time that emergence from diapause occurs, reinforcing that the local diapausing population makes a large contribution to the seasonal activity. Calculations are based on actual pheromone trap catches and seasonal temperatures for Jimbour, 1999.

# Lifecycles

Lifecycles of *H. armigera* and *H. punctigera* take 4-6 weeks from egg to adult in summer, and 8-12 weeks in spring or autumn. The helicoverpa lifecycle stages are egg, larva, pupa and adult (moth) (Figure 6).



**Figure 6.** Lifecycle of *helicoverpa* (Crop insects: The Ute Guide. Northern Grain Belt Edition).

## The moth

Adult moth wingspan is 30-45 mm; the forewings are brownish or reddish-brown (females) or dull greenish to yellow or light brown (males); hindwings are pale with a broad, dark outer margin. *Helicoverpa armigera* moths have a pale patch near the centre of this dark region (Figure 7).

Moths feed on nectar. They live for around 10 days during which time females lay 1000 eggs. Eggs are laid singly, or in clusters, on leaves, flower buds, flowers and developing fruits, and sometimes on stems and growing points. Moths tend to lay eggs on the top third of healthy plants and on vigorously growing terminals.



**Figure 7.** Moths of *H. punctigera* (left) and *H. armigera* (right) showing the characteristic differences in the markings on the hindwings. *Helicoverpa armigera* moths have a pale patch in the dark marking on the hindwings. There is no pale patch on the hindwings of *H. punctigera* (Photo: J. Wessels, DPI&F).

## Eggs

Fertile eggs hatch in about three days during warm weather (25°C average) and 6-10 days in cooler conditions. As they develop, eggs change from white to brown to a black-head stage before producing a hatchling (Figure 8). Not all eggs are fertile. Physical factors can dramatically affect egg survival and larval establishment. Heavy rainfall and wind can force eggs off leaves. High temperatures can dehydrate and kill eggs and very small larvae.



**Figure 8.** The four stages of *helicoverpa* egg development. Freshly laid *helicoverpa* eggs are white, turning a light brown colour over the next 1-2 days. Close to hatching, the black head capsule of the developing larva is visible through the eggshell. (Photo: B. Scholz, DPI&F).



## Larvae

The hatching larva (neonate) eats through the eggshell to make an exit hole and emerges. Neonate larvae are 1–1.5 mm long, with a brown–black head and white or yellowish–white, dark-spotted body. Initially larvae graze on tender young foliage, and then move to feed on buds, flowers or young pods, bolls or fruits.

Larvae develop through six growth stages (instars) and become fully grown in 2–3 weeks in summer or 4–6 weeks in spring or autumn (Figure 9). Development is more rapid at higher temperatures, up to 38°C, after which development slows. Larval activity and feeding stops when temperatures fall below 12°C.

Ninety per cent of all feeding (and therefore damage) by *helicoverpa* is done by larva from the third instar (small medium larva that are 8–13 mm long) onwards. Large *helicoverpa* larvae (longer than 24 mm) are the most damaging stage, since larvae consume about 80 per cent of their overall diet in the fifth and sixth instars. This highlights the importance of controlling *helicoverpa* larvae while they are still very small to small (less than 7 mm).

Full-grown sixth instar larvae are up to 40 mm long with considerable variation in colours and markings (Figure 10).



**Figure 10.** Late instar *helicoverpa* larvae can vary greatly in colour and markings. (Photo: D. Ironside, DPI&F)

Instar	Larval appearance	Actual larval length (mm)	Size category
First		1–3	very small
Second		4–7	small
Third		8–13	small medium
Fourth		14–23	medium large
Fifth		24–28	large
Sixth		29–30+	large

**Figure 9.** Guide to *helicoverpa* larval instars/size categories.

## What do larvae eat?

*Helicoverpa* larvae feed on leaves, flower buds and flowers, developing pods, fruits and seeds. In most crops, young larvae will graze on leaves alone, moving on to feeding on developing pods, bolls, cobs and grain once they are third instar or older (8 mm or longer) (Figure 11). In some crops, such as mungbeans and cotton, hatchling larvae infest reproductive structures (flowers, squares) as soon as they hatch. Once established in these concealed feeding locations, larvae are much more difficult to control with insecticides.



**Figure 11.** A large *helicoverpa* larva feeding inside a chickpea pod (Photo: J. Wessels, DPI&F)

The two *Helicoverpa* species prefer different hosts. *Helicoverpa punctigera* prefers to feed on broadleaf species (e.g. cotton, chickpea, native herbs); *H. armigera* eats these crops and grass-related species (e.g. corn, sorghum and wheat). Crop and pasture weeds such as noogoora burr, common sowthistle, fat hen and marshmallow are also attacked. This broad diet demonstrates why *Helicoverpa* is a pest of the broad farming system and not just a few specific crops.

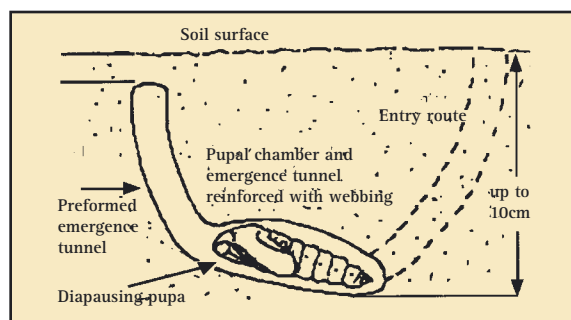
## Pupae

Once larvae are fully grown, they crawl to the base of the plant, tunnel up to 10 cm into the soil and form a chamber in which they pupate (Figures 12 & 13).

**Figure 12.** *Helicoverpa armigera* pupa in pupal chamber (partially opened soil clod)(Photo: R. Lloyd, DPI&F)



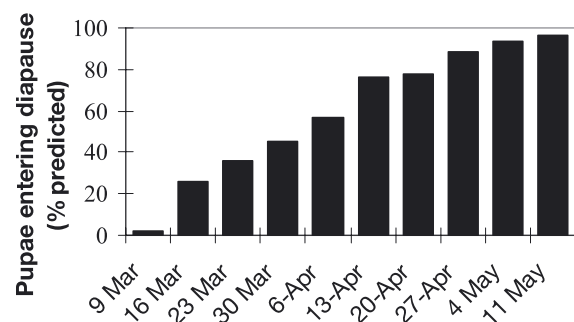
Pupae will normally develop to produce a moth in 10–16 days. The moth emerges, feeds, mates and is then ready to begin the cycle of egg laying and larval development. As with all insect development, the duration of pupation is determined by temperature, taking around two weeks in summer and up to six weeks in spring and autumn. However, diapausing pupae take much longer to emerge.



**Figure 13.** *Helicoverpa* pupa in pupal chamber showing the entry and exit tunnels formed before the larva pupated.

## Diapausing pupae

Both species survive the winter as pupae in the soil when host plants, and thus food sources, are scarce. *H. punctigera* are capable of overwintering in southern cropping regions, but only a few are ever found. In contrast, substantial numbers of overwintering *H. armigera* pupae can be found under late summer crops, particularly when *Helicoverpa* activity has been high late into March. In southern Queensland, pupae typically start to go into diapause from around mid-March and emerge in spring (Figure 14). Not all pupae that form in late summer go into diapause: a proportion continues to develop, perhaps emerging during winter, or early in spring.



**Figure 14.** Predicted rate of *Helicoverpa* diapause induction for Dalby, Queensland. The graph shows that from mid-March onwards, a significant proportion of larvae present in crops will enter diapause and not emerge as moths until the following spring (October). These predictions are based on long-term average temperatures for Dalby.

Overwintering pupae can be killed without using chemicals. Pupae in the soil are susceptible to soil disturbance and disruption of the emergence tunnel. Cultivation is enough to create this disturbance.

For more information on managing populations of overwintering pupae, see the DPI&F brochure 'Chemical-free heliothis pupae control'.

# Predators, parasitoids and pathogens

A variety of predatory and parasitic insects, spiders, birds, bats, rodents and diseases attack helioverpa at different stages of its lifecycle.

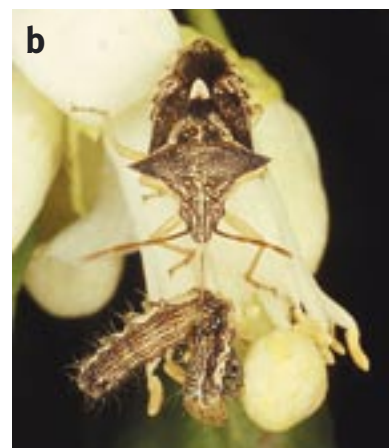
Natural enemies will rarely eradicate all eggs or larvae, but may reduce infestations to below economic threshold if predators and parasitoids are not disrupted by broad-spectrum insecticides.

The amount of disruption that insecticides cause to natural enemy activity varies depending on which chemicals are used and which natural enemies are active. For more information on the impact of insecticides, see the table 'Impact of insecticides on key beneficial groups in cotton' (in the *Cotton Pest Management Guide*).

## Predators

Many predators are opportunity feeders that feed on prey other than helioverpa. Some predators found commonly in crops will not feed on helioverpa at all; some may only feed on certain stages (e.g. larvae of a particular size, or only eggs). Knowing what predators eat is useful when making helioverpa management decisions. For more information on specific predators see 'Crop insects: The Ute Guide. Northern Grain Belt Edition' or the 'Cotton Pest and Beneficial Guide'.

The most common helioverpa predators in field crops are predatory bugs, predatory beetles, spiders, lacewings and ants (Figure 15). Some predators are relatively permanent residents in fields (e.g. ants); others migrate from nearby fields, other vegetation or even further away.



(Photo: C. Freebairn, DPI&F)



(Photo: J. Wessels, DPI&F)



(Photo: P. Reid, CSIRO)



(Photo: P. Reid, CSIRO)

**Figure 15.** Common predators found in broadacre crops: a) lynx spider, b) predatory shield bug, c) green lacewing larva, and d) red and blue beetle.



## Parasitoids

Some wasps and flies attack helioverpa eggs, larvae and pupae. Parasitoids kill their helioverpa host to complete their development. The parasitoids most active in field crops include smaller wasp species such as *Trichogramma*, *Telenomus* and *Microplitis*; relatively large parasitoid wasps (*Netelia*, *Heteropelma*, *Ichneumon*); and flies (*Carcelia* and *Chaetophthalmus*).

Parasitoids that attack helioverpa larvae do not kill their hosts immediately. However, they do stop or slow down caterpillar feeding, which reduces the impact of the pest on the crop. When parasitoids attack late instar larvae or pupae, they stop moths developing that would otherwise produce further eggs and larvae.

For more information, see the DPI&F brochure '*Parasitoids: Natural enemies of helioverpa*'.

## Pathogens

Pathogens are viruses, fungi or bacteria that infect insects. Many naturally occurring diseases infect and kill helioverpa. The commonest pathogens infect larvae, including the nucleopolyhedrovirus (NPV) and fungal pathogens (*Metarhizium*, *Nomurea* and *Beauveria*). Another disease, ascovirus, stunts larval development, and is spread by wasp parasitoids.

Two helioverpa pathogens are available commercially to control larvae: NPV and the bacterium *Bacillus thuringiensis* (commonly called *Bt*).

NPV occurs naturally and frequently causes natural outbreaks (epizootics) in helioverpa populations. The commercial helioverpa NPV is a highly selective biopesticide that infects only *H. armigera* and *H. punctigera* larvae. NPV is harmless to humans, wildlife and beneficial insects.

Bt is available as a selective spray that only kills moth larvae. Genes from the Bt organism have been used to genetically modify cotton plants so that the toxin is expressed in the plant's tissues. When young helioverpa larvae feed on a Bt cotton plant, the Bt toxin kills susceptible individuals.

Figures 16, 17 and 18 show some typical symptoms of infection.

For more information on NPV, see the DPI&F brochure '*Using NPV to manage helioverpa in field crops*'. For more information on the ascovirus pathogen, see the DPI&F brochure '*Microplitis demolitor and ascovirus: Important natural enemies of helioverpa*'.



**Figure 16.** NPV-infected helioverpa larva. Larvae infected by NPV crawl to the top of a plant, turn black and liquefy before disintegrating. (Photo: M. Miles, DPI&F)



**Figure 17.** Metarhizium-infected larva. On larvae killed by Metarhizium, the green fungus is visible growing out of the larva's body. (Photo: C. Hauxwell, DPI&F)



**Figure 18.** Ascovirus-infected larvae are small and pale and can look as though they have been grazing lightly in the one place, leaving small 'windows' in the nearby leaf. (Photo: M. Miles, DPI&F)



# Control options

## Chemical control

Controlling *Helicoverpa* effectively with insecticides depends on knowing which species are present in the crop because *H. punctigera* and *H. armigera* have differing susceptibilities to many insecticides.

*Helicoverpa punctigera* is easily killed by all registered products, including products to which *H. armigera* is resistant (e.g. synthetic pyrethroids). Because *H. punctigera* moths migrate annually into eastern Australian cropping regions, they lose any resistance they develop as a result of exposure to insecticides in crops. In contrast, *H. armigera* populations tend to remain local so they maintain their resistance to insecticides from season to season.

The need to minimise insecticide resistance in local populations has driven the development of a Farming Systems Insecticide Resistance Management Strategy (FS-IRMS). The FS-IRMS integrates the needs of grain growers into the IRMS developed for the cotton industry.

The FS-IRMS aims to provide a strategy that helps growers work out which insecticides they can use without contributing to insecticide resistance. Compliance with the strategy is voluntary, but does give all industries the best chance of maintaining a suite of effective insecticides for the control of *H. armigera*. For more information on the FS-IRMS see the annual 'Cotton pest management guide'.

## Control without insecticides

Insecticides are not the only options for controlling and managing *Helicoverpa*.

Pupae busting remains an important, non-chemical option to reduce the size of overwintering populations. Pupae busting also reduces the carryover of insecticide-resistant individuals from season to season.

Weed management in and around crops can prevent the build-up of *Helicoverpa* and other insect pests.

Other non-insecticide control methods include spring trap crops (an area-wide management tool for reducing the size of the overall *Helicoverpa* population) and, as discussed, using *Helicoverpa*'s natural enemies (predators, parasitoids and pathogens).



## Poorly timed sprays are costly.

Poor timing can result in a poor level of control, which consequently increases crop damage and the costs of re-treating the field. Poor timing also increases insecticide resistance by exposing larvae to doses of insecticide that do not kill entire populations, but select for resistant individuals.

Timing and coverage are both critical to achieving good control of *helicoverpa* larvae, whether using a chemical insecticide or a biopesticide (like NPV or *Bt*).

## Good timing of spray applications against *helicoverpa* larvae occurs when sprays target:

- very small (1-3 mm) to small (4-7 mm) larvae (that require a lower dose to kill)
- larvae that are feeding or moving in the open, and therefore more easily contacted by spray droplets
- larvae before they move into protected feeding locations (e.g. flowers, cobs, pods or bolls).

Good coverage is increasingly important with the introduction of ingestion-active products because the larvae must actually feed on plant material covered with the insecticide or biopesticide.

For more information on pesticide application go to [www.dpi.qld.gov.au/fieldcrops/3494.html](http://www.dpi.qld.gov.au/fieldcrops/3494.html) and see the article *Using agricultural pesticides - 1. Pesticide application (boomsprays)*

Targeting the most susceptible stages, the first and second instars, is the best way to manage *helicoverpa*. Regular crop scouting determines both the number of *helicoverpa* larvae in the crop and the age structure of the population (Figure 19).



**Figure 19.** Using a beat sheet to sample for *helicoverpa* larvae in a chickpea crop. Check crops regularly and thoroughly to ensure that control measures are appropriately timed.  
(Photo: J. Ferguson, DPI&F)

# A whole-farm approach

## A whole-farm approach to heliCOVERpa management involves:

- Being familiar with the heliCOVERpa lifecycle and knowing what to look for, and when.
- Checking crops regularly to identify when crops are most susceptible (from flowering onwards) and to time control most effectively.
- Being familiar with the economic thresholds for different crops and using them as a basis for your control decisions.
- Basing chemical choices on the FS-IRMS.
- Applying sprays to achieve the best possible coverage.
- Conserving populations of predatory and parasitic insects by using selective insecticides.
- Managing the local population, for example, with trap cropping, pupae busting, or effective chemical control.
- Cultivating to destroy overwintering pupae.
- Destroying weed hosts within the crop and surrounding areas.



**Figure 20.** Managing heliCOVERpa requires a whole-farm approach.

(Photo: D. Schmidt, DPI&F)

# 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](http://www.dpi.qld.gov.au).

*Chemical-free heliothis pupae control*. 1998. QI98036.

*Parasitoids: Natural enemies of helicoverpa*. 2005. QI04081.

*Egg parasitoids of heliothis*. 2000. QI00097.

*Microplitis demolitor and ascovirus – important natural enemies of helicoverpa*. 2005. QI04079.

*Using NPV to manage helicoverpa in field crops*. 2005. QI04080.

*Crop insects: The Ute Guide. Northern Grain Belt Edition*. 2000. ISSN 0727-6273. QI00102.

*Heliothis Stateline* newsletter. ISSN 1441-4244.

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

DPI&F summer and winter crop management notes on CD-ROM.

## Other publications

*Spring trap crop management guidelines*. Australian Cotton Cooperative Research Centre. QI00049.

*SPRAYpak: Cotton growers' spray application handbook*. Cotton Research & Development Corporation. ISBN 1 876354 83 6.

*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 insect pest management for the cotton industry*. Available from the Australian Cotton CRC's 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](http://www.dpi.qld.gov.au/fieldcrops) is constantly updated with the latest pest management information.

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

The Australian Cotton CRC website [www.cotton.crc.org.au](http://www.cotton.crc.org.au) has 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 The Cotton Pest and Beneficial Guide*.

## 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.

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