The complexities of predicting predation on Helicoverpa

By Sarah Mansfield[1,2] and Louise Lawrence[2]

A three banded ladybird is a predator on aphids and Helicoverpa. It is one of the species being studied to help understand the impact of insect predators in cotton. (Photo: David McClenaghan.)

For environmental and commercial reasons, cotton growers are improving the way they manage *Helicoverpa armigera*, the main insect pest of cotton. Interest has shifted to area wide management of the pest and the use of an integrated package of methods, rather than a reliance on pesticides, known as Integrated Pest Management (IPM).

Scientists are investigating many components of the cotton system to provide new tools and knowledge to further develop these approaches. One of the most important areas of study is the role of beneficial insects in managing Helicoverpa populations.

The role of insect predators

CSIRO Entomology, as a partner in the Australian Cotton CRC, is researching the role of the many insect predators found in cotton. These come in all shapes and sizes and include predatory bugs and beetles, ants and spiders. The smaller predators feed on insect eggs or small larvae, while larger predators destroy larger caterpillars and other larger prey.

Over the past 30 years, a lot of information has been collected on the life histories and seasonal patterns of abundance of insect predators in cotton. But the comparison of these studies has been difficult for several reasons. Sampling methods vary and the efficiency and accuracy of sampling can be affected by factors such as time of day, size of the crop and even the operator.

Growers and consultants need to know how many beneficials are needed to keep *H. armigera* below the threshold for economic damage. They also need to have confidence in predictions based on observed predator numbers if they are going to implement IPM and maximise the value of conserving beneficial insects.

While the predator:prey ratio, developed by Robert Mensah (NSW Agriculture), is a useful tool for IPM, researchers still need to discover how much each species contributes to Helicoverpa control.

To start filling in these gaps, we are looking for evidence of predation on *H. armigera*. We are also examining interactions between predator density, prey density and availability of prey other than *H. armigera*. The latter is important because predators may have different foraging patterns depending on the presence or absence of preferred prey.

Another important issue is to understand the interactions which may occur among the predators themselves. Predators can interfere with each other through direct competition for resources, such as prey, or by feeding on one another instead of the pest. When this happens, increased predator diversity may reduce pest control, not enhance it.

It is also important to determine the effect of agronomic practices on predators. One obvious issue is the impact that various insecticides may have on beneficial insects. A range of insecticides is available some of which have a reduced impact on beneficials (‘soft’ insecticides). Current knowledge of insecticide impacts is presented within the IPM guidelines and there

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is ongoing research on the impact of new insecticides on different predator species (*http://www.cotton.pi.csiro.au/Publicat/Pest/*).

When the use of Ingard cotton or ‘soft’ insecticides leads to an increase in beneficial insects, what effect does that have on pest abundance? What additional effects do irrigation or cultivation have on beneficial insects? All these questions need to be answered.

Measuring predation

Predation is difficult to quantify in the field. In most cases, predators leave no trace after taking prey, unlike parasitism where the parasitised host usually persists for some time.

Direct observation is one way to measure predation but this is time consuming and many predators are nocturnal or secretive, making observation difficult. Experiments in the laboratory, glasshouse or field cages can also be used to quantify predation but confining predators may affect their behaviour.

To help overcome these problems, we are now using specific antibodies to detect prey in the gut contents of individual predators, a technique that allows direct measurement of prey consumption in the field. But even this isn’t perfect as results can be affected by the time since the prey was eaten, temperature and the number of prey eaten.

Ants and ladybirds reveal complexities

Ants are a good example of some of the complexities involved in predator research. Dr James Lytton-Hitchins showed that although four ant species forage in cotton crops, only two of these are significant predators of Helicoverpa eggs.

As foraging activity by ants is greatest early in the season, before the first irrigation, this is when their impact on Helicoverpa will be greatest. Flooding between the crop rows, during irrigation, destroys colonies, forcing the workers to carry eggs up into the crop canopy.

Cultivation disturbs colonies and disrupts foraging activity for several days. The impact of both these factors will limit the effectiveness of ants as egg predators of Helicoverpa in the current production system.

Another conspicuous predator group in cotton is the ladybird beetles. They feed primarily on aphids but may also take some Helicoverpa eggs or even small larvae. Over the past season, we examined the consumption of *H. armigera* eggs by two ladybird species — the three banded and the variable. We also looked at the effects of predator density, prey density, and an alternative food source — aphids.

In laboratory experiments, three banded ladybirds consistently ate more *H. armigera* eggs than did the variable ladybirds. Consumption of eggs by both species increased as the number of eggs available increased. The provision of aphids did not affect egg consumption for these two species.

Results were slightly different in glasshouse cages. Both ladybird species consumed similar numbers of *H. armigera* eggs, but their responses to predator and prey density differed. Egg consumption by three banded ladybirds increased as prey density increased but increased predator density did not lead to increased egg consumption. In contrast, egg consumption by variable ladybirds increased with both predator and prey density, particularly at the higher prey densities — the green bars in Figure 1.

Field cages differed yet again, with the results being inconclusive. Slightly more eggs were consumed in control cages and cages with variable ladybirds than in open cage controls and cages with three banded ladybirds. Aphid numbers were low in the 2001–02 season so there were too few aphids present in the cages to provide any

FIGURE 1: Helicoverpa armigera egg consumption by two ladybird species at different predator and prey densities over 24 hours in perspex cages under glasshouse conditions

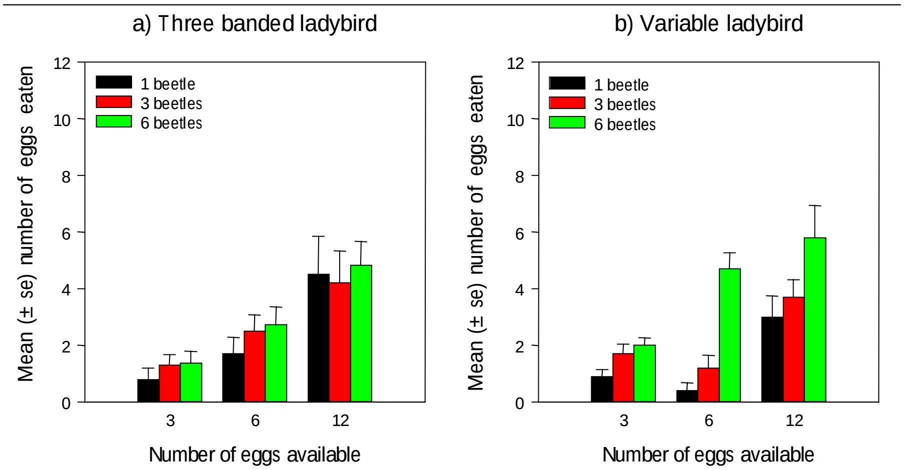
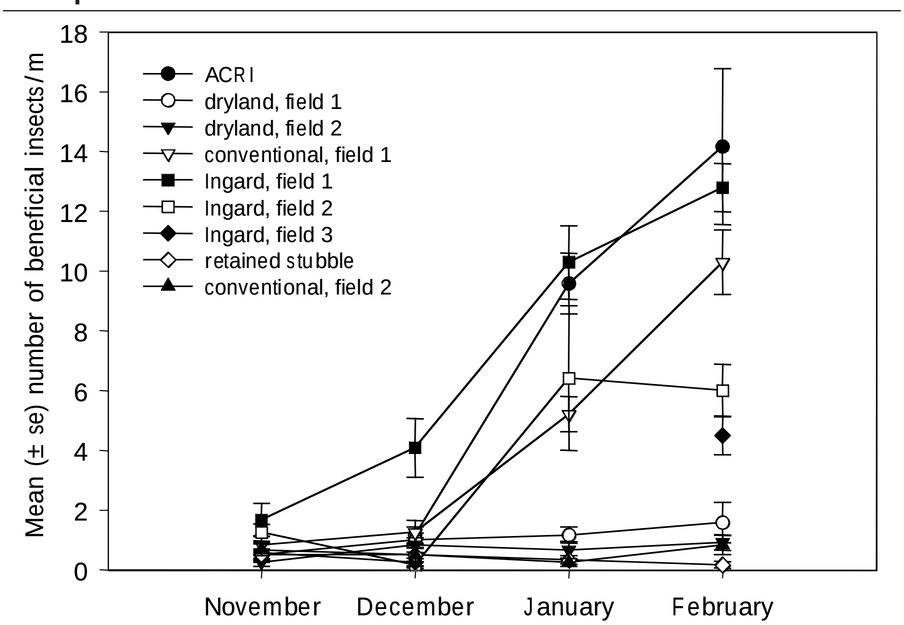


FIGURE 2: Abundance per metre row of cotton for all beneficial insects and spiders collected in each field and each month



Very soft or no spray regimes (BDI<7) were applied to conventional field 1, Ingard fields 1, 2 and 3 and at ACRI. Harder spray regimes (BDI of 28–36) were applied to dryland fields 1 and 2, conventional field 2 and the retained stubble field

information on the effects of aphids as alternative prey.

To look directly at what prey is being consumed, we are using an ELISA assay to detect the presence of *H. armigera* proteins in individual predators. One complication is that the predator starts digesting the prey as soon as it's eaten, so the ability to detect predation depends on how quickly the prey passes through the predator's gut.

Results from tests on red and blue beetles that had consumed one egg, showed the chance of detecting predation declined rapidly from 35 per cent immediately after the meal to about three per cent after 24 hours. But the probability of detection increases with the number of eggs eaten in the previous 24 hours.

Last season, 758 red and blue beetles were collected from fields in the Namoi, Gwydir and Macintyre regions. All of these have been tested and only six were positive for *H. armigera*! While this doesn't sound very impressive, only 12 per cent of Helicoverpa eggs and larvae collected from these fields were *H. armigera* so there weren't many around to be eaten. This ELISA technique is also being developed for several of the common ladybirds and predatory bugs found in cotton.

In the same fields, beneficial insects and spiders were counted and insecticide use measured using the beneficial disruption index (BDI). The lower the BDI (which was developed by Martin Dillon, CSIRO Entomology and Ziaul Hoque, NSW Agriculture), the 'softer' the applications were on beneficials, and the more likely that they would survive the insecticide.

Figure 2 summarises the trends in beneficial abundance over the season. It is notable that the five fields that had a low BDI value at the end of the season showed steady increases in beneficial insect and spider abundance. This contrasts with the trend in the four fields that had a much higher BDI value.

GLOSSARY

ELISA: An enzyme-linked immunosorbent assay is a highly sensitive technique for detecting and measuring specific proteins.

BDI: The beneficial disruption index scores insecticides according to their impact on beneficial insects. The impact is expressed as a percentage reduction in beneficials after chemical application on a scale from one to seven. The lower the score, the lower the impact on beneficials. The index was first introduced at the 10th Australian Cotton Conference in 2000 by Ziaul Hoque and his collaborators.

FUTURE WORK

In coming seasons, the work comparing predator information from Ingard, conventional and unsprayed cotton fields will continue and also extend into other cropping systems, such as dryland cotton and cotton planted into standing wheat stubble.

The improved understanding of predator ecology gained from this research will provide a basis for better guidelines for the management of beneficial insects, an essential component of any Helicoverpa management package which aims to minimise the use of insecticides. It will make it possible for IPM thresholds and recommendations to be based on direct measurement of predation and should increase confidence in the use of beneficial insects for pest management.

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Contact: Dr Sarah Mansfield, CSIRO Entomology and Australian Cotton CRC, Narrabri. Ph 02: 6799 1576; fax 02 6793 1186; email sarah.mansfield@csiro.au

1: Australian Cotton Cooperative Research Centre, 2: CSIRO Entomology.