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# THE COTTON PEST AND BENEFICIAL GUIDE

B. A. Pyke and E. H. Brown



CRDC



COOPERATIVE RESEARCH CENTRE FOR  
SUSTAINABLE COTTON PRODUCTION



# The Cotton Pest and Beneficial Guide

B. A. Pyke and E. H. Brown



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Forrester, N. W. and Wilson, A. G. L. (1988). Insect pests of cotton. *NSW Agfact P5.AE.1, first edition*, 18pp. Sydney: NSW Agriculture.

Room, P. M. (1979). *Insects and Spiders of Australian Cotton Fields*, 69pp. Sydney: NSW Agriculture.

Shepard, M., Lawn, R. J. and Schneider, M. A. (1983). *Insects of Grain Legumes in Northern Australia*, 89pp. St. Lucia, Qld: University of Qld Press.

Flint, M. L. (1994). *Whiteflies in California: A Resource for Cooperative Extension Advisors*. (University of California, Statewide Integrated Pest Management Project).

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**This book is dedicated to the memory of Elaine Brough.**

## INTRODUCTION

More than 1,000 different kinds of insects and spiders can be found in Australian cotton fields, though only about 50 of these ever become abundant, and as few as 30 insects and mites have ever been recorded causing damage to the cotton plant. Many spiders and insects are beneficial because they feed on pests, but the majority are benign, casual visitors to cotton en route between other habitats. No insects, spiders or mites are restricted just to cotton fields and some cotton pests are also important pests of other crops.

Of the thirty pests, three are of major importance requiring control measures in most regions in most seasons: these are the two heliothis species, the native budworm, *Helicoverpa punctigera* (Wallengren), and the cotton bollworm, *Helicoverpa armigera* (Hübner) and spider mites. The cotton aphid is also an important pest that often requires control in its own right, but is usually suppressed by the chemical control measures used for heliothis.

Of the remaining pests, many are capable of considerable damage to cotton in any year, when they may even rival the major pests in importance. However, their occurrence can be highly variable and their abundance is usually in conjunction with other weed or crop hosts which are in turn favoured by the growing conditions in that particular season. Other sporadic pests tend to assume importance only if the major pests do not require control for lengthy periods or when cotton is grown in very isolated localities.

Yields of cotton increased dramatically after World War II with the introduction of insecticides such as DDT. More recently, DDT has been replaced by other groups of chemicals such as the synthetic pyrethroids, organophosphates and carbamates. Most of these chemicals kill the beneficial insects and spiders as well as the pests. Unfortunately, some pests have developed resistance to many insecticide groups and these still kill the beneficial species but allow larger numbers of pests to multiply relatively unharmed. Entire cotton industries have collapsed in various parts of the World, including the one on the Ord River in Australia, because it was (and still is) impossible to make a profit by returning completely to unsprayed conditions and the associated low yields.

In addition to the problem of resistance, use of insecticides is being increasingly regulated by legislation. This reflects concern over pesticide contamination of food and water for human consumption and the potential effects of pesticides in agricultural areas, in the riverine environment and on wildlife. Pest control in cotton is inevitably being forced towards minimising reliance on broad spectrum insecticides by these developments. Consequently, such things as pest-resistant cotton varieties and pest-specific insecticides (e.g. microbial diseases) are being developed for use in conjunction with food sprays to capitalise on the natural control provided by beneficial insects and spiders.

The application of these new techniques will mean that conventional pesticide use will decline and non-pest insects and spiders will be more numerous in commercial cotton fields. A future reduction in the reliance on pesticides could also mean that the relative importance of certain pests will change. It is beyond the scope of this book to predict the exact nature of such changes in pest status. The aim of this book is to help cotton growers, field consultants and agronomists correctly identify the wide range of pests and beneficials that can be found in the crops they manage. Accurate identification is one of the foundations for making sound pest management decisions. When pests are correctly identified, the relevant thresholds can be applied and appropriate control measures selected. For beneficials, correct identification means that their potentially important role in regulating pest populations can be utilised more effectively.

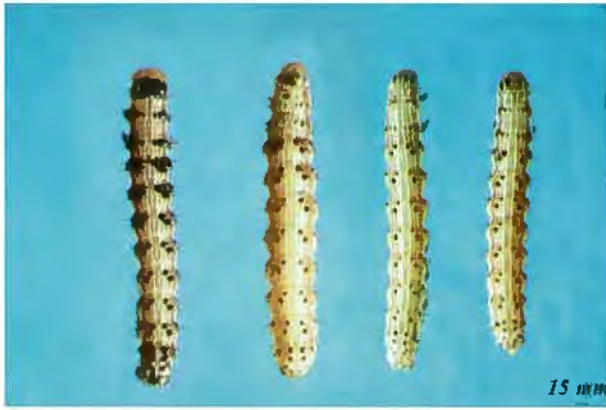


*Microplitis demolitor* larva emerging from heliothis caterpillar after feeding internally on its host  
Photo: M. Shepard

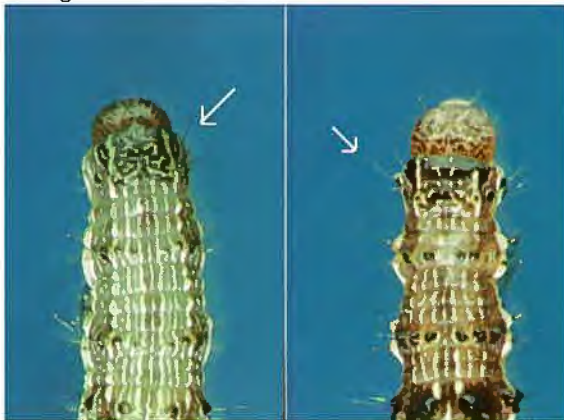
Each stage of cotton crop development has a complex of pests and these are listed in Table 1 - modified from Forrester & Wilson, 1988.

**Table 1. Cotton pests in Australia**

Crop stage attacked	Scientific name	Common name
<b>Pests of major importance</b>		
Early to mid season Mid to late season	<i>Helicoverpa punctigera</i> <i>Helicoverpa armigera</i> <i>Tetranychus urticae</i>	'punctigera', native budworm 'armigera', cotton bollworm two-spotted mite
<b>Pests of sporadic occurrence</b>		
Early seedling	<i>Agrypnus variabilis</i> <i>Pterohelaeus darlingensis</i> <i>Gonocephalum macleayi</i> <i>Saragus</i> spp. <i>Agrotis</i> spp. <i>Smynthuroides betae</i> <i>Spodoptera exigua</i> <i>Epiphyas postvittana</i> Family Gracillariidae <i>Thrips tabaci</i> <i>Frankliniella schultzei</i> <i>Petrabia latens</i> Order Collembola <i>Chaetocnema</i> sp. <i>Nisotra</i> sp. <i>Nomadacris guttulosa</i> <i>Teleogryllus</i> spp.	true wireworm eastern false wireworm southern false wireworm false wireworms cutworms bean root aphid lesser armyworm tortrix, lightbrown apple moth unidentified leafminer tobacco thrips tomato thrips brown wheat mite springtails brown flea beetle redheaded flea beetle spur-throated locust field crickets
Late seedling to squaring	<i>Austroasca viridigrisea</i> <i>Amrasca terraereginae</i> <i>Creontiades dilutus</i> <i>Taylorilygus pallidulus</i> <i>Campylomma liebknechti</i> <i>Crociosema plebejana</i> <i>Bucculatrix gossypii</i>	vegetable leafhopper (jassid) cotton leafhopper (jassid) green mirid brokenbacked bug apple dimpling bug (yellow mirid) cotton tipworm
Boll production/ maturation	<i>Aphis gossypii</i> <i>Anomis flava</i> <i>Tetranychus ludeni</i> <i>Tetranychus lambi</i> <i>Myzus persicae</i> <i>Trialeurades vaporariorum</i> <i>Bemisia tabaci</i> <i>Dysdercus sidae</i> <i>Tectocoris diophthalmus</i> <i>Nezara viridula</i> <i>Oxycarenus luctuosus</i> <i>Earias huegeliana</i> <i>Pectinophora scutigera</i> <i>Spodoptera litura</i>	cotton leafperforator cotton aphid cotton looper bean spider mite strawberry spider mite green peach aphid greenhouse whitefly cotton whitefly pale cotton stainer cotton harlequin bug green vegetable bug cottonseed bug rough bollworm pinkspotted bollworm cluster caterpillar



4th instar larvae of *H. armigera* on left (note 'saddle' on 4th segment back from the head) and *H. punctigera* on right Photo: L. Turton



*H. punctigera* (above left)  
*H. armigera* (above right)  
showing 'armigera' 'saddle' and white hairs and 'punctigera' black hairs with no 'saddle' (arrowed) Photo: L. Turton, M. Cahill



*H. punctigera* pupa (left)  
- spines together and  
*H. armigera* pupa (right)  
- spines apart  
Photo: L. Turton  
Drawings: W. Manley



Adult moths of *H. punctigera* (left) and *H. armigera* (right) - note pale patch on hind wing (arrowed) Photo: P. Room

## MAJOR PESTS

### *Helicoverpa armigera* and *Helicoverpa punctigera*

The **cotton bollworm**, *Helicoverpa armigera* (Hübner), and the **native budworm**, *Helicoverpa punctigera* (Wallengren) are very similar in both their appearance and damage to cotton and are therefore discussed together. Correct identification is important because *H. armigera* has developed high levels of resistance to synthetic pyrethroids and endosulfan, and lower levels to organophosphates and carbamates.

- **Identification.** The two species can be separated visually only for some stages of their life cycle e.g. medium and large larvae, pupae and adults (Fig.1). It is not possible to visually differentiate heliothis eggs or early larval stages, however, a simple squash test (the LepTon™ Test Kit) has been developed by CSIRO and Abbott Australia Ltd. for this purpose. This Kit has become an important tool for better management of infestations dominated by resistant *H. armigera*.

Medium or fourth instar *H. armigera* larvae can be identified by the presence of a 'saddle' of darker pigments on the fourth segment back from the head. Large or final instar larvae can be separated on the basis of colour of the large hairs on the first segment behind the head, white in *H. armigera*, black in *H. punctigera*. Pupae can be separated using two small 'tail' spines which are apart and slightly smaller in *H. armigera*, close together and longer in *H. punctigera*. Adults can be identified using the hind wings; *H. armigera* has a small light or pale patch in the dark section of the wing while the dark section is uniform in *H. punctigera*.

- **Distribution and ecology.** *H. armigera* is a major pest of cotton in Africa and Asia as well as Australia, but *H. punctigera* is mainly confined to Australia. *H. armigera* occurs in the north of Western Australia, throughout the Northern Territory, Queensland and New South Wales and into eastern Victoria.

Both species are capable of long distance movement, however, this characteristic is more clearly true migratory behaviour in *H. punctigera*.



Eggs of *H. armigera* Photo: D. A. Ironside



Egg of *H. armigera* - 'brown-ring' stage  
Photo: P. Room



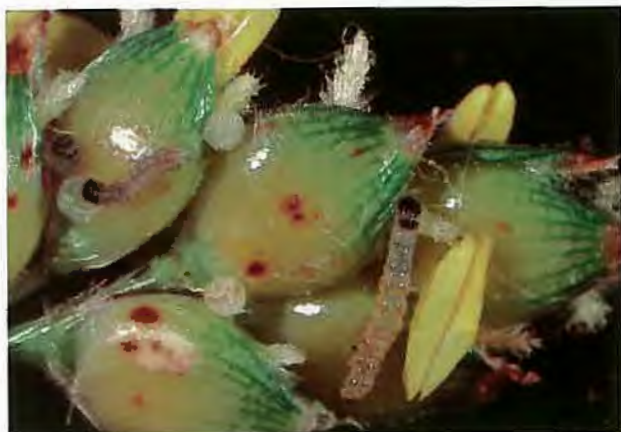
*H. armigera* larva hatching from egg  
Photo: B. Scholz



*H. armigera* - 1st instar larva Photo: C. Mares

The pattern shown by *H. punctigera* is typically for it to breed during winter in many of the flowering plants that grow in the outback areas of Australia following rain. In spring these moths migrate into the cropping areas, assisted by frequent, predominantly eastward moving, weather fronts. Under the right conditions, *H. punctigera* can reach the cropping areas of southern Queensland and northern NSW from, say, the Channel Country in southwest Queensland in just one to two nights flight. The timing of these migratory flights means that *H. punctigera* tends to be an early season pest in cotton. The extent and suitability of the outback weed hosts is also an indicator of the potential size of the *H. punctigera* population that will enter the cropping areas. It will be small if autumn/winter conditions in the outback have been dry, and large if conditions have been wet. While *H. punctigera* can be the dominant early season pest in cotton, it tends not to persist to the end of the season and few overwinter in the cropping areas. Although *H. punctigera* has the capacity to develop resistance, the migratory behaviour of large numbers of moths from insecticidally unsprayed weeds seems to suppress resistance from developing into a problem even in frequently sprayed crops like cotton.

In contrast, relatively few *H. armigera* breed in the outback and migrate, rather it tends to overwinter under late summer crops as pupae in a suspended state of development known as diapause. Diapausing *H. armigera* pupae emerge as moths in spring, but numbers are usually much lower than the migratory *H. punctigera*. Consequently, it takes *H. armigera* one to two generations in spring and early summer to build up in numbers and this tends to make it an important cotton pest more in the middle to latter part of the season (January to April in northern NSW and southern Queensland; December to May in central Queensland). Compared to *H. punctigera*, a larger proportion of the *H. armigera* population tends to infest crops and, therefore, has a higher exposure to pesticides. Without large influxes of susceptible moths from insecticide untreated areas, resistance genes are not significantly diluted in *H. armigera* populations which partly explains why this pest has the capacity to develop resistance very rapidly.



8 mm

*H. armigera* eggs and young larvae on sorghum head  
Photo: D. A. Ironside



35 mm

Mature larva of *H. punctigera* (top) and  
*H. armigera* (bottom) Photo: D. A. Ironside



24 mm

*H. armigera* at rest Photo: D. A. Ironside



20 mm

*H. punctigera* at rest Photo: P. Room

• **Host plants and damage.** Both species attack a wide range of cultivated plants and wild hosts. *H. punctigera* mainly prefers broadleaved plants, while *H. armigera* is also found on graminaceous plants such as wheat, sorghum and maize. *H. armigera* attacks a broader range of crops, while *H. punctigera* has a broader range of non-crop hosts (Table 2). In cotton, all stages of plant growth may be attacked, but reproductive tissue is preferred. Seedlings may be 'tipped out' (ie. terminal buds eaten), squares and small bolls damaged then shed, and maturing bolls lost due to direct larval feeding or secondary fungal attack. Although less common, seedlings along field borders may be completely destroyed by large larvae moving from maturing or cultivated weeds or other host crops.

Heliothis larvae may be damaging to cotton at low population densities. Averages of only one to two small larvae or up to 10 eggs per metre of row may constitute a potentially damaging infestation during squaring and boll production phases. Such populations would warrant spray application to prevent larvae developing to a more destructive size when they also become difficult to kill. *More detailed information on thresholds is given in the Cotton Pesticides Guide published annually and Research Review - Heliothis thresholds pre-flowering, also Agfact AE.48, Heliothis caterpillars.*

• **Life cycle and host plant sequence.** The eggs of both species are most commonly laid on the top third of the cotton plant, but can be deposited on any structure. The incubation period varies, but at 25°C takes 4 days, with eggs turning white to brown (commonly called the 'brown ring' stage) as they develop. Larval and pupal development times at 25°C are 17 and 16 days respectively. With the inclusion of the time from moth emergence to fertile egg production of around 5 days, a generation is estimated to be completed in about 42 days during summer (Fig.2). Four to five generations occur per growing season.

The seasonal sequence of hosts of the two species is best known in the Namoi/Gwydir valleys of northern NSW and the Darling Downs of Queensland, but seems to be similar elsewhere. *H. punctigera* appears in the spring 2 to 4 weeks before *H. armigera* and larvae initially infest cultivated crops (such as faba beans, chickpeas, safflower, linseed and rapeseed), pasture species (particularly naturalised medics) and the spring flush of weeds during September to November.

## Life Cycle of *Helicoverpa armigera*

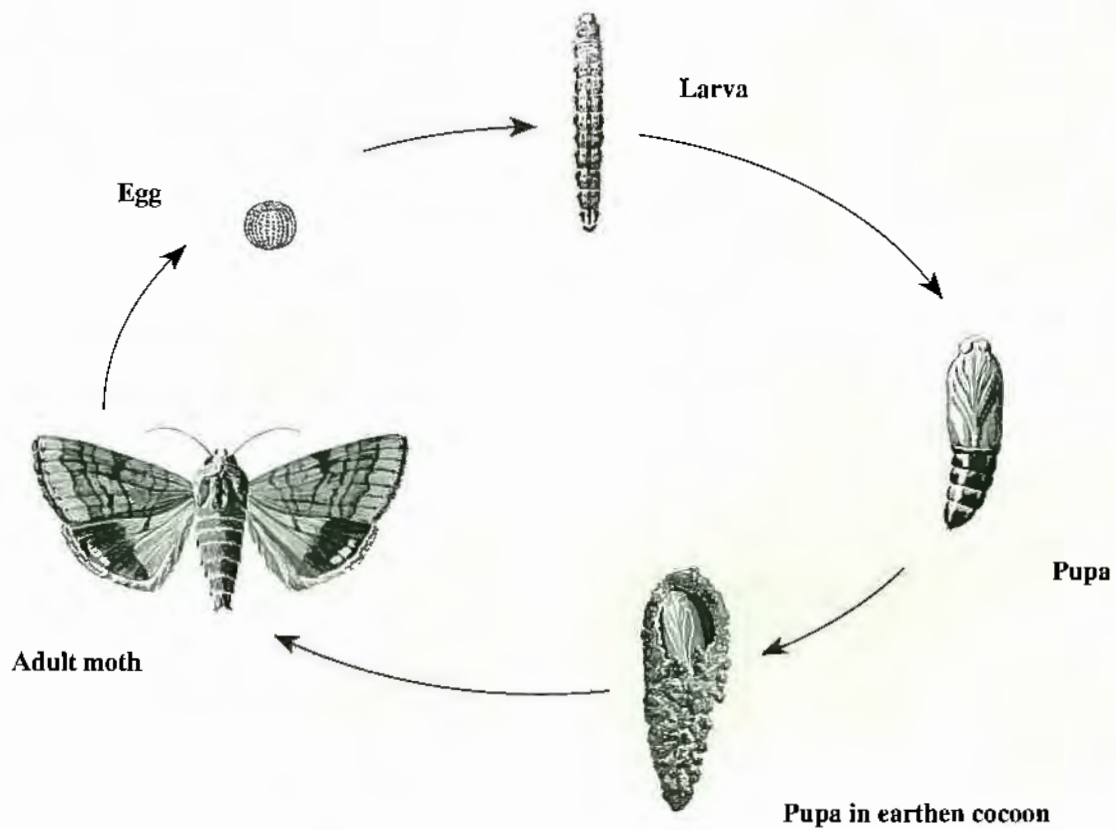


Fig.1 Drawings: I. W. Helmsing

Development times for heliothis eggs, larvae and pupae at 5 constant temperatures

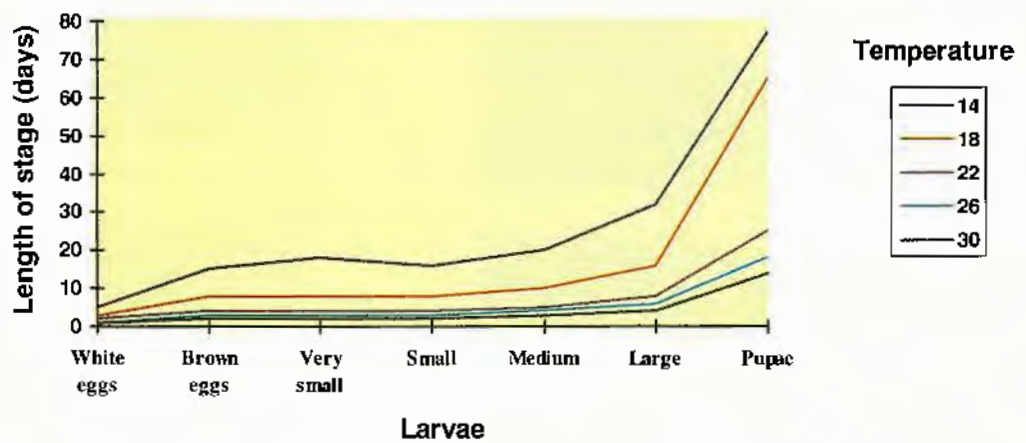


Fig.2 Graph: G. Fitt



*Heliothis* damage to square Photo: D. A. Ironside



*Heliothis* larva in damaged cotton boll  
Photo: NSW Agriculture

The subsequent generations infest cotton, summer oilseed and grain legume crops. Numbers of *H. punctigera* are usually low during late summer and autumn. A small proportion of the pupae produced during March-May enter diapause, but it is now known that the non-diapausing proportion of the population, which occurs on the host weeds of inland Australia, is of more importance, giving rise to adults that migrate and lay their eggs on spring weeds and winter sown crops. Larvae from this generation are well developed before moths emerge, in October-November, from those pupae that did diapause in the cropping areas.



Newly emerged *H. armigera* adult Photo: C. Mares

*H. armigera* appears during October-November when the moths emerge from pupae that have overwintered under crops that were grown in late summer or autumn. Larvae may be found in low numbers on wheat, grain legumes (particularly chickpeas) winter oilseeds and on some weeds. Following generations are found on cotton and other summer crops such as sorghum, maize, sunflowers, soybeans, pigeon peas, mung beans, navy beans and cowpeas. Infestations tend to be highest on late maturing crops of the above hosts during March-May. The survival of the overwintering population under cotton is of great importance to the carryover of *H. armigera* populations and resistance into the next season, particularly in northern NSW and southern Queensland. Post-harvest cultivation to reduce the survival of the overwintering stage is one of the most important non-chemical resistance management tactics available to the cotton grower (Fig. 4).

- **Factors affecting abundance.** Two important characteristics of heliothis are their mobility in the adult stage and the large number of eggs they can produce. Given a suitable sequence of host plants, populations can build up to outbreak numbers very rapidly. Conversely, numbers may remain low if a suitable succession of hosts is not available. With *H. armigera* a particular correlation has been observed both in Australia and overseas between the area of sorghum and maize grown in a region and the level of infestation in cotton. The impact of long distance movement has already been discussed.

**Table 2. General Preferred Hosts of *Heliothis*.**

	<i>H. punctigera</i>	<i>H. armigera</i>
Crop hosts	18	63
Non-crop hosts	173	38
Plant families	41	31

A variety of parasites, predators and pathogens has been observed attacking various stages of the life cycle. There is increasing evidence that predators, in combination with other natural mortality factors particularly wind, rainfall and temperature extremes, can reduce the survival of heliothis in commercial cotton crops to non-economic levels even though yield expectations are high and pest tolerance low. Often the build-up of natural enemies occurs after pest populations are above commercially acceptable densities. However, as new technology such as predator food sprays (Envirofeast®) and Bt cotton (eg. Ingard®) becomes widely used, beneficial numbers in commercial cotton crops will increase to levels where they will have a greater impact on pest numbers.

Physical factors can dramatically affect egg survival and larval establishment. Heavy rainfall may wash eggs off leaves, high temperatures may desiccate eggs and larvae, and wind may dislodge eggs and larvae. These factors may cause heavy mortality and often less than half of the eggs laid will result in established larvae. Aside from such adverse conditions, there is also a level of natural infertility in eggs. These mortality factors, combined with natural enemies, can frequently reduce low to moderate infestations of heliothis to below economically damaging levels (Fig.3). If crop monitoring is adequate and frequent enough, this free natural control can be used to reduce pesticide use without affecting yield or crop maturity. Reduced spraying carries with it the added benefits of less selection for resistance, less opportunities for environmental contamination, reduced likelihood of a resurgence of secondary pests and minimal disruption of heliothis predators.

Pupae appear less susceptible to mortality factors than other life stages. However, cultivation of crop residues to a depth of at least 5 cm will damage or disturb the pupae sealing their emergence tunnels (Fig. 4). This leaves survivors open to predation by birds, mice and earwigs and makes them more accessible to wasp parasites. Cultivation to destroy overwintering pupae is an important resistance management tactic.

Two similar species *Helicoverpa zea* (Boddie) and *Heliothis virescens* (Fabricius) are important pests of cotton and other crops in the Americas.

**Copies of all publications mentioned in this book are available from the Technology Resource Centre (067) 991 534.**

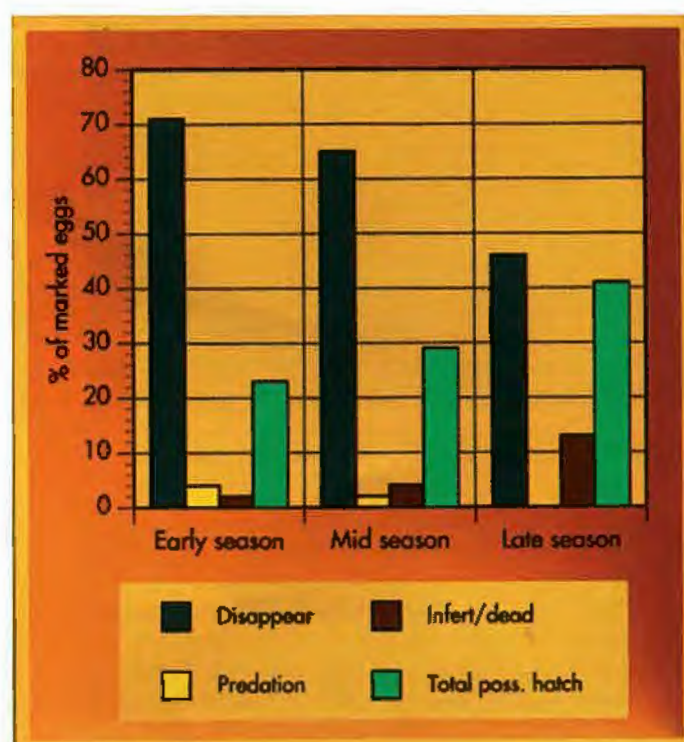


Fig.3 Natural mortality of heliothis eggs Graph: G. Dillon

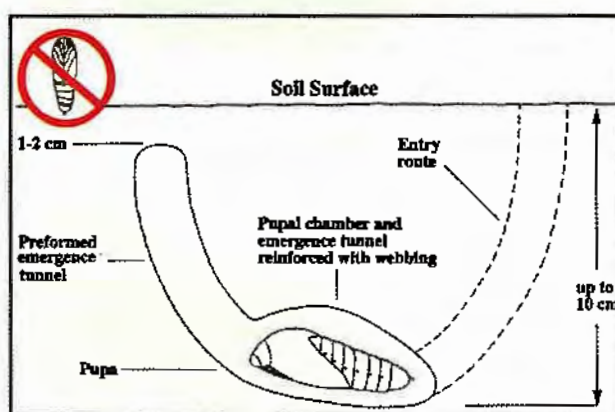
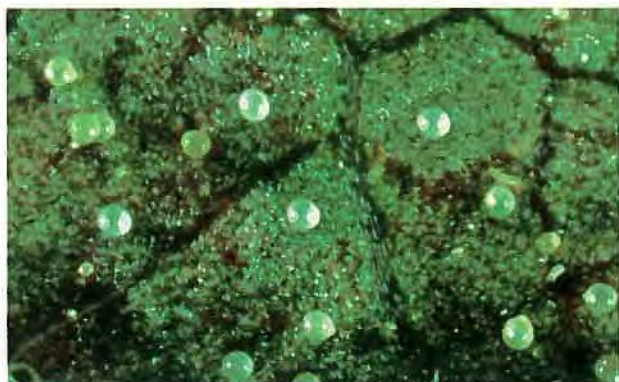


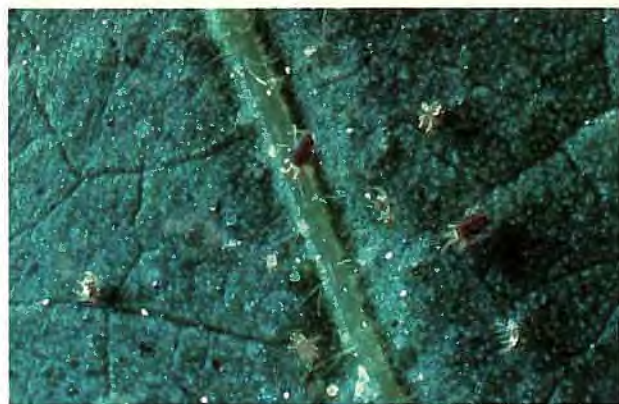
Fig.4 Position of heliothis pupa in soil  
Drawing: J. Beard



Adults and pupae of *H. zea* (left) and *H. virescens*  
Photo: USDA



Eggs of two-spotted mite Photo: D. A. Ironside



Two-spotted mite under cotton leaf Photo: P. Reid



Two-spotted mite Photo: M. Hill

0.5 mm

Overwintering adult of two-spotted mite (red form)  
Photo: C. Bower

## Spider mites

Spider mites are important pests in many cotton growing areas, particularly the Macquarie Valley. Three species have been identified from cotton. The **two-spotted mite**, *Tetranychus urticae* Koch is the most numerous, while the **bean spider mite**, *Tetranychus ludeni* Zacher and the **strawberry spider mite**, *Tetranychus lambi* Pritchard and Baker are sometimes found but rarely. Mites live on the underside of leaves and are difficult targets for aerial sprays. Mites prefer mature, active leaves rather than young, unfolding leaves or older senescent leaves so the highest populations are found near the top of the plant, particularly on main stem nodes 3 to 5 below the terminal.

- **Damage.** Mites are inconspicuous when numbers are low. The first sign of mite damage is bronzing of the upper leaf surface near the petiole or leaf folds. As the infestation progresses and mite numbers increase, leaves turn red and become covered with fine webbing. Eventually the leaves desiccate and fall off. Recent research has indicated that high mite populations can significantly affect both the yield and quality of cotton. Under Australian conditions, the okra leaf varieties have been found to sustain lower populations and less damage than the conventional normal or broad-leaved varieties, due to a less rapid build-up of mites. The earlier in the season that infestations develop, the greater is the potential loss of yield and quality for both leaf shapes (Figs 5 and 6).

Although mites do not normally increase in numbers in cotton until January or later, they frequently infest seedling cotton, especially near field edges. These infestations usually decline within a month and rarely justify control, but they are an important indicator of whether or not the infestation is likely to later require control and should be monitored closely.

- **Description and life cycle.** The spherical, semi-translucent eggs are laid singly on the underside of the leaf and give rise to a six-legged larval stage which is followed by two eight-legged nymphal stages. All stages feed actively with piercing mouthparts. The larval and nymphal stages of both species may show dark coloured spots on each side near the middle of the body and are yellow-green. Adults of *T. urticae*



Red female, male and egg of bean spider mite 0.5 mm  
Photo: M. Hill



Strawberry spider mite Photo: C. Mares 0.3 mm



Mite infestation on cotton - okra leaf  
Photo: L. Wilson

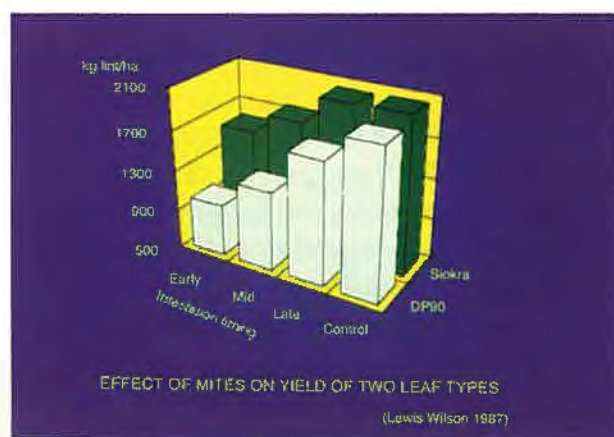


Fig.5 Effect of leaf shape on yield  
Graph: L. Wilson

resemble their nymphs, whereas adults of *T. ludeni* are uniformly red without spots and *T. lambi* adults are small with several pairs of spots on either side of the body. In autumn *T. urticae* may take on the uniform, bright orange colour of the non-feeding overwintering form. However, the summer colour form can be found throughout the winter on weeds such as marshmallow, deadnettle, medics, wireweed and sowthistle.

- **Factors affecting abundance.** Mites have a relatively high reproductive potential of about 70 eggs per female. A generation may be completed in only 7 to 14 days during the summer. Small ladybirds, apple dimpling bug, predatory mites and lacewing larvae are known to prey on two-spotted mites especially in the spring, but thrips appear to be the major predator in cotton. Mite infestations may increase after application of some broad spectrum insecticides (e.g. synthetic pyrethroids, organophosphates, and larvicidal rate thiodicarb) for control of heliothis and other pests. This increase occurs because these sprays kill natural enemies of mites but have little effect on the mites themselves. Heavy mite infestations in cotton have often been found to originate in adjoining fields of early sown corn from which mites have been carried by air currents for considerable distances downwind.

- **Assessment.** Mites are far too numerous to count individually. Instead the presence of an infestation, either adults, immatures or eggs is rated on a presence/absence assessment system. For consistency, it is preferable to rate a particular leaf where mite abundance can be expected to be high. In Australia the leaves on the third to fifth mainstream node down from the plant terminal are the best to sample. Thresholds have been established which take into consideration: days from planting, season length, percentage of sample units infested, rate of increase and predicted yield loss (*available from the Technology Resource Centre (067) 991 534 or published annually by NSW Agriculture in the Cotton Pesticides Guide*).

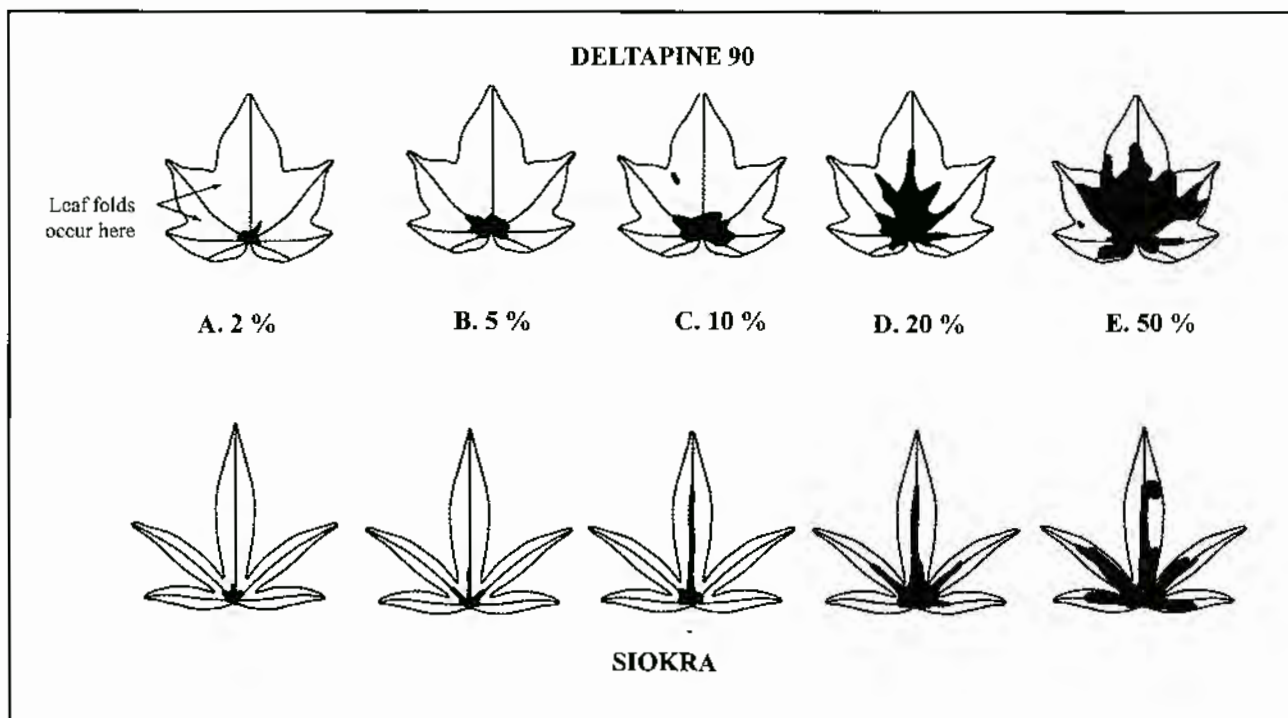


Fig.6 Typical shape of two-spotted mite colonies causing increasing levels of leaf damage from (A) 5% to (E) 50% of the leaf surface on okra leaf (Siokra) and normal leaf (Deltapine 90) cotton varieties. Colonies are indicated by shaded areas. (Wilson, 1992)



Brown wheat mite Photo: T. Passlow

1 mm

- Mites on seedling cotton.** All of these mite species mentioned above can be found on seedling cotton. While it is rare that infestations at this time of the season will require spraying, they should be monitored carefully. Seedling infestations are good indicators of the potential for mite problems later in the season. Another mite, the **brown wheat mite**, *Petrobia latens* Müller, can also infest seedling cotton. On the rare occasions they have been found they cause cotyledons to go straw-coloured. They are dark coloured mites, about the size of a pinhead, with long, red front legs and can be difficult to sample because they will readily jump off plants if disturbed. Infestations are usually found in fields adjacent to native pasture.

## MINOR PESTS

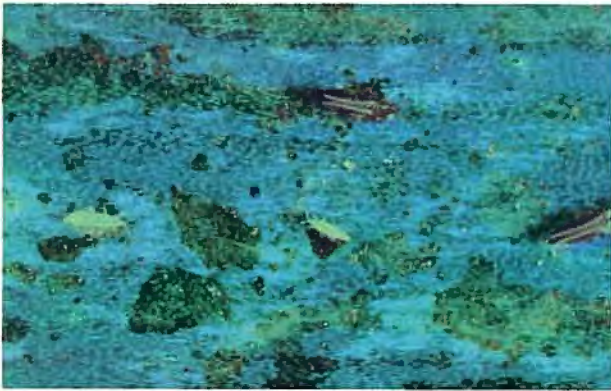
### Thrips

Although thrips are one of the most common early seedling pests in most cotton growing districts, their damage is usually cosmetic and rarely affects yield or earliness. Severe damage, resulting in plant tip loss or seedling death, tends to occur only under extreme infestation levels or in combination with cool weather. Control is warranted under these circumstances.

The most common species infesting cotton are **tobacco thrips**, *Thrips tabaci* Lindeman and **tomato thrips**, *Frankliniella schultzei* (Trybom). **Plague thrips**, *Thrips imaginis* Bagnall, although previously suggested to be an important species, is found rarely in cotton. Adults are small, cylindrical insects less than 1.5 mm in length, and colours range from yellow to grey to black. They have two pairs of narrow wings fringed with long hairs. The nymphs are less than 1 mm in length, pale yellow and wingless.

- **Damage.** Thrips are pests only during the seedling stage of growth. They infest the underside of cotyledons, young leaves and also the growing point of the plant. They use their mouthparts to pierce the leaf surface and suck out plant juices. Damaged leaves take on a silvery, bleached appearance and younger leaves become distorted in shape. Under most circumstances, this form of damage is cosmetic, plants recover quickly and control is not warranted.

Thrips infestations tend to be serious under cool, dry conditions when seedlings are unable to grow away from the damage. Severe damage can result in destruction of the growing point ('tipping out') leading to extensive lateral branching. Seedling death can be associated with extreme infestations or a combination of desiccation by thrips and damping off diseases. If damage to this extent is allowed to occur, heavy losses of plant stand may necessitate replanting the crop, while severe multiple branching may cause a maturity delay of 7 to 14 days. This delay, if compounded by damage from other pests, may cause a yield loss.



Tobacco thrips Photo: D. A. Ironside



Tomato thrips Photo: L. Wilson



Sixspotted thrips feeding on mite egg on cotton  
Photo: L. Wilson



Moderate tobacco thrips  
damage to cotton seedling  
Photo: D. A. Ironside

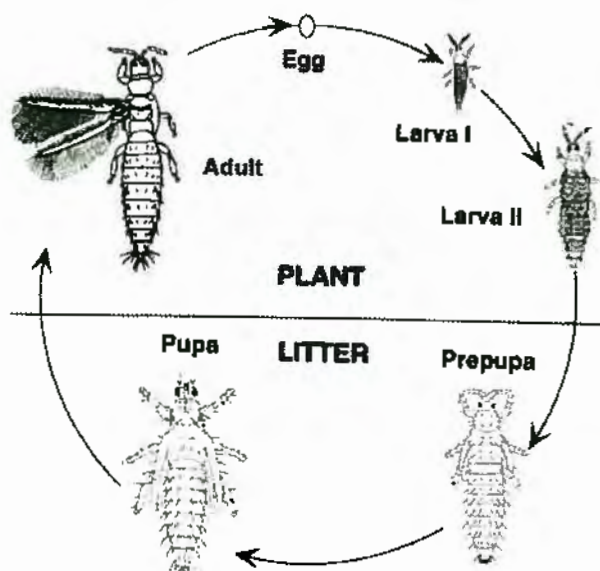


Fig.7 General life cycle of thrips species found in cotton - extracted from Ellington, 1980 and Palmer *et al*, 1989  
Composed by L. Wilson

- **Life cycle and abundance.** Adult thrips may swarm over cotton and cause damage to young leaf tissue for only a few days before disappearing, but it is more common for them to lay eggs in slits which they cut in leaves and growing points. This produces a generation of nymphs which also damage seedlings. Nymphs particularly attack the growing point and folded tip leaf where they are well concealed. The nymphs pupate in the soil. The length of the life cycle (Fig.7) from egg to adult varies from 44 days at 11°C to 9 days at 25°C. Populations decline at temperatures greater than 30°C.

Large numbers of thrips have been observed in early spring on flowers of cereal crops (wheat, barley) and on weeds such as Mexican poppy, turnip weed and Paterson's curse. The thrips then transfer to cotton when the cereal crops and weeds dry out or hay off. A wet winter followed by a cool, dry spring appears most favourable for thrips abundance, prolonging the flowering period of weeds and therefore the supply of pollen. Cotton crops adjacent to cereal crops are especially at risk from thrips and should be monitored closely for signs of thrips damage. In the absence of pollen on seedling cotton, thrips feed on other sources of protein such as eggs or larvae of some cotton pests, particularly mites. Destruction of thrips populations with broad spectrum insecticides is one of the most important contributors to mite populations reaching damaging levels.



Light thrips damage to cotton seedling - viewed from above Photo: A. Bishop

Another thrips species, the **sixspotted thrips**, *Scolothrips sexmaculatus* (Pergande), is a predatory species and feeds mainly on mite eggs and motile stages. The nymphs of *S. sexmaculatus* are difficult to distinguish from other thrips.

- **Sampling and treatment thresholds.** Thrips adults are highly mobile, and nymphs are very small and difficult to find, therefore counts may vary with the time of day. The damage potential also varies according to crop vigour and temperature. Seedlings will tend to grow away from infestation if the temperatures are warm. On the other hand, thresholds may need to be lowered in adverse conditions such as cold weather, where herbicide damage to plants has occurred, or where damping-off disease is widespread. *For more information see the Cotton Pesticides Guide or entomoLOGIC.*

- **Control.** Seed dressings can reduce early damage but will degrade over 14 to 21 days post planting. By then leaf area should be sufficient for above-ground applications of systemic insecticides to be effective if necessary. Systemic granular insecticides, applied at planting, provide longer control, but in some districts they are not necessary for thrips control due to low numbers or good growing conditions. If using seed dressings or granular insecticides be aware that adult thrips will continue to be found in the crop as they move from cereals and weeds. These adults will feed and die, causing no damage. The best indicator of declining control is the presence of thrips nymphs which indicates that the pesticide is no longer effective.



Green mirid eggs inserted into leaf tissue leaving egg caps (arrowed) outside leaf Photo: M. Khan



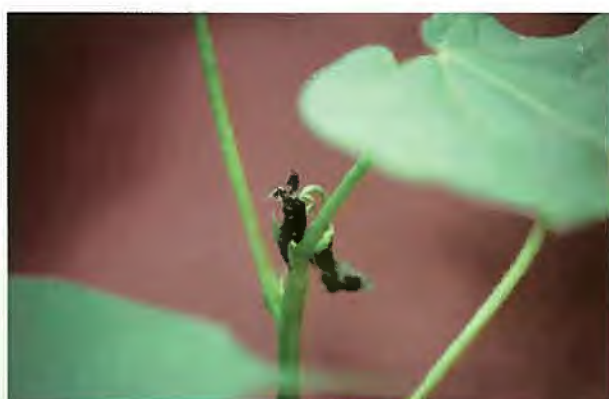
Nymph of green mirid Photo: C. Mares

3 mm



Green mirid adult Photo: P. Room

7 mm



Green mirid damage to cotton seedling tips  
Photo: M. Miles

## MIRIDS

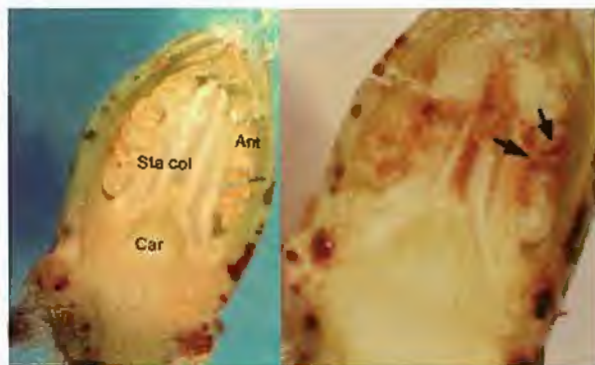
Several species of insects from the family Miridae have been associated with blackening and subsequent shedding of small squares and two of these also with the destruction of terminals. Most of these mirids also display a degree of predatory activity.

### Green mirid

The most important mirid pest is the **green mirid**, *Creontiades dilutus* (Stål), which has a wide host range, including field crops such as lucerne, safflower, sunflowers and potatoes and many weed species. The damage caused by this pest to cotton is very similar to that caused by *Lygus* spp. in the US and other parts of the world.

- **Life cycle.** Eggs are laid singly within the plant tissue with only an oval egg cap showing above the leaf or petiole surface. Eggs hatch after seven to ten days and there are five nymphal instars. The green to yellow/green nymphs range in size from 1 mm up to 6 mm and all instars are highly mobile with long antennae. Under summer conditions, a generation can be completed in about three weeks. Adults can live for three to four weeks.

- **Damage.** During feeding green mirids pierce the plant tissues with their sharp mouthparts or stylet and release a chemical (pectinase) which destroys cells in the feeding zone. The affected tissue rapidly dulls in colour, then blackens, desiccates and dies. Favoured feeding sites include plant terminals (particularly on seedlings), small squares and young leaves. It is common for these structures, especially terminals and squares, to be destroyed by mirid feeding. Green mirids can also feed on large squares and small bolls, but it is not known if this can affect yield or quality. Under current commercial practices, pesticides used for heliothis control normally prevent mirids from attacking larger squares or small bolls, however, this situation could change when transgenic cotton carrying heliothis resistance genes (e.g. Ingard®) is widely grown and those chemicals are no longer used. In effect mirids could become more significant pests when transgenic varieties are grown.



Transverse section of cotton square showing damage by green mirid on right (arrowed) - undamaged square left Photo: A. Chinajariyawong

If seedling tipping out and early square loss caused by green mirids is excessive, maturity can be delayed and yield reduced. Adult green mirids can cause more damage than nymphal instars 1 - 4 and similar to slightly more damage than the final instar 5.

- **Treatment.** Field cage studies indicate that up to four adult green mirids can be tolerated per metre in cotton prior to flowering before maturity is significantly delayed or yield threatened. However, green mirids are very mobile pests and are easily disturbed during sampling, making accurate estimates of the population in the field very difficult to achieve (Fig.8). It is common, therefore, for commercial thresholds to be well below four per metre (often less than one per metre).

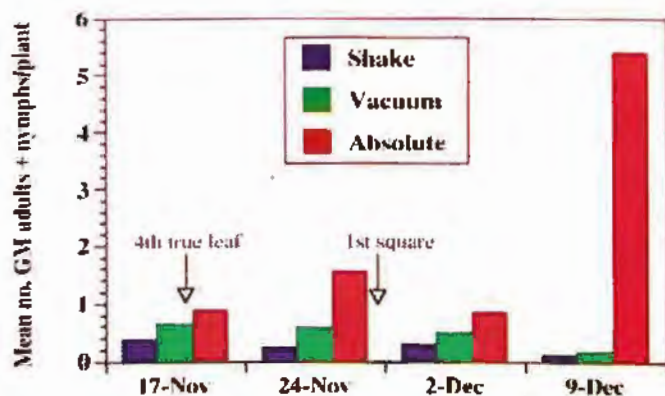


Fig.8 A comparison of 3 sampling methods for green mirids (GM) in cotton at Theodore, 1992. (Absolute = very careful visual inspections). Graph: M. Miles

At present there are no selective insecticides available for mirid control and natural enemies appear to be too few to be effective. Therefore, the use of broad spectrum insecticides such as organophosphates and synthetic pyrethroids are usually needed to give adequate control. Unfortunately these insecticides are very destructive to populations of the beneficials that can affect other pests such as mites, aphids and heliothis. In order to prevent unnecessary sprays for mirids, it is important to monitor tipping out and early square retention when mirids are known to be present. Low population levels can often be tolerated without reducing moderate yield or delaying maturity.

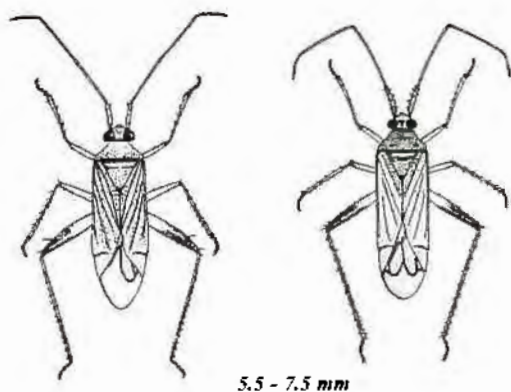
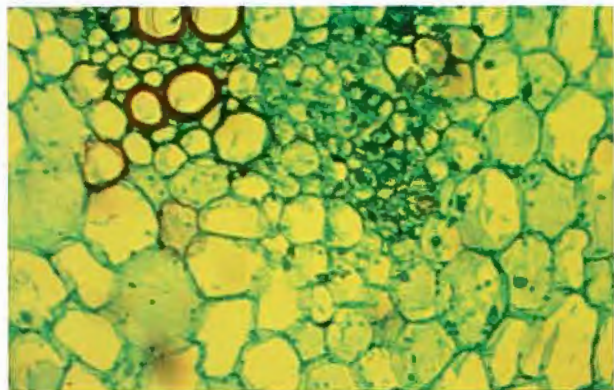


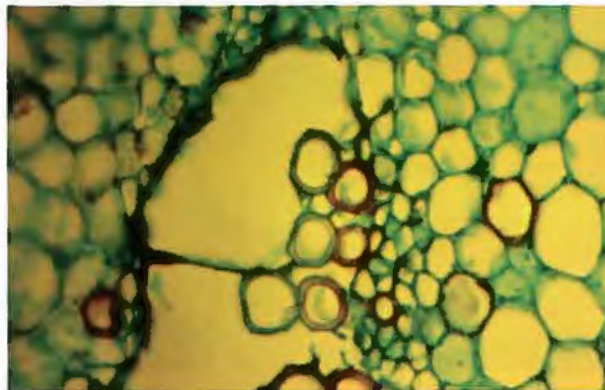
Fig.9 Green mirid adult (left) and brown mirid adult (right) Drawing: K. Liao

- **Factors affecting abundance.** Local weeds and crops, such as safflower and sunflower, are thought to be the source of many green mirid infestations in cotton. There is also evidence that green mirids are introduced to cotton growing areas with the passage of weather fronts, particularly in the October to December period. Green mirids are known to breed in large numbers in the same Outback hosts that support *H. punctigera* during winter-early spring and it is possible that the widespread and repeated influxes of mirids which are sometimes observed in cotton areas early in the season could be due to long range movement.

Recent research with lucerne strips within commercial scale crops of cotton suggest that lucerne (a more favoured host than cotton) could be an effective trap crop for mirid infestations.



Slide of undamaged plant cells before mirid attack  
Photo: M. Khan



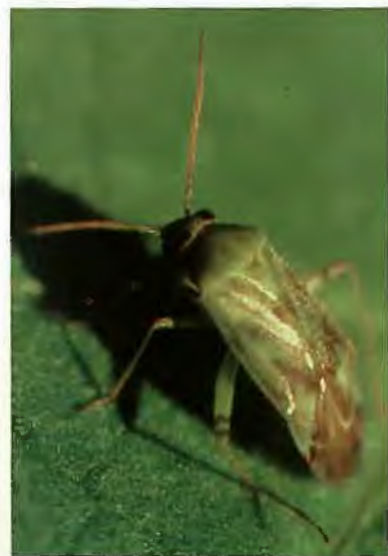
Slide of damaged plant cells after mirid attack  
Photo: M. Khan



Brown mirid adult Photo: M. Miles 7.5 mm

### Brokenbacked bug

The **brokenbacked bug**, *Taylorilygus pallidulus* (Blanchard) is smaller than the green or brown mirid and is not often found in large numbers in cotton. Little is known about this insect, but it does not seem to be capable of significant damage.



Brokenbacked bug adult 5 mm  
Photo P. Room

### Brown mirid

The **brown mirid**, *Creontiades pacificus* (Stål) is slightly larger and similar in appearance to the green mirid, but carries more dark pigments (Fig.9). While the brown mirid can cause similar damage it is usually found in much lower numbers than the green mirid on cotton.

### Apple dimpling bug (Yellow mirid)

The **apple dimpling bug (yellow mirid)**, *Campylomma liebknechti* (Girault) is about one third the size of the green mirid. It is an important pest of apples and is known to damage small squares early in squaring on cotton but it is generally regarded more as a predator of heliothis eggs and mites than a pest. More detail on this insect appears on p.43.



Apple dimpling bug adult 3 mm  
Photo: R. H. Broadley

## APHIDS

The **cotton aphid**, *Aphis gossypii* Glover is the predominant species causing economic losses to cotton. Chance infestation by winged adults of other species such as the **cowpea aphid**, *Aphis craccivora* Koch may occur in spring, but nymphs soon die and adults fly off in search of more suitable hosts. The **green peach aphid**, *Myzus persicae* (Sulzer) is occasionally found in cotton crops late in the season and has the potential to become more prominent because it has developed resistance to some OP and carbamate insecticides. The **bean root aphid**, *Smynturodes betae* Westwood can affect seedling plants, but its occurrence is rare.



Cotton aphid showing variation in colour  
Photo P. Reid 1-2 mm

### Cotton aphid

Female *A. gossypii* produce young without mating. The first arrivals on cotton in the spring or early summer are winged, blackish-green females. These produce dusky green to orange-coloured nymphs, which mature as wingless females in as little as four days and in turn produce more nymphs. Multiplication can continue until the colony becomes overcrowded or until young plant growth is no longer available when the winged forms are again produced. Aphids can have fifty or more generations a year.

The application of pesticides for other pests usually controls aphids for most of the cotton season. However, as pesticide use for heliothis or mites ceases late in the season, aphids often colonise the young regrowth of cotton terminals which is produced during the final maturation of the boll load.

- **Damage.** Large numbers of aphids feeding on young leaves can have a debilitating effect on cotton growth, but do not normally limit yield. Far more important is the excretion of sugars or honeydew which interferes with photosynthesis and in the late season causes stickiness and discoloration of lint. Severe downgrading of honeydewed lint may result because of the problems it causes to modern spinning machinery. In some countries, but so far not in Australia, aphids may act as vectors for severe viral diseases of cotton.



Honeydew on cotton  
Photo: QDPI

- **Factors affecting abundance.** Natural enemies are frequently associated with aphid infestations. These include predators such as ladybirds, larvae of lacewings and hoverflies, small parasitic wasps which mummify their aphid host, and during periods of heavy rainfall, fungal diseases. When conditions are only moderately favourable to aphids natural enemies may successfully limit populations. However, under conditions favourable for mass dispersal and rapid aphid increase natural mortality factors may not be effective. In addition, some broad spectrum insecticides (many pyrethroids and carbamates) can induce aphid problems because of their detrimental effect on natural enemies combined with their inherent poor efficacy against aphids. Insecticide resistance in cotton aphid is an increasing problem in some cotton-producing countries but has not yet developed in Australia, probably because of the very wide range of unsprayed hosts.

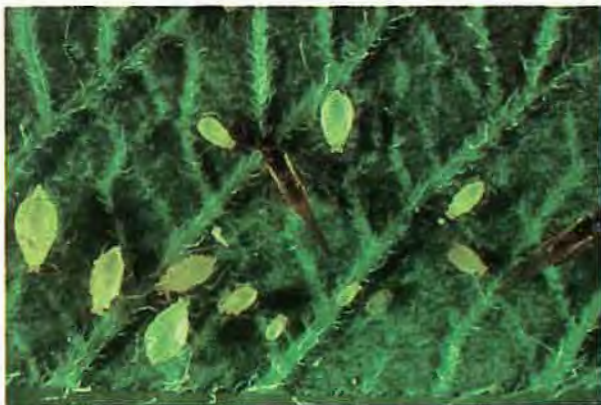
- **Treatment threshold.** A high threshold of 90 percent infested plants is suggested until boll opening commences. If honeydew is present when bolls are opening, the threshold is dropped to 10 percent because of the potential for severe downgrading of the lint value.

## Green peach aphid

The **green peach aphid**, *Myzus persicae* has been reported from cotton in the past but has not often been distinguished from the more abundant cotton aphid, *A. gossypii*. However, in recent years, there have been increasing instances of aphids resistant to the standard OP sprays used in cotton. These aphid infestations have been identified as *Myzus persicae*.

The green peach aphid is pale yellow-green and more oval shaped than the cotton aphid. Seen with a hand lens or microscope, *Myzus persicae* has a small tubercle at the junction of the antenna and head, which is absent in *A. gossypii*. (Fig.10).

The life cycle, economic damage and thresholds for *M. persicae* in cotton are similar to that of *A. gossypii*. It has a wide host range including a number of weed hosts common in cotton or nearby fields. These include peach vine, turnip weed, marshmallow and thornapple.



Green peach aphid Photo: D. A. Ironside

2-3 mm

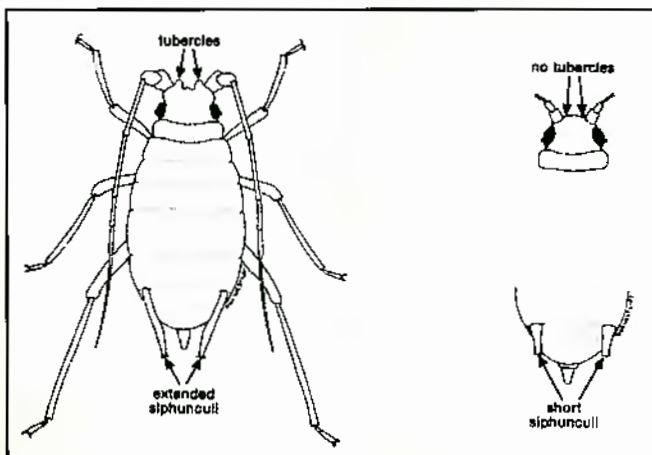


Fig.10 Diagram of the distinguishing features of the green peach aphid (left) and the cotton aphid (right) - extracted from Forrester & Wilson (1988)

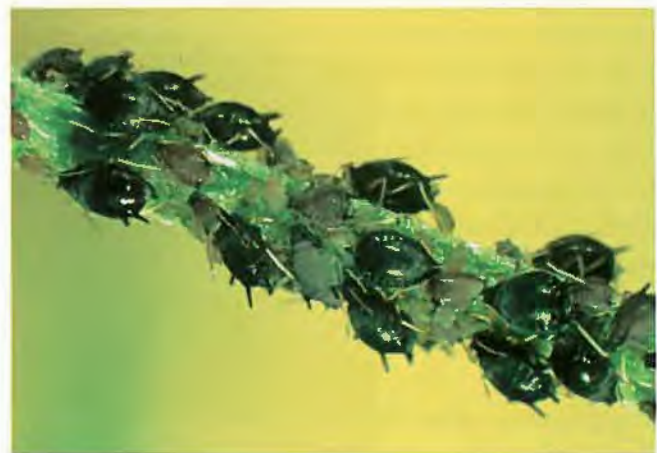
## Bean root aphid

The **bean root aphid**, *Smynturodes betae* can affect seedling plants, but is rare. When infestations do occur, they can cause seedling death and be confused with seedling disease. Careful uprooting of aphid-affected seedlings will reveal colonies of small, globular, wingless aphids at a depth of 10 cm or so. They are tended by ants which construct small chambers to allow aphid movement around the roots. These chambers are covered with a white, waxy dust from the aphids. No effective chemical control is known, although irrigation may have some beneficial effect. In most cases identified so far, infestations have occurred in seedbeds previously heavily infested with burr medic.



1-2 mm

Bean root aphids on cotton seedling. The tap root has been removed from the root channel to reveal aphids and waxy dust on the root and the root channel. Photo: M. Cahill



Cowpea aphid on pigeon pea - the winged form occasionally infests seedling cotton for short periods  
Photo: J. Wessels



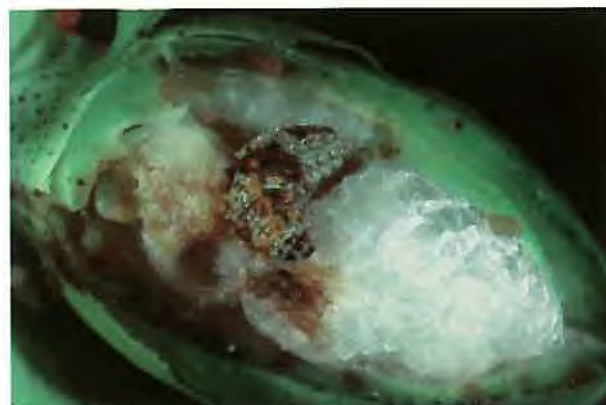
Rough bollworm egg about to hatch < 1 mm  
Photo: C. Mares



Rough bollworm larva Photo: P. Room 10 mm



Rough bollworm adult Photo: J. Wessels 11 mm



Rough bollworm larva in damaged boll  
Photo: D. A. Ironside

## OCCASIONAL PESTS

### Rough bollworm

**Rough bollworm**, *Earias huegeliana* Gaede occurs widely on malvaceous plants including cotton in Australia and the Pacific Islands. One other species is of minor importance on cotton in northern Australia, *Earias vittella* (Fabricius), the **northern rough bollworm**. It is widely distributed throughout Asia and is an important pest of cotton in India.

The weed, bladder ketmia, *Hibiscus trionum*, is the major host of *E. huegeliana*. Upsurges of rough bollworm in cotton are frequently associated with the maturing of wild hosts. Damage is caused directly to bolls by larval tunnelling, although larvae can also be found in squares. Larvae may also tunnel down the mainstem causing destruction of the primary growing point at any growth stage including seedlings.

- **Description and biology.** Rough bollworm eggs are small, blue/green and difficult to find. They take about 3 days to incubate in summer. There are five larval instars lasting in total about 2 weeks while pupae are housed in papery, brown cocoons on the stem or on an old leaf. A generation takes about 5 weeks to complete under optimum conditions. There appears to be no diapause in winter, but the life cycle can be very prolonged at temperatures below 10°C.

- **Abundance.** Although rough bollworm may cause serious damage to unsprayed cotton, it is normally controlled incidentally by sprays applied for heliothis.



Bladder ketmia Photo: QDPI

Consequently, it is not usually of much importance in commercial cotton except on isolated farms which are surrounded by native pasture or late in the season, when a decline in heliothis activity and therefore spraying may allow rough bollworm to infest crops.



Cotton tipworm white egg on left and egg at 'red-ring' stage on right Photo: M. Cahill



Cotton tipworm larva Photo: C. Mares

5 mm



Cotton tipworm larva and damaged cotton terminal Photo: D. A. Ironside



Comparison of heliothis larva (left) and cotton tipworm larva (right) Photo: NSW Agriculture

## Cotton tipworm

The **cotton tipworm**, *Crocidosema plebejana* Zeller infests a range of malvaceous plants including cotton. Substantial infestations appear to be more frequent in southeast Queensland than in central Queensland or New South Wales cotton producing areas. The larvae tunnel into the terminal destroying the single stem habit of cotton seedlings and causing multiple branching. If this damage occurs in the seedling or early squaring stages of crop growth, it may result in increased vegetative growth (branching) at the expense of early reproductive growth, and crop development can be delayed. If a delay is compounded by other adverse factors (e.g. cool weather) then fibre quality and yield can also be reduced. Tipworm damage is generally less important once substantial vegetative growth and square production has commenced. However, on the rare occasions that conditions allow it to reach high numbers in cotton, it can also attack squares and bolls.

- **Description and life cycle.** The small moth lays oval-shaped, flattened, translucent eggs which are placed singly, often next to a leaf vein on the underside of a leaf or among the small terminal leaves. As the egg develops its colour becomes whiter and a 'red ring' develops just before hatching.

Young tipworm larvae can be difficult to distinguish from those of heliothis without a hand lens, but larger larvae (up to 15 mm in length) can be more easily separated, having a pigment-free, cream-coloured body and a dark head capsule. Newly hatched larvae quickly move to more suitable feeding sites. On young cotton this is usually the terminal, but on older cotton, squares and bolls can also be attacked. The young larvae graze in the terminals, then later tunnel down into the stem. Young larvae grazing in the terminals can 'ringbark' small squares. This damage can be confused with the blackened squares caused by mirid or heliothis feeding. Older larvae may move from plant to plant to complete development. Mature larvae drop to the soil to pupate.

Two or more generations may occur per season, the first in October-November and the second in November-December. The pest normally disappears from cotton in January-February.

• **Factors affecting abundance.** Outbreaks are associated with winter and spring rainfall and cool spring temperatures inducing unusually late and vigorous growth of the tipworm's main host, marshmallow (*Malva parviflora*), which is a common weed of stock routes, roadsides and pastures. As marshmallow dies off in spring to early summer the pest transfers to cotton. The degree of local, late marshmallow infestation can be used as a guide to the potential tipworm problem because of the limited dispersal capacity of the small adult moth.

• **Treatment.** Tipworm control is best carried out on eggs and young larvae. Once larvae begin to tunnel in the stem, insecticides cannot give adequate control. There is very little information on spray thresholds, but survival is poor on seedlings less than 4th true leaf. For cotton 4th true leaf or older, it is suggested that 10 eggs per metre or 1 to 3 small larvae per metre is probably the minimum level at which control should be considered. The key to tipworm control is good application and timing.

## Cotton looper

The **cotton looper**, *Anomis flava* (Fabricius) is so named because of the looping movement of its greenish larvae. The small, bluish-green eggs are laid on leaves. The larvae prefer to eat older leaves and defoliation progresses upwards on the plant. As much as 80 percent defoliation of unsprayed cotton has been recorded. The pupae are found in rolled up leaves. Because of sprays applied against heliothis, looper infestations in commercial cotton are uncommon. See **Agfact AE.39, Looper caterpillars.**



Cotton looper damage Photo: QDPI



Cotton looper eggs Photo: C. Mares



Cotton looper pupae on cotton leaf  
Photo: D. A. Ironside



Cotton looper larva Photo: C. Mares

40 mm



Cotton looper adult Photo: D. A. Ironside

20 mm



Pinkspotted bollworm moths and larva  
Photo: P. Room



Section of cotton boll showing pinkspotted bollworm and its damage Photo: D. A. Ironside



Cottonwood tree Photo: NSW Agriculture



Broadleaf bottle tree Photo: NSW Agriculture

## Pink bollworms

Two species of pink bollworm occur in Australia. Neither infests cotton in New South Wales or southern Queensland. The **pink bollworm**, *Pectinophora gossypiella* (Saunders), has widespread distribution overseas where it is a major cotton pest, but in Australia it occurs only in the north of Western Australia and in the Northern Territory. Because cotton is not grown commercially in these regions at present, it cannot be regarded as a pest, although it could cause serious damage if it spread to, and established in, the eastern cotton-producing regions.

The **pinkspotted bollworm**, *Pectinophora scutigera* (Holdaway), occurs in coastal and central Queensland, and will attack cotton as well as its primary hosts (cottonwood tree - *Hibiscus tiliaceus* and broadleaf bottle tree - *Brachychiton australis*). In recent years moths have been caught as far south as Goondiwindi, but so far pinkspotted bollworm has only been found regularly breeding on cotton at Biloela and Theodore.

- **Life cycle and damage.** With both species the small, inconspicuous eggs give rise to larvae which tunnel into large squares, flowers or bolls, usually completing development in the one structure. Mature larvae pupate in bolls, stems or surface trash. The whole life cycle takes about 6 weeks, but usually only one generation of pinkspotted bollworm of economic importance occurs at Biloela/Theodore during late January-March. As far as is known, pinkspotted bollworm does not have an overwintering diapause. However, larvae can remain alive for long periods and survive by feeding on dry cotton seed in trash. Live larvae have even been found in seed cotton in modules awaiting ginning. Effective burial of cotton crop residues by late August has been found to minimise spring emergence and reduce subsequent infestations in cotton.

On the other hand, the pink bollworm does enter diapause and can be spread to new areas within cotton seed. Within Australia fumigation of seed cotton or cotton seed being transported from known pink bollworm infested areas to non-infested areas is mandatory.



Larva (18 mm) and pupa (10 mm) of lightbrown apple moth Photo: D. A. Ironside



Lightbrown apple moth male and female (right) Photo: D. A. Ironside



Redheaded flea beetle adult in foreground - brown flea beetle (2 mm) in background Photo: C. Mares



Brown flea beetle damage to cotton seedling Photo: C. Mares

## Tortrix (Lightbrown apple moth)

The **lightbrown apple moth**, *Epiphyas postvittana* (Walker) is also known as **tortrix** in the cotton industry. It can be found infesting cotton seedlings in low numbers, particularly in cool seasons but under hot, dry conditions it is seldom present. The pale, greenish/yellow eggs are laid in flat masses of 20 to 30 eggs overlapping each other like fish scales. These egg masses are not covered in moth scales like those of the lesser armyworm, *Spodoptera exigua* (see p.26). Young larvae feed by tying the terminal leaves together with a fine web which becomes dotted with pellets of frass. These young larvae superficially resemble small tipworm larvae, having a black head and pale body. However, they can be easily distinguished from tipworm larvae by the presence of webbing and the fast, twisting movement of the larvae when prodded. Older larvae vary from light to dark green with a light brown head and can grow up to 20 mm long. They pupate in silk-lined burrows in the soil after feeding for about 3 weeks. The host range includes many broadleaved weeds and crops such as lucerne. Damage to cotton is very rarely important.

## Flea beetles

Seedling damage caused by flea beetles is reported occasionally. They are small, shining, metallic beetles of the subfamily Halticinae, noted for their jumping ability. At least two species have been observed in seedling cotton, the **redheaded flea beetle**, *Nisotra* sp. and the **brown flea beetle**, *Chaetocnema* sp.

The redheaded flea beetle causes characteristic shot-hole perforations to leaves but rarely causes sufficient damage for control to be warranted.

The brown flea beetle causes linear surface feeding patterns particularly on the cotyledons. Occasionally infestations of this flea beetle are so large that control measures are needed to prevent desiccation of the seedlings.



Vegetable leafhopper Photo: P. Room

4 mm



Cotton leafhopper Photo: NSW Agriculture

3 mm

Leafhopper damage to okra-leaf cotton  
Photo: C. Mares

Mealybug on cotton Photo: C. Mares

3 mm

## Leafhoppers (Jassids)

Leafhoppers are commonly also known as jassids throughout the cotton industry. They are small, leaf-feeding insects ranging in colour from green, through yellow-green to brown. There are at least two species found in cotton, the **vegetable leafhopper**, *Austroasca viridigrisea* (Paoli) and the **cotton leafhopper**, *Amrasca terraereginae* (Paoli). The vegetable leafhopper is the most common of these pests found on cotton in New South Wales. The cotton leafhopper also occurs in New South Wales but is more abundant in Queensland.

Adults are small, elongate, wedge-shaped insects about 3 mm long, quick to hop and fly off when disturbed. Eggs are laid in slits made in soft plant tissue. Nymphs resemble adults but are smaller, paler and wingless. Leafhoppers occasionally damage seedlings and new growth, but they are more likely to attack mature leaves during the flowering stage. They feed on the tissues between leaves and produce a stippling effect but do not appear to reduce yield.

Overseas, cotton is attacked by a range of leafhoppers some of which feed on leaf veins and can severely distort growth, vector cotton viruses and reduce yield. Hairy-leaved cotton has been found to resist leafhopper attack but this trait is not used in Australian cotton cultivars because it makes the plant more susceptible to heliothis and mites and also reduces quality.

In Australia leafhoppers are normally controlled by sprays applied for heliothis and other pests and, therefore, have not been a problem in commercial cotton.

## Mealybugs

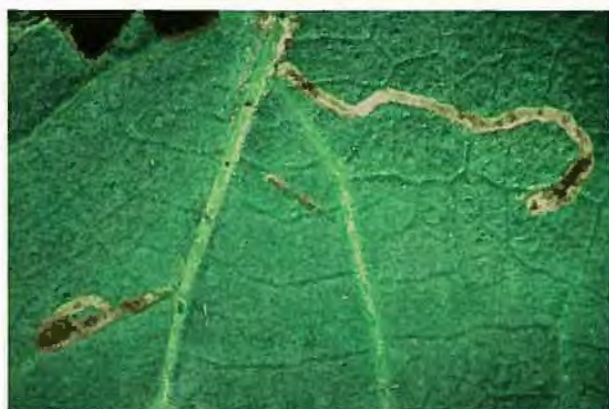
Mealybugs (family Pseudococcidae) are small, sucking insects related to aphids. They are occasionally seen on cotton in most areas and have, on rare occasions, reached minor outbreak levels or 'hotspots' in commercial crops in central Queensland e.g. **hibiscus mealybug**, *Maconellicoccus hirsutus* (Green). (Other mealybugs which also may have been collected from cotton include **striped mealybug**, *Ferrisia virgata* (Cockerell) and *Phenacoccus* (?) *solani* Ferris).

They form colonies on stems and leaves developing into dense, waxy, white masses. Infestations are usually close to field borders. Control is seldom warranted.

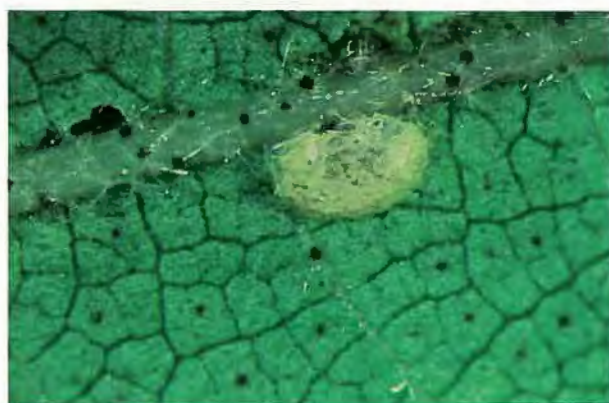


Cotton leafperforator adult Photo: C. Mares

4 mm

Cotton leafperforator early instar leafmining stage  
Photo: C. MaresLarva of cotton leafperforator and damage to cotton  
leaf Photo C. Mares

5 mm

Cotton leafperforator 4th instar larva in silk shelter  
on cotton leaf Photo: C. Mares

## Cotton leafperforator

The **cotton leafperforator**, *Bucculatrix gossypii* Turner occurs mainly in Queensland but has been recorded on occasions in New South Wales. The young larvae, instars 1 - 3, mine between the upper and lower surfaces of leaves emerging in the fourth instar to feed directly on the leaf. The fourth instar larva forms a thin, silk shelter in which it moults into the final instar. It is this fifth instar which causes the most obvious damage, skeletonising the leaf by feeding on the lower leaf surface leaving numerous windows and small holes. Older larvae (less than 10 mm long) are pale grey with four black spots just behind the head. Pupae are formed in white, ribbed cocoons attached to the leaf. Adults are cream/grey moths with wings which are densely fringed with hairs, particularly the hind wings. Damage is rarely important.

Larvae of this pest are occasionally noticed surviving early season endosulfan sprays for heliothis and are often mistaken for endosulfan resistant *H. armigera*. They are, however, not resistant to endosulfan, merely protected from the spray within their mines from which they emerge as late instar larvae.



Pupa of cotton leafperforator Photo: C. Mares

8 mm

Cotton leaf showing both mining and chewing  
damage of cotton leafperforator Photo: C. Mares



Mature cluster caterpillar larva

35 mm

Photo: D. A. Ironside



Cluster caterpillar adult and egg mass

25 mm

Photo: D. A. Ironside



Lesser armyworm larva Photo: M. Hill

25 mm



40 mm

Cutworm or Bogong moth larva Photo: P. Room



Cutworm damage to seedlings Photo: J. Wessels

## Cluster caterpillar

The **cluster caterpillar**, *Spodoptera litura* (Fabricius) was a serious cotton pest in the Ord River area but not in eastern Australia. Its habits resemble those of cutworms except that eggs and small larvae are always found in groups. The white eggs are laid under leaves and are covered with fine, brown hairs like scales from the female moth. Young larvae are grey/brown and they skeletonise leaves at night. Larger larvae consume whole leaves and heavy infestations defoliate large areas, destroying squares and flowers as well. Pupation occurs in the soil and the adults have dark brown forewings patterned with grey, white hindwings bordered with grey, and a wingspan of about 35 mm.

## Lesser armyworm

**Lesser armyworm**, *Spodoptera exigua* (Hübner) is often present in low numbers on young cotton, but prefers various weed hosts. Larvae may occasionally infest seedlings heavily enough to cause defoliation, and resowing may be necessary. The moth is about 10 mm in length with grey, mottled forewings. The hindwing is of a pearly-white colour. Eggs are laid in 'rafts' of 10 to 30 and are covered by webbing-like scales by the female moth. The young larvae remain near the egg raft and skeletonise the leaf. Mature larvae are often mistaken for heliothis but are green to brown, about half the length of a mature heliothis larva, with a white stripe along each side of the back. See **Agfact AE. 15, Armyworm caterpillars.**

## Cutworms

Cutworms, *Agrotis* spp. attack cotton seedlings at or above soil level and may destroy seedlings by either chewing through the stem or eating entire leaves. Cutworms are the larvae of the **Bogong moth**, *Agrotis infusa* (Boisduval) and related species. The moths are brown to black and slightly larger than a heliothis moth. They lay white eggs in the soil or on seedlings. The larvae are dark-grey to brown, smooth bodied, and 25 to 50 mm in length when fully grown. They feed in late afternoon and at night, spending the days hidden in the soil, except under very overcast conditions. Insecticide treatment for cutworms should be made in late afternoon or evening to minimise insecticide degradation prior to larvae emerging to feed.



Redshouldered leaf beetle Photo: A. Bishop 5 mm



Redshouldered leaf beetle adult and damage to cotton leaf Photo: A. Bishop



Spur-throated locust on cotton Photo: QDPI 65 mm



Underside of spur-throated locust showing spur at throat Photo: QDPI

## Redshouldered leaf Beetle

This beetle, *Monolepta australis* (Jacoby) rarely attacks cotton. It chews terminal buds, leaves, squares and the surfaces of bolls. Significant damage is uncommon and is usually confined to the edges of fields. Breeding apparently takes place in bushland where the eggs are laid in the soil. Larvae feed on plant roots and pupation is in the soil. Adults also feed on maize, citrus, avocado, macadamia and stone fruits.



Black field cricket - *Teleogryllus commodus* (Walker) Photo: D. A. Ironside

## Crickets and locusts

Field crickets, *Teleogryllus* spp. may damage cotton occasionally when present in plague numbers. The adults and late stage nymphs feed on the leaves and stems of seedlings and may reduce a stand to the extent that replanting is necessary. Occasional migratory swarms of the **spur-throated locust** *Nomadacris guttulosa* (Walker) can destroy large areas of young plants and can damage fruiting branches on older plants. The smaller **Australian plague locust** *Chortoicetes terminifera* (Walker) does not damage cotton.



Spur-throated locust damage to cotton Photo: QDPI



Greenhouse whitefly adults (1.5 mm) and immatures (0.5 - 1 mm) Photo: NSW Agriculture



Adult greenhouse whitefly Photo: G. Garrard



Immature stage of cotton whitefly Photo: B. Scholz



Cotton whitefly adult Photo: B. Scholz

1.5 mm

## Whiteflies

Whiteflies are in fact not flies but bugs belonging to the same general group as aphids, leafhoppers and mealybugs. Two species of whitefly have been found on cotton in Australia, although neither has so far reached economic pest status. The **greenhouse whitefly**, *Trialeurodes vaporariorum* (Westwood) can occur in high numbers on sunflowers and vegetables and has been occasionally found in large numbers on cotton. See Agfact AE.21, *Greenhouse whitefly*.

The **cotton whitefly**, *Bemisia tabaci* (Gennadius) has been present in Australia for at least 10 years but it has not yet caused any problems.

Of more concern is the recent introduction of **silverleaf whitefly**, *B. tabaci* biotype B to Australia. This insect has reached major pest status in cotton in many other countries (Africa, the Middle East, Asia and America) due to its prolific development rate, huge host range, copious honeydew production, pesticide resistance and transmission of gemini viruses. Although not internationally recognised as yet, B-type *B. tabaci* has been given separate species status in the USA, (*B. argentifolii* Bellows and Perring - silverleaf whitefly). In Australia, it has been detected in nurseries, glasshouses and some gardens of many towns servicing cotton districts. Specimens have also been found on cotton, tomatoes and sunflower. Its spread into commercial cotton crops is now highly likely.

- **Identification.** The greenhouse whitefly adult holds its wings flat, almost parallel to, and obscuring its body when viewed from above. Adults of the cotton and silverleaf whiteflies hold their wings more like the roof of a house that doesn't quite join at the apex, so when viewed from above, the body can be seen between the wings. Cotton and silverleaf whitefly adults cannot be separated visually, but a squash test, similar to the LepTon™ Test for heliothis, has been developed by NSW Agriculture which allows the silverleaf whitefly to be identified biochemically. Silverleaf whitefly feeding causes distinctive silverleaf damage that is not seen with the other whitefly species.

The feeding immature stages resemble scale insects and are difficult to identify. The non-feeding part of the 'pupal' stage, however, has long, waxy filaments in the greenhouse whitefly which are lacking in the cotton and silverleaf whiteflies (Fig.11).



Adult silverleaf whitefly Photo: G. Garradd

1.5 mm

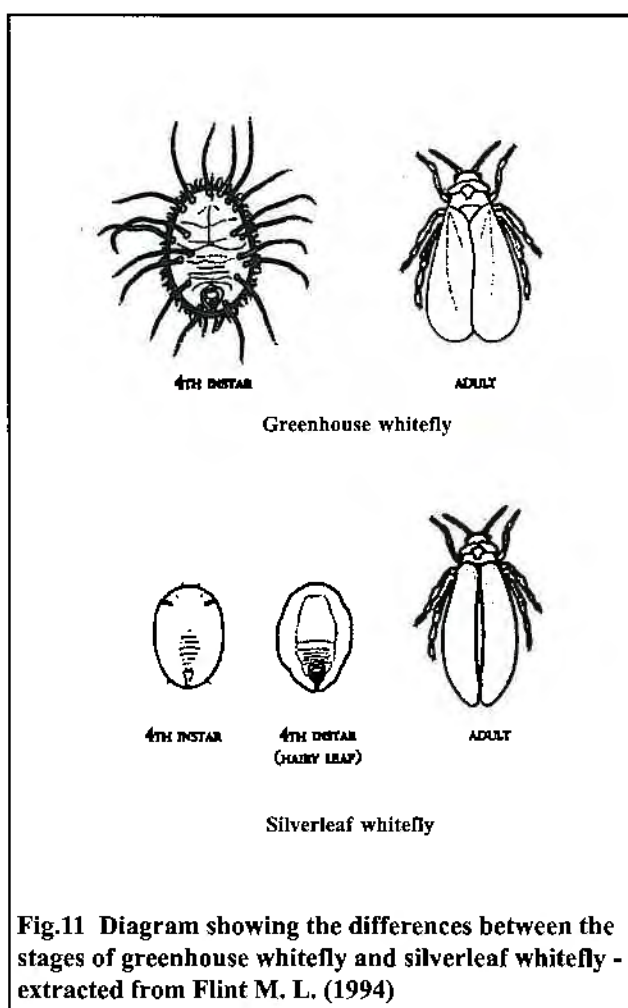


Fig.11 Diagram showing the differences between the stages of greenhouse whitefly and silverleaf whitefly - extracted from Flint M. L. (1994)

- **Damage.** Damage caused by whitefly is similar to that caused by aphids. Heavy infestations can cause plants to wilt but the main problem is the production of honeydew which interferes with the plant's photosynthetic rate and soils lint reducing its value. Whiteflies are vectors of viral diseases of cotton in other parts of the world (e.g. gemini viruses **cotton leaf curl** and **cotton leaf crumple**).

- **Life cycle and factors affecting abundance.** Whitefly adults lay minute, stalked eggs in clusters on the underside of leaves. Only the first nymphal instar is mobile, whereas the small, scale-like second and third instar nymphs remain attached to the underside of the leaf where they feed. The fourth instar nymph is sometimes called a 'pupa', but since it feeds for the early part of the stage, it is clearly not a pupa in the strict sense. When the adult emerges from the 'pupal' case it will feed on plant sap, but tends not to produce honeydew in the same quantity as the nymphal stages.

Infestations develop in humid, sheltered situations within the canopy, where whiteflies are very difficult to reach with aerially applied sprays. Other factors thought to encourage abundance are the destruction of natural enemies by sprays such as pyrethroids applied for other pests and high nitrogen applications which make the cotton plant a more favourable host. Some cotton varieties, particularly those with the okra leaf shape may be partially resistant to whitefly because of their more open canopy.

Silverleaf whitefly has a wide host range and its potential to develop as a major cotton pest is often linked to the growing and/or sequence of crops or weeds which allow winter and spring generations to reach high levels. *Further information on the silverleaf whitefly can be obtained from the Technology Resource Centre (067) 991534.*

## True and false wireworms

There are two types of wireworm larvae found in cotton. The **true wireworm**, *Agrypnus variabilis* (Candeze) is a soft-bodied, cream-coloured larva growing to about 20 mm long with a flattened, dark brown head. False wireworms are a mixture of species, principally **eastern false wireworm**, *Pterohelaeus darlingensis* Carter, **large false wireworm**, *Pterohelaeus alternatus* Pascoe, **southern false wireworm**, *Gonocephalum macleayi* (Blackburn) and *Saragus* spp. They are all very similar, hard-bodied, shiny, tan-coloured larvae growing to about 30 mm long. The true wireworm is the larval stage of a click beetle whereas false wireworms are the larvae of beetles of the family Tenebrionidae which includes the pie dish beetles. Both damage cotton by either boring into germinating seeds or chewing through young seedlings just below ground level. Damage can occur for up to 4 weeks after sowing, resulting in patchy plant stands which can necessitate replanting.

- **Life cycle and abundance.** Eggs are laid in summer and autumn, and larvae feed on organic matter in the soil until they reach full size in spring. True wireworms prefer wet soil for egg laying (e.g. irrigated summer crops), whereas false wireworms prefer drier conditions protected by stubble or weeds. Spring infestations can be expected to be worst in newly developed fields, in fallowed fields (particularly with heavy trash cover) and in fields following summer crops (particularly soybeans). There should be no problems with fields following cotton, as the insecticide spray schedules in that crop prevent beetles from surviving and laying eggs for the following season. The reduction in insecticide use anticipated when transgenic cotton is introduced may change this situation and allow more soil insects to survive. Birds following cultivators are a good indication of potential wireworm problems.

Wireworms are most difficult to sample. They descend in the soil as it dries out and venture near the surface only after rain or watering-up. Hence, they are often not noticed until damage appears. However, by this time it is not possible to control them. Any control measures must be applied before, or at, sowing. The most effective control is an infurrow band application of either granular or liquid insecticide. See **Agfact AE.22, Wireworms and false wireworms**.



True wireworm larva Photo: D. A. Ironside 20 mm



True wireworm adult Photo: J. Wessels 15 mm



Large false wireworm larvae Photo: QDPI 35 mm



Adults of large false wireworm and southern false wireworm (right) Photo: D. A. Ironside



Cotton stainer adult Photo: M. Cahill 10mm



Adult cotton harlequin bug with egg cluster 20 mm  
Photo: C. Mares



Cotton harlequin bug nymphs Photo: C. Mares 12 mm



Green vegetable bug adult (12 mm) and nymphs  
Photo: P. Reid, C. Mares

## Bugs attacking bolls

Although a number of bugs can injure green and maturing bolls, economic damage is unusual in commercial cotton because bugs are controlled incidentally by sprays applied for heliothis and other pests. The piercing/sucking mouthparts of bugs are used to penetrate green boll tissues and withdraw nutrients from the developing seed. As well as causing direct damage, feeding allows the entry of boll-rotting fungi, leading to staining of developing lint and sometimes a condition known as 'tightlock' in which the lint does not fluff out when the boll opens. Tightlock can also occur if prolonged rainfall coincides with boll splitting, just as bolls begin to open. This form of tightlock is also due to fungal infection but entry to the boll in this case is not by way of sucking bug feeding wounds. The reduction in pesticide use with the transgenic cottons may see an increase in these pests and boll damage symptoms.

Bugs which fall into this category include the **pale cotton stainer**, *Dysdercus sidae* Montrouzier, the **cotton harlequin bug**, *Tectocoris diophthalmus* (Thunberg) and the **green vegetable bug**, *Nezara viridula* (Linnaeus). See Agfact AE.34, *Green vegetable bug*.

- **Life cycle.** The life cycles of the pale cotton stainer and the cotton harlequin bug have not been fully studied. These two bugs are found mainly on malvaceous plants and related plant families, whereas the green vegetable bug, an introduced pest, attacks a wider range of plants.

The pale cotton stainer lays eggs in the soil, whereas the green vegetable bug lays eggs in 'rafts' on the underside of leaves. The cotton harlequin bug lays eggs in a whorl around a branch which is tended by the female until the eggs hatch. Small nymphs of all three species are gregarious and feed on seeds that can be reached by their short stylets that is, either in very small bolls or in opening bolls. The adults remain quiescent through the winter until suitable wild hosts become available in spring and summer. Generally damage occurs only in the autumn.



Rutherglen bug adult 4mm Photo: P. Room  
Rutherglen bug nymphs Photo: QDPI



Cottonseed bug adult Photo: NSW Agriculture 3.5mm



Yellow peach moth larva and damage to cotton boll  
Photo: QDPI 20 mm



Yellow peach moth adult Photo: J. Wessels 13 mm

## Rutherglen bug and grey cluster bug

Adult **Rutherglen bugs**, *Nysius vinitor* Bergroth and the very similar **grey cluster bug**, *N. clevelandensis* Evans are often found on cotton but they do not tend to feed and are unable to reproduce on the crop. They are important pests of sunflower and also attack several other field crops, fruit crops and weeds. Starving nymphs can occasionally cause damage to border areas of cotton adjacent to sunflower crops that have started to desiccate.

## Cottonseed bug

Adult **cottonseed bugs**, *Oxycarenus luctuosus* (Montrouzier) can be found sheltering on cotton plants from the late seedling stage onwards but do not feed or reproduce until cotton bolls open and ripe seeds are available. The eggs are laid in open bolls, and the bright red nymphs can be found in clusters among the lint. The only economic damage is from reduction of seed weight in late bolls, which may be by as much as 15 percent and also reduction of seed viability under moist conditions favourable to feeding. Because this damage tends to be only to seeds in late bolls it is not normally considered a pest requiring control measures.

## Yellow peach moth

**Yellow peach moth**, *Conogethes punctiferalis* (Guenée) is a rare late season pest of cotton in coastal Queensland. It has not been recorded from cotton in New South Wales. Eggs are laid on bolls and the grey/pink larvae bore into bolls and sometimes stems. Small larvae resemble those of the pinkspotted bollworm but produce masses of webbing and excreta at the entrances to their tunnels. The moth is a bright yellow/orange dotted with black spots and has a wingspan of about 25 mm. The wide range of host plants includes sorghum and maize.

## Springtails

**Springtails** are minute, (about 1 mm long), grey, soft-bodied wingless insects. They are occasionally seen on young cotton seedlings during prolonged cool, wet conditions. They can be found on the plants at night or on overcast days, otherwise sheltering in the soil by day. They cause similar damage to thrips but seldom require control unless cool, wet conditions persist.

## OTHER COMMON INSECTS

### Flower beetles

Small groups of black beetles, **flower beetles**, *Carpophilus* spp. are a common sight in cotton flowers. The larvae are white with a pale brown head. Adults and larvae appear to feed on pollen but do not cause any damage in the process. Larvae are sometimes mistaken for other pests such as the **boll weevil**, *Anthonomus grandis* Boheman a major pest in the Americas, but one that has not been recorded in Australia. (The typically 'C' shaped boll weevil larvae grow much larger and remain in cotton squares, many of which drop to the ground with the weevil larva still inside).



3.5mm

Flower beetle adults in cotton flower Photo: P. Room



2.5mm

Flower beetle larva Photo: P. Room



Adult boll weevils on cotton square in Texas  
Photo: W. Sterling

### Shield bugs

The **brown shield bug**, *Dictyotus caenosus* (Westwood) and the **redbanded shield bug**, *Piezodorus hybneri* (Gmelin) are not commonly found in cotton. The brown shield bug may be easily confused with the glossy shield bug, a predator (see p.41). The main distinguishing features of the brown shield bug are the matt brown surface, shorter head and smaller eyes. The habits of these bugs are not well known but they feed on a range of grasses bean crops and lucerne but not cotton.



8mm

Brown shield bug adult Photo: P. Reid



9 mm

Redbanded shield bug adult Photo: M. Shepard



Redbanded shield bug nymph Photo: J. Wessels

## PARASITES and PATHOGENS

### Parasites of Heliothis

All four parasites pictured left belong to the family Ichneumonidae. Little is known of their biology except that they inject their eggs into either larvae or pupae with a hypodermic, needle-like ovipositor. The larval parasites which feed inside their hosts do not cause death until after the hosts have pupated. All of these parasites attack larvae or pupae of a range of Noctuid moths, including those of heliothis. They are common in gardens and often enter houses, becoming trapped by closed windows. All of them seem to have wide geographical ranges including New Zealand and much of Asia.

**Two-toned caterpillar parasite** - *Heteropelma scaposum* (Morley).

**Banded caterpillar parasite** - *Ichneumon promissorius* (Erichson) is a true pupal parasite, laying its eggs in pupae in the soil.

**Orange caterpillar parasite** - *Netelia producta* (Brullé), notable for being attracted to light at night, sometimes in large numbers. This parasite emerges from the larval host in the soil before the host pupates. It forms a black, ovoid cocoon with black, fuzzy strands surrounding it.

**Orchid dupe** - *Lissopimpla excelsa* (Costa) The male orchid dupe is famous for being fooled into pollinating ground orchid flowers of the genus *Cryptostylis*. Flowers of these orchids mimic females of the wasp and male wasps become covered in pollen when they attempt to mate with the flowers!



Two-toned caterpillar parasite Photo: P. Reid 20 mm



Banded caterpillar parasite Photo: P. Reid 14 mm



Orange caterpillar parasite Photo: C. Mares 18 mm



Orchid dupe Photo: NSW Agriculture 20 mm



*Trichogramma* sp. on Noctuid egg  
Photo: M. Badgley 0.4 mm



Pupa of *Microplitis* sp. on 4th instar heliothis larva  
Photo: D. A. Ironside 3.5 mm



*Microplitis demolitor* ovipositing into heliothis larva  
Photo: M. Shepard 3 mm



Unparasitised heliothis larva (top) and larvae parasitised by (from top down) *Microplitis* sp., *Cotesia* sp. and *Hyposoter* sp. with pupal cocoons of each  
Photo: QDPI

Other heliothis parasites are very difficult to identify in the field. Minute wasps, *Trichogramma* sp. and *Telenomus* sp. attack eggs. Parasitised eggs turn black after 3 days and fail to hatch. One or more small, parasitic wasps may emerge from an egg 8 to 10 days after parasitisation (Fig.12). Egg parasitoids are most abundant later in the season from January to March and tend to reach higher levels of parasitisation in the northern cotton areas compared with the southern ones.



*Telenomus* sp. on eggs of *H. armigera*  
Photo: B. Scholz

The native *Microplitis demolitor* Wilkinson prefer to lay their eggs in small larvae. Parasitised larvae are killed before completing about 10 percent of the potential damage (feeding) of unparasitised larvae. When mature, the *Microplitis* leaves the host and spins a characteristic fawn-coloured cocoon nearby in which it pupates.

Two exotic species of larval parasitoids of heliothis, *Cotesia kazak* (Telenga) and *Hyposoter didymator* Thunberg, have been released in east Australian cropping regions since 1991. These wasps lay their eggs in small heliothis larvae and the host dies as a medium larva (Fig.13). Each wasp species forms a characteristic pupal cocoon. The establishment of these species in our cropping areas will complement the action of native heliothis parasitoids e.g. *Microplitis*.



Tachinid eggs on head capsule of heliothis larva  
Photo: D. A. Ironside



*Carcelia* sp. Photo: J. Wessels



Cotton aphid 'mummies' Photo: D. A. Ironside

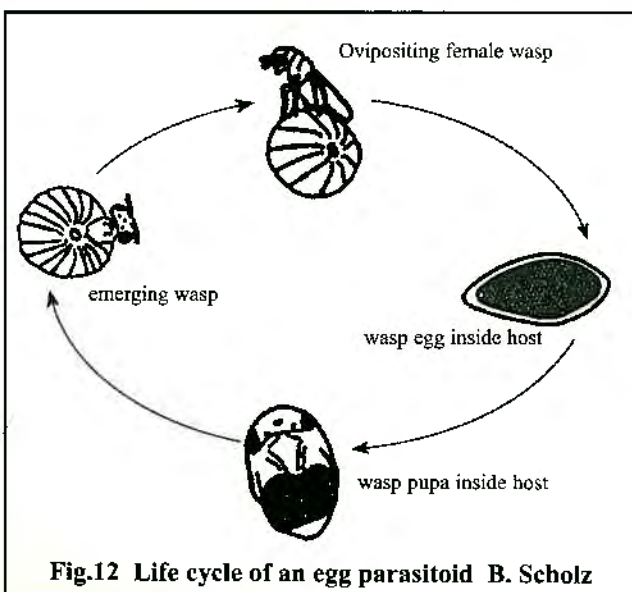


Fig.12 Life cycle of an egg parasitoid B. Scholz

Several species of flies such as *Carcelia* spp. and *Goniophthalmus* spp. (family Tachinidae) parasitise larvae. Some kill the larva while others kill the pupa. The Tachinid larvae feed within the host larvae and the adult flies emerge from the pupae.

*Argyrophylax proclinata* Crosskey, the **yellow peach moth parasite**, is another Tachinid which parasitises yellow peach moth larvae in a similar manner.



Adult fly and pupa of yellow peach moth parasite beside parasitised pupal cocoon of yellow peach moth  
Photo: D. Smith

Aphids are also subject to parasitisation in the field by small wasps. The parasitised aphids are called 'mummies' and are easily seen due to their distinctive, bloated shape and dark colouring.

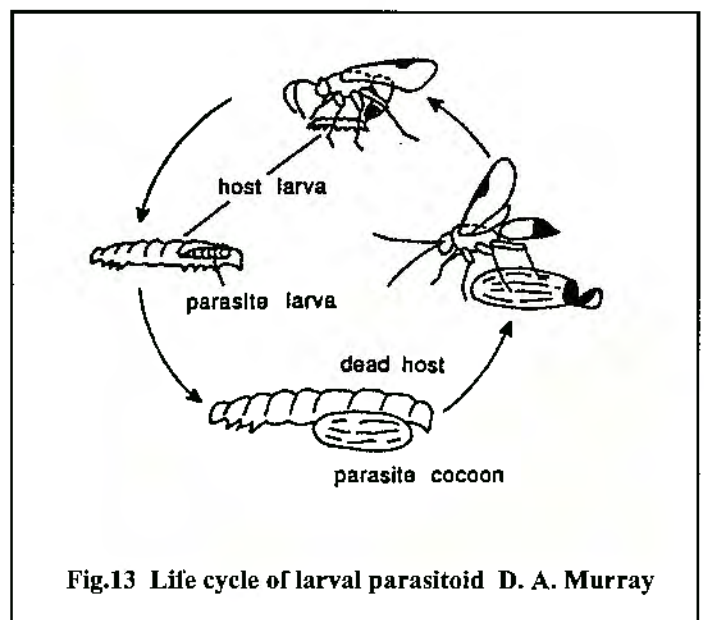
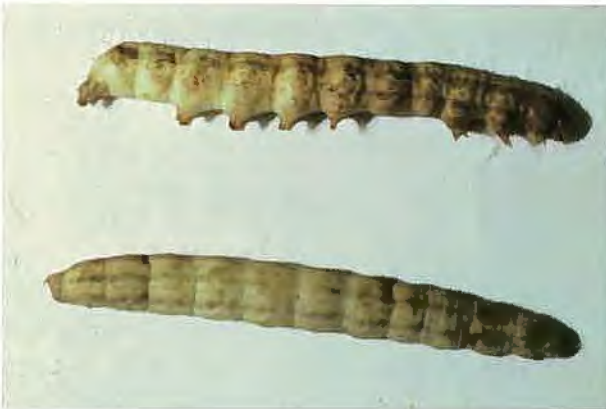


Fig.13 Life cycle of larval parasitoid D. A. Murray



Cotton looper affected by NPV  
Photo: D. A. Ironside



Larvae of *Helicoverpa punctigera* infected by granulosis virus Photo: QDPI



Larvae of *Helicoverpa armigera* infected with *Nomuraea rileyi* - before (above) and after (below) spore development Photo: QDPI



*Heliothis* larva infected with *Beauveria* fungus on right (healthy larva on left) Photo: QDPI

## Viral diseases

Viral diseases such as **nuclear polyhedrosis virus (NPV)** affect larvae of cotton pests such as heliothis, cotton looper, and cluster caterpillar. Outbreaks usually only occur when larval numbers are high. Larvae affected by NPV turn pale and die, usually near the top of the plant. They are frequently found on foliage, as if squashed, or hanging by the pro-legs. The body darkens and the skin becomes fragile and readily ruptures to release the virus-laden fluid contents of the body. The disease spreads to other larvae when they eat contaminated foliage.

## Fungal diseases

Fungal diseases may affect larvae of heliothis, cotton looper, cluster caterpillar and armyworms. Prolonged, moist conditions favour the development of fungal diseases such as those caused by *Nomuraea rileyi* (Farlow)Samson and *Beauveria bassiana* (Balsamo)Vuillemin. Larvae infected by fungus become stiff and are anchored to the plant by fungal threads. Later, they are completely covered in white fungus which produces a velvety layer of spores under moist conditions, green in the case of *N. rileyi* or white for *Beauveria* spp. These spores infect other larvae and other species of insects producing fungal threads which penetrate their bodies.

## Bacteria

Bacterial disease may also affect larvae of various cotton pests such as heliothis. Commonly, bacterial infections can be observed after artificial infection with *Bacillus thuringiensis* (Berliner), sold commercially as Bt sprays.



*Heliothis* larva infected with Bt Photo: QDPI

# PREDATORY BEETLES

## Ladybirds

Adults and larvae of ladybirds are important predatory insects in cotton, especially early season and when chemicals have not been used against pests. They are voracious predators of aphids and, under most conditions, ladybirds, along with lacewings and hover flies, stop aphid populations from increasing explosively. Ladybirds are also important predators of mites, heliothis eggs and small larvae. Ladybird eggs are generally yellow, spindle-shaped and laid standing on end in groups. The larvae are characteristically tapered, often with prominent tubercles, whilst the adults are round and highly convex in shape.

The most common ladybirds found in cotton are: **transverse ladybird**, *Coccinella transversalis* Fabricius, **striped ladybird**, *Micraspis frenata* (Erichson) and the maculate or **three banded ladybird**, *Harmonia octomaculata* (Fabricius). **Minute two-spotted ladybird**, *Diomus notescens* (Blackburn) is another common predator in cotton, particularly of mites. The tiny **mite-eating ladybirds**, *Stethorus* spp. are also good mite predators.



Ladybird eggs on cotton Photo: C. Mares

1 mm



Transverse ladybird adult Photo: NSW Agriculture

4 mm



Striped ladybird adult Photo: C. Mares

4 mm



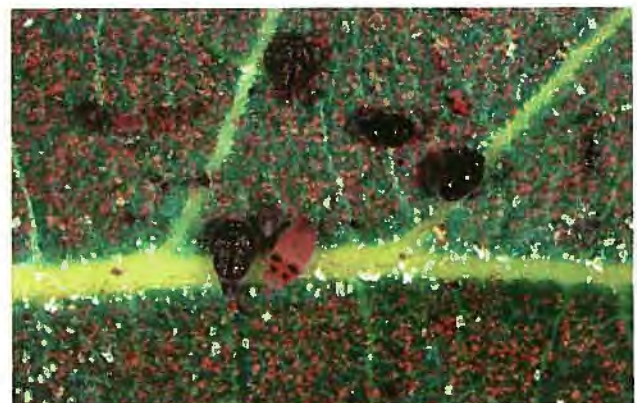
Three banded ladybird adult Photo: D. A. Ironside

5 mm



2.5 mm

Larva and adults of minute two-spotted ladybird Photo: D. A. Ironside



Mite-eating ladybird adults, pupae and larva with remains of mite infestation Photo: D. A. Ironside

1 mm



Variable ladybird adults Photo: R. H. Broadley 5 mm



Common spotted ladybird adult Photo: D. A. Ironside 7 mm



Three banded ladybird larva, pupa and adults Photo: D. A. Ironside 6 mm



Transverse ladybird larva and adults attacking aphids Photo: D. A. Ironside

Two species common on cotton in Queensland (but generally not further south) are **common spotted ladybird**, *Harmonia conformis* (Boisduval) and **variable ladybird**, *Coelophora inaequalis* (Fabricius).



Common spotted ladybird larva feeding on aphids Photo: D. A. Ironside 7 mm



Eggs of three banded ladybird Photo: D. A. Ironside



Variable ladybird larva feeding on aphids in citrus Photo: D. A. Ironside



Red and blue beetle Photo: QDPI

5 mm



Green soldier beetle Photo: P. Reid

10 mm



Green carab beetle Photo: P. Reid

24 mm



4 mm

Small carabid beetle predator found in cotton field  
Photo: C. Mares

## Red and blue beetle

The distinctive **red and blue beetle**, *Dicranolaius bellulus* (Guérin-Méneville) is extremely abundant in a range of habitats in some years and is rare in other years. The adults are partly carnivorous and search actively over cotton plants during the day. They eat eggs and small heliothis larvae and probably other slow-moving insects. In rice crops, adults have been found to feed on pollen anthers and stamens and are therefore sometimes referred to as pollen beetles. The egg, larval and pupal stages occur in the soil.

## Green soldier beetle

The **green soldier beetle**, *Chauliognathus pulchellus* W.S. Macleay sometimes occurs in large, flying swarms of low density. Some swarms seem to be mating aggregations while others seem to be mass dispersal flights. Large numbers of these beetles can arrive in a crop in a very short time. It is now thought that the adults of these beetles are plant feeders although they are not classified as a pest of cotton. The larvae are predaceous although they have not been found in cotton fields.

## Green carab beetle

Beetles belonging to the family Carabidae are general predators which vary greatly in size and colour. **Green carab beetle**, *Calosoma schayeri* Erichson is a large, active beetle hunting caterpillars and other slow-moving prey. It flies at night and is attracted to lights. If handled roughly these beetles give off an unpleasant smell. The larvae are predaceous also but have not been found in cotton fields.



Glossy shield bug adult Photo: C. Mares

12 mm



Glossy shield bug nymph Photo: J. Wessels

8 mm



Adult predatory shield bug Photo: C. Mares

12 mm



Predatory shield bug nymph Photo: J. Wessels

8 mm

## PREDATORY BUGS

### Glossy shield bug

Larvae including those of loopers and heliothis are the usual food of the **glossy shield bug**, *Cermatulus nassalis* (Westwood) and its nymphs. The black eggs which are laid in 'rafts' of 50 or more have short, white spines around the rim. Nymphs are dark red and brown with the early instars being bright red. Maximum numbers are found in unsprayed cotton during midsummer. In early summer they can be found in linseed and lucerne crops infested with heliothis. This species is easily confused with the brown shield bug (see p.33).

### Predatory shield bug

The **predatory shield bug**, *Oechalia schellenbergii* (Guérin-Méneville) is another species which feeds with piercing/sucking mouthparts mainly on caterpillars. Adults can be found at any time of year on weeds or crops infested with caterpillars. The black eggs are laid in 'rafts' usually in multiples of 14, with long, white spines around the rim. The nymphs are dark red and brown. Adults and nymphs are usually most abundant in cotton from December to February.



Predatory shield bug with heliothis larva  
Photo: J. Wessels



Egg raft of predatory shield bug Photo: J. Wessels



Damsel bug with heliothis egg Photo: QDPI 8 mm



Damsel bug on cotton leaf Photo: C. Mares 8 mm



Bigeyed bug Photo: C. Mares 3 mm



Assassin bug *Pristhesancus* sp. feeding on a larva of heliothis Photo: M. Shepard 20 mm

## Damsel bug

The **damsel bug**, *Nabis kinbergii* Reuter inserts its eggs singly into soft plant tissues so that the circular emergence caps protrude above the surface. Nymphs are small and wingless but otherwise similar to the adults. Nymphs and adults use piercing/sucking 'beaks' to feed on many insects including eggs and larvae of moths and also mites. They are usually present in any kind of crop infested with caterpillars. Maximum numbers occur in unsprayed cotton at the same time as maximum numbers of heliothis larvae. Adult damsel bugs may be found on weeds and crops during winter.



Bigeyed bug showing the characteristically large eyes Photo: D. A. Ironside

## Bigeyed bug

The huge eyes on the **bigeyed bug**, *Geocoris lubra* Kirkaldy provide easy identification. The cylindrical, white eggs are laid singly on terminals and under leaves. Adults and nymphs are fast-moving, daytime hunters of a range of soft-bodied insects and mites which they kill with piercing/sucking mouthparts. Numbers in cotton are highest during flowering. *Ger-malus* sp. is a slightly larger, related species also common in cotton but the two may be distinguished by colour. *Geocoris* is dark brown to black whereas *Ger-malus* is brown and green.

## Assassin bug

Several kinds of **assassin bugs** (Reduviidae) may be found in cotton but no one species is regularly abundant. They range from 10 to 30 mm in length, have distinct heads with prominent eyes and their abdomens have a slight waist. They use powerful piercing-sucking 'beaks' to feed on a range of insects.



Adult brown smudge bug with prey  
Photo: D. A. Ironside

4 mm

### Brown smudge bug

The habits of the **brown smudge bug**, *Deraeocoris signatus* (Distant) are not well known, though it has been found to feed on heliothis eggs, aphids and the apple dimpling bug. The maroon coloured nymphs and the adults are very aggressive predators of mites. It is most abundant in unsprayed cotton in December, January and February.



Apple dimpling bug adult  
Photo: R. H. Broadley

2.5 mm

### Apple dimpling bug (Yellow mirid)

The **apple dimpling bug**, or **yellow mirid** *Campylomma liebknechti* (Girault) feeds on plant as well as insect tissues (see p.16). Tiny, ovate, white eggs are hidden in terminal buds of cotton and hatch in 4 to 6 days to give yellow nymphs with red eyes. Nymphs mature in about 4 weeks. Adults and nymphs have dark spines on the legs, are fast-moving and are generally found on the top 10 cm of terminals. They use piercing/sucking mouthparts to feed on soft plant tissues (causing some small squares to shed) and eggs of heliothis and mites. Adults vary from yellow to pale, mottled green in colour, can kill very small heliothis larvae and will readily prey on mites. Other host plants include linseed, lucerne, sunflower, medics and turnip weed.

### Pirate bugs

**Pirate bugs**, *Orius* spp. prey on thrips and eggs of other insect pests in cotton. They often appear in large numbers at flowering when thrips are in abundance.



Apple dimpling bug nymph Photo: M. Cahill

2 mm



Pirate bug adult  
Photo: R. H. Broadley

2.5 mm



Eggs of green lacewing Photo: J. Wessels 0.7 mm



Green lacewing larva Photo: NSW Agriculture 4 mm



Green lacewing adult Photo: D. A. Ironside 12 mm



Brown lacewing adult, larva and prey Photo: D. A. Ironside 6 mm

## OTHER PREDATORS

### Green lacewings

At least two species of **green lacewings**, belonging to the genus *Mallada* are found on cotton. Their eggs are unmistakable, being white, oval and attached in groups to the undersides of leaves by long, flexible stalks.

The larvae are squat, six-legged, voracious hunters which camouflage themselves by lodging corpses of their victims on their backs. They have large, hollow, sickle-shaped jaws which they drive into soft-bodied insects or eggs before sucking up the contents.

The pupal cocoon is also camouflaged with corpses. Adults have a slow, fluttering flight and are not predaceous. Greatest numbers are found on cotton in mid to late season, especially if aphids are present. Larvae also feed on mites.

Large numbers of green lacewing eggs are often found in commercial cotton crops, but larvae are seldom seen. This is thought to be due to: the camouflaged nature of the larva making detection difficult; high mortality due to the use of broad-spectrum insecticides; and the often high level of egg parasitisation by *Telenomus* sp. (see p.35).

### Brown lacewing

The brown lacewing, *Micromus tasmaniae* Walker lays cream, oval eggs singly attached by one side to the underside of leaves. Larvae have sickle-shaped, hollow jaws like green lacewings. They differ from green lacewings by being longer and thinner and by not camouflaging themselves. Larvae are voracious predators of all insects and adults have been seen to eat heliothis eggs. Adults fly at night and are attracted to light.



Common brown earwig feeding on a heliothis larva  
Photo: M. Shepard

24 mm



Black field earwig Photo: D. A. Ironside

14 mm



Hover fly larva preying on cotton aphid  
Photo: C. Mares

5 mm



Hover fly pupa on cotton Photo: C. Mares

5 mm

## Common brown earwig

Earwigs have distinctive pincers at the 'tail' and hide on and in the ground during the day. Adult females guard their oval, white eggs and young nymphs in burrows in the ground. The **common brown earwig**, *Labidura truncata* Kirby is a nocturnal predator of caterpillars. It also attacks heliothis pupae in their chambers in the ground. Adults have wings folded beneath the slate-blue covers on the thorax and can fly.

**Black field earwig**, *Nala lividipes* (Dufour) also commonly occurs in cotton fields. It is smaller and entirely black in colour and can be a pest of seeds and seedlings.

## Hover flies

Adult **hover flies** (Syrphidae) are harmless but mimic bees and wasps with black and yellow bands across their abdomens. They feed on nectar and pollen of flowers. They fly swiftly and hover. White, oval eggs are laid on their sides near colonies of aphids. Larvae are blind, slug-like maggots which feed voraciously on aphids. The brown, tear-shaped puparia are found under leaves or in ground litter.



Hover fly adult Photo: QDPI

9 mm



Female wolf spider guarding her egg sac 18 mm  
Photo: D. A. Ironside



Female lynx spider with egg sac 12 mm  
Photo: C. Mares



Nightstalking spider in cotton Photo: C. Mares



Nightstalking spider preying on heliothis larva  
Photo: W. Sterling

## Wolf spiders

Several species of wolf spider, belonging to the genus *Lycosa* occur in cotton fields. Most have a shallow burrow in the soil as a retreat and range over the ground searching for prey. Their coloration merges well into a background of soil. They occasionally climb plants and large specimens have been seen killing large heliothis larvae. Females of these spiders carry their eggs in a grey ball attached to the abdomen. Wolf spiders are most easily seen in early summer before the cotton canopy closes over furrows.

## Lynx spiders

**Lynx spiders**, *Oxyopes* spp. are active hunters usually seen near the tops of plants. They do not make a web but use their good eyesight to locate prey, then jump on it from a distance. Their legs bear numerous characteristic spines. Their abdomens are narrow and pointed and usually pale brown to green and striped. As in almost all spiders, the young disperse by 'ballooning' from tall plants where the silk is played out into the breeze until the pull lifts and carries them away. Most spiders arrive on cotton in this way in early summer and do not mature and reproduce until the crop is flowering. Lynx spiders will eat small heliothis larvae.

## Nightstalking or sac spiders

Small **nightstalking spiders**, *Cheiracanthium* spp. are pale yellow with a faint grey mark on the abdomen. The 'head' of larger specimens may become pale orange (**yellow nightstalking sac spider** - *Cheiracanthium mordax* L. Koch). During the day they hide in silken retreats, often under leaves and during the night they stalk over plants searching for slow-moving prey. They will eat heliothis eggs as well as larvae. Adults are the largest spiders regularly found among cotton foliage and can give a painful bite with their large jaws. Mating takes place in midsummer in large silk retreats and the females guard their eggs in the retreats until they hatch.



Tangle web spider Photo: D. A. Ironside 7 mm



Redback spider Photo: M. Shepard 14 mm



Jumping spider with heliothis larva in its jaws 8 mm  
Photo: W. Sterling



Crab spider in cotton Photo: C. Mares 6 mm

## Tangle web spider

The **tangle web spider**, *Achaearanea veruculata* (Urquhart) is the commonest of several spiders making tangled webs in cotton. It has a globular, mottled abdomen and fairly long legs. The spiders hide in a retreat under a leaf and wait for insects to become caught in their webs which are usually found high on the cotton plant. They will eat heliothis larvae. Small spiders often build nests in mite colonies and feed on them.

## Redback spider

The **redback spider** *Latrodectus hasselti* Thorell is related to the tangle web spider but is much larger and more dangerous and is usually found close to the ground. It is much less abundant in cotton fields than the tangle web spider.

## Jumping spiders

**Jumping spiders** (family Salticidae) have two particularly large, forward-facing eyes which give them excellent binocular vision. They rest during the night and actively roam plants during the day jumping on prey detected by eyesight. They will eat small heliothis larvae. Except for the first pair, the legs are relatively short. Most species on cotton are predominantly dark or grey in colour.

## Flower spiders, crab spiders

Flower or **crab spiders**, (family Thomisidae) have crab-like legs and are often brightly coloured. They specialize in hiding on flowers where they are well camouflaged and ambush small insects attracted to nectar and pollen. They make no web but females cover their eggs with a silken shelter, usually under leaves.



*Araneus* sp. in web in cotton Photo: C. Mares 15 mm



*Argiope* sp. in cotton Photo: C. Mares



Red imported fire ant preying on heliothis egg  
Photo: W. Sterling



Red imported fire ants attacking heliothis larva  
Photo: W. Sterling

## Orbweavers

The familiar, circular orb webs are built in cotton by several different kinds of spiders, **orbweavers** belonging to the genera *Araneus* and *Argiope*. The webs are most noticeable when the plants are fairly large but before the canopy closes over the furrows. *Araneus* commonly wait under nearby leaves for flying insects to become trapped in their webs whilst *Argiope* rest in the centre of their webs, often with their legs in the shape of a cross. Remains of heliothis moths are often found hanging in the webs which are usually rebuilt every evening.

## Ants

Some ants (Hymenoptera: Formicidae) are important predators overseas. One such American species is the **red imported fire ant**, *Solenopsis invicta* Buren shown here.

The role of ants in Australian cotton however, is poorly understood but may be important in some instances e.g. under raingrown conditions and in lighter soils where ant colonies can establish within the field.



Fire ant attacking heliothis larva Photo: W. Sterling

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