BENEFICIALS PARASITISING HELIOTHIS: AUGMENTATION AND EFFICACY

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Various parasitoids are active on cotton crops from early seedling growth right through to defoliation. The parasitoids of greatest interest on the cotton crop are those that attack the key pest, heliothis, and which may add to the mortality of egg, larval and pupal stages that is provided by other biotic and abiotic factors. During recent years most research on parasitoids has concentrated on native agents attacking the egg and early larval stages.

Life cycle of an egg parasitoid

Egg parasitoids, scientifically referred to as *Trichogramma*, are small wasps (0.3 - 0.5 mm long) that attack the egg stage of heliothis. The wasp lays its eggs in the heliothis egg, and the wasp larvae which hatch consume the contents of the host egg. Instead of a small heliothis larva hatching, up to four wasps may emerge from each host egg. Thus the host is killed before causing damage. Parasitised eggs turn black after about 4 days. The life cycle from egglaying to emergence of adult wasps takes 8-10 days at 25°C.

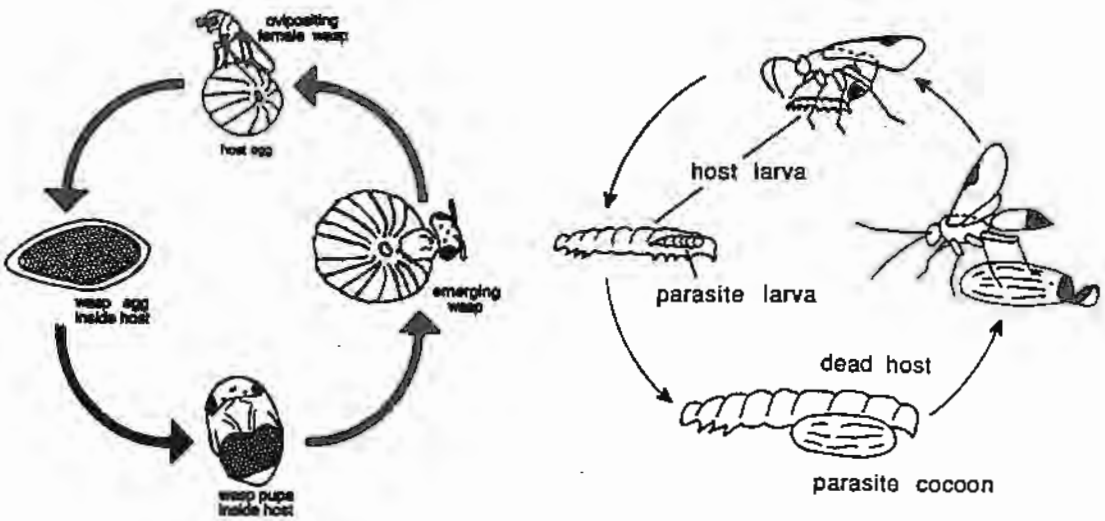

Figure. Life cycles of egg and larval parasitoids

Life Cycle of a Larval Parasitoid

Microplitis demolitor is the most common larval parasitoid encountered in cotton. The adult wasp is much larger than *Trichogramma*, about 3 - 4 mm long. The female wasp inserts an egg into the body cavity of small host larvae, usually second instar. After hatching, the parasite larva grows as it consumes the internal structures of its host. When fully grown, the parasite larva exits from the host and spins a fawn coloured cocoon in which it pupates beside the host. At 25°C it takes about 12 days from egg lay to adult emergence.

How important are parasitoids in management programs?

In unsprayed cotton crops, parasitoids complement the action of other natural enemies (predators). The trend on the Darling Downs is for egg and larval parasitism to increase during the season. It is not until later in the season that natural egg parasitism sometimes reaches high levels (>90%), and much of this parasitism is due to *Trichogrammatoidea bactrae*. Under unsprayed conditions these parasitoids alone are often unlikely to provide the level of control required to successfully manage a pest problem.

Unfortunately, some of the factors that make heliothis such formidable pests, their high mobility and high fecundity, can work against achieving biological control in the cotton crop. Heliothis moths often arrive suddenly at a location and deposit high egg densities, and the natural enemies invariably are unable to respond quickly enough to prevent serious crop damage.

Manipulation of natural enemies

There are various ways to manipulate natural enemies within the cropping system in order to gain greater benefit from them. Conserving parasitoids by using selective sprays is an important concept when developing integrated pest management programs. It is thus important to know how the commonly used cotton insecticides affect parasitoids. Two factors to consider are their direct contact toxicity and their residual toxicity to parasitoids. Data on the residual toxicity of some cotton insecticides to *Trichogramma* are in these proceedings (Scholz 1994). These data are essential knowledge for the successful use of biocontrol agents.

Although some treatments may not kill adult parasitoids outright, we have no information about non-lethal effects on survivors. We also need to know how insecticides affect developing parasitoids within hosts. Some of these aspects will be investigated under a new Cooperative Research Centre for Sustainable Cotton Production project.

Mass rearing and supplementary or inundative releases are manipulative options now being evaluated for egg parasitoids. Progress with egg parasitoids has been made possible through the success of commercial insectaries in Australia. Larval parasitoids were evaluated only on an experimental basis because of their high production costs. Exotic larval parasitoids have also been introduced and released in various cropping areas to supplement native species.

Current status of egg parasitoid production

There are now three commercial insectaries producing egg parasoitoids in Australia. Two species of *Trichogramma* are available to pest managers, and at least six other egg parasitoid species are recorded from heliothis eggs in cotton. The major use of *Trichogramma* has been in vegetable crops (tomatoes, sweet corn), but the 1993/94 season saw the first commercial use of egg parasitoids in cotton, specifically in organic cotton. *Trichogramma* were also used experimentally in several trials last season.

How were egg parasitoids used?

Trichogramma were used in two ways. Firstly, they were released early to mid season to try to establish them earlier than would occur naturally - a form of supplementary release. Secondly, they were released in large numbers (up to 150 000 per hectare) as a biological insecticide - an inundative release. Releases were timed to coincide with heliothis egg lays in the cotton crop.

How were *Trichogramma* applied?

Trichogramma were supplied by the insectaries as pupae in the eggs of their facultative rearing host, *Sitotroga*. They were applied manually on egg cards, aerially using fixed wing aircraft and helicopters, and via ground rigs. Development of the pupae was timed so that parasitoid emergence occurred within a few hours of application.

Results of 1993/94 trials

The results from the 1993/94 season were not outstanding in terms of *Trichogramma* use. Despite egg parasitism levels on the Darling Downs during 1993/94 averaging about 60% later in the season, the extremely high heliothis pressure was overwhelming and economic control of heliothis was not achieved. Naturally occurring egg parasitism over-shadowed the released species in a number of cases where data were carefully collected. The inference from these data is that we may not be releasing the best species for the task.

The question remains - which species should be released? Releases to date have mostly used species not normally found in the cotton crop. Although parasitism has increased following releases, the contribution of released species towards total egg parasitism has not always been high. Many questions remain unanswered in the quest to use egg parasitoids.

Some of the problems encountered!

There were several practical problems encountered in the use of *Trichogramma*. This was to be expected for any developing technology. Orders for *Trichogramma* are required in advance, and pest managers must make a commitment to the supplier to accept material on a prescribed date. Because of the unpredictable nature of heliothis egg lays, it was not always possible to time *Trichogramma* delivery with egg lays. Fortunately, *Trichogramma* pupae can be stored for several days at low temperature without affecting field performance. Insectaries can provide accurate data on development so that field releases can be properly timed. There is no point applying *Trichogramma* which will emerge a day or two later as they will invariably suffer high mortality in the field. In one trial, *Trichogramma* pupae were put out on cards. Emergence was delayed more than 24 hours, and during the first night about 30% of pupae on cards were consumed by predators.

Trichogramma should be applied at night or early morning, and development carefully timed so that emergence occurs soon after dawn. In this way pupae not settling on the plant or in shaded areas will emerge before exposure to high soil surface temperatures and inevitable death.

What happens to field released *Trichogramma*? Their small size precludes tracking individuals in the field, so the main assessment of their survival and performance is by monitoring egg parasitism levels before and after release. These data do not assist day to day decision making because by the time a parasitised egg has turned black (about 4 days), unparasitised eggs will have hatched and the optimal window for neonate control passed. Thus pest managers must be confident that *Trichogramma* releases will be effective against specific pest egg densities. Release rates will also be influenced by egg densities against which they are to be targeted. However, as *Trichogramma* cost 25 cents per thousand, there is a economic ceiling for release rates (100 000 per ha = $25 per ha).

What does the future hold for parasitoids?

There have been encouraging results using *Trichogramma* in horticultural crops. In parallel with these achievements has been a reduction in the use of disruptive insecticides except in the most severe pest situations. The use of parasitoids in cotton pest management has not been fully developed, and recent progress in the use of food sprays and the potential of transgenic cottons to reduce broad spectrum insecticide usage, suggest that natural enemies, and parasitoids in particular, will have an increasingly important role in the future. Presumably, there will be no fewer eggs laid on transgenic cotton crops than on traditional cotton crops, so the ability to maintain egg parasitoid populations on cotton will not change. Larval parasitoids may be fully exploited late in the season when there is the possibility of survivorship on transgenic plants. Research will explore these aspects. QDPI is also continually evaluating species of *Trichogramma* to choose those with the greatest potential as biocontrol agents. *T. funiculatum* has displayed potential, has been given to commercial insectaries and should be available for detailed field trials in 1994/95.