Helicoverpa Predators: Do We Know Anything About Them?

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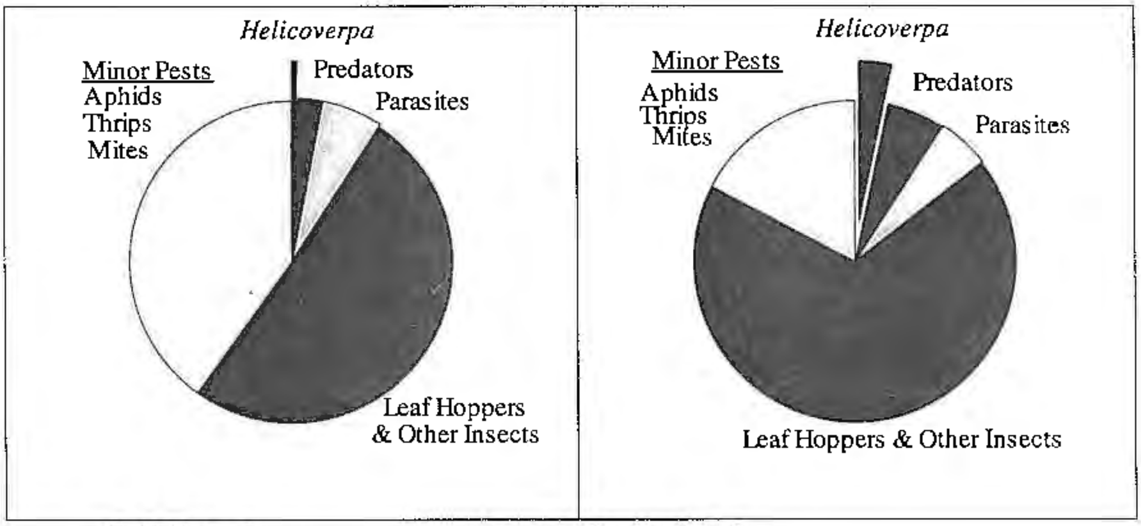
The insect community in cotton fields

Insects in cotton fields form a diverse and volatile community. Room (1979) collected some 500 species of insect (plus spiders) in Australian cotton fields. Some (the ones we notice most) are pests. Others are beneficials, that is, predators or parasites of the pests. Room considered more than half of the species he found were predaceous to some extent. However, in most cases, the majority of insects in a cotton field are neither pests nor beneficials. They may feed on cotton, but cause negligible damage (for example, flower beetles and leafhoppers). They may be predators and parasites of these innocuous plant feeders, or of beneficials. They may be soil-dwelling species which rarely enter the foliage. They may feed on nectar or the honeydew produced by aphids and leafhoppers. Finally, they may be just passing through, having arrived accidentally on the wind. All these insects are what we might call "incidental" species - incidental for conventional pest management, but not necessarily in their importance to the pests' ecosystem. Figure 1 summarises the results of sampling on two fields at Auscott's "Midkin" (Moree) property during the 1992/3 season. The numerical dominance of the "incidental" species is plain. Even when pest pressure is high, the numbers of major pests like *Helicoverpa* spp. are much lower than those of the incidental species.

Predators: generalists or specialists?

Most predators are generalists. Some are plant feeders as well as predators. For the green mirid, *Megacoelum dilutus*, the damage caused in this role far outweighs any beneficial impact. For others, like the apple dimpling bug, *Campylomma liebknechti*, the equation is less certain. Others such as the red and blue beetle *Dicranolaius bellulus* feed on pollen, though their impact on the crop is negligible. Still others, such as most ladybirds and lacewings, are predominantly predators, though they will take virtually any small soft-bodied insect. As the crop develops, many insects accumulate which appear to be associated with the mass of resident insects, including aphids, thrips and "incidental" insects like leafhoppers (green and brown jassids). Analyses of our data from Auscott reveal interesting spatial correlations between many predators and leafhoppers, but not *Helicoverpa* (Table 1). In any given field at any given time, we get more predators in places where there are more leafhoppers, but not where there are more *Helicoverpa* eggs or larvae.



'Soft Option' pest management (Total insects sampled 222,000) | Conventional pest management (Total insects sampled 59,000)

Figure 1 The relative abundance of arthropods sampled over the 1992/93 season in 'soft option' and conventional cotton fields from Auscott, 'Midkin', Moree

In the 1993/4 season we obtained similar results from organic crops at Boggabilla and North Star. At present, we are unsure about how to interpret of these results. They may mean that the dominant functional predator/prey relationships involve leafhoppers, not *Helicoverpa* or other pests. This is a reasonable working hypothesis, in view of the numerical dominance of these insects (Figure 1), but other interpretations are possible.

What is an "effective" predator?

The picture of insect communities which is developing is of a complex and dynamic system, in which we focus most on the relatively small pest component. It may be that this focus is leading us to ask the wrong questions about predators. If we impose a *Helicoverpa* egg lay on

Beneficial	Pest *Helicoverpa* Eggs	*Helicoverpa* Larvae	Mites	Aphids	Thrips	Leaf Hoppers
Transverse ladybird	+*				+*	+*
Two-spot ladybird			+***			
Red & Blue beetle						+***
Big-eyed bug					+***	+***
Damsel bug						+***
Minute pirate bug		-***			+***	+**
Apple dimpling bug		+*				+***
Spiders					+*	+***
Trichogrammatids						+***

+ = positive correlation, - = negative correlation   * = p<0.05, ** = p<0.01, *** = p<0.001

Table 1. The spatial correlations between pests and natural enemies in the 1992/3 season at Auscott, "Midkin", Moree. Positive correlations mean that, at any given time, there are likely to be more of the beneficial species present at any sample location if pest numbers are high. Negative correlations mean there are likely to be less.

this complex and dynamic system, a question like "how effective are the *Helicoverpa* predators?" perhaps should be "will the predators of incidental species turn their attention to *Helicoverpa*, and significantly reduce their numbers?" Issues such as predator abundance, predation rate and predator:prey ratios are of major importance, but we must also consider the possible confounding effects of the abundant alternative prey.

Evidence for predation

a) Visual

Like murder, acts of predation are brief, infrequent and rarely leave a recognisable trace of the perpetrator. Assigning predation to a particular species is difficult, and measuring relative predation by different species is even more difficult. Problems are the huge observation effort required to catch predators in the act, and the potential for confounding effects of human presence on predator behaviour. In an extensive visual study of *Helicoverpa* on tobacco, Titmarsh (1982) reported very few direct observations of predatory events. By relying on observable remains of predatory acts, Dillon *et al.* (1992) could assign only a small percentage of *Helicoverpa* egg disappearance to predation. However, laboratory studies show that some predators leave no recognisable remains. Video cameras may be a way around some of these difficulties, but present some formidable technical problems.

b) Tracers

Room (1979) used radioactively labelled *Helicoverpa* to detect species which fed on them. This work showed that some of the common predatory insects in cotton fields will take eggs and small larvae. However, these methods do not give a good idea of how much predation is taking place, and they do not distinguish primary from secondary predation, that is, they cannot tell whether a labelled insect has acquired the label from an egg or from another insect which has fed on an egg. Immunological markers, such as antigens like the ones used in the Lepton^{R} test kit, can also be used (Greenstone & Morgan, 1989), but they also have problems. The dynamics of antigen decay in predator guts must be understood, and we currently lack this understanding.

c) Laboratory studies

Placing predators and pests together in petri dishes in the laboratory can give a crude estimate of prey consumption. Room (1979) used this method to identify most of the species we currently consider significant predators. However, petri dish trials can give unrealistically optimistic results. We have found that red and blue beetles will take between 4 and 20 *Helicoverpa* eggs each per day, over a period of 12 days. Some simple calculations will show that, at this rate, 3-5 beetles per meter would be sufficient to deal with all but the most extreme pressure. Yet we have seen red and blue beetles in these numbers fail to control even moderate egg lays.

d) Field cages

Confining predators and prey in field cages gives a more realistic indication of predation rates than laboratory experiments. A general indication of the total rate of predation by all predators can be obtained by comparing egg or larval survival in closed cages with that in open cages. Dillon *et al.* (1992) have used this method to show that predation is a relatively minor component of the mortality in *Helicoverpa* eggs in Australian cotton. In other countries (eg Kenya; Van Der Berg and Cock, 1993), predators may have a major effect. In the Kenyan study, field cages seeded with 150-400 *H. armigera* eggs and left open for predators (mostly minute pirate bugs and ants) had only 0.3 larvae/ meter after 2 weeks, compared with 6.25 larvae/ meter when predators were excluded. The differences between the Australian and Kenyan studies suggest that further work is needed. Closed field cages can also be used to manipulate predator and prey numbers, and to exclude all but the particular predator being studied. In our trials, at egg densities similar to moderate field pressure, the results suggest that red and blue beetles did not find any eggs. At higher egg densities (40-200/ meter) 10% of the eggs were predated/ day when 30 beetles/ meter were present. The consumption rate averaged 0.9 eggs per beetle per day, much lower than that observed in the laboratory. At 5 beetles/ meter (typical of a "soft" field) there was no detectable predation above background mortality. Further studies showed that red and blue beetles and lacewing larvae were capable of reducing *Helicoverpa* larval populations when both predator and prey numbers were high and there were no alternative prey. 30 beetles or lacewings per meter reduced larval survival by 20% over a pest density range of 20-120 larvae per meter. With alternative prey (aphids) present, there was no detectable predation on *Helicoverpa* by red and blue beetles, although aphid infestations were reduced by 20%.

A limitation of all field cage studies is that it is difficult to know if predator behaviour is altered in confined spaces. For example, predator searching sequences in a field cage may be different from those in normal field conditions. We did not see any evidence that the searching behaviour of red and blue beetles was disrupted by our field cages, but we cannot be sure that subtle effects did not occur.

e) Unsprayed or biological fields

Unsprayed or biological fields usually harbour greater numbers of predators than fields under commercial pest management. If in biological fields *Helicoverpa* were kept below economic threshholds then the impact of predation would be obvious. But this rarely happens at naturally occurring predator levels. Identifying predation by comparing sprayed and unsprayed fields is confounded by the effect of insecticides on pest survival. Pest resurgence, (the accelerated growth of the pest population shortly after the application of a broadspectrum insecticide) is often cited as evidence that the limiting effect of natural enemies has been removed. There are some indications of this occurring in cotton fields. For example, more *Helicoverpa* larvae may survive to later instars in plots affected by spray drift (G.P.Fitt, pers. comm. 1993).

Conclusions

At this stage, we have no conclusive evidence that predator complexes, or any of the species they contain, can regulate *Helicoverpa* populations at levels close to current economic thresholds. Furthermore, all the research techniques we might use to obtain such evidence have significant problems. This does not necessarily mean that predators are of no benefit in cotton pest management. We believe it does mean that we need to think more carefully about how we might use predators, and that we should not be unrealistic in our expectations of them.

References

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