Mating disruption for *Heliothis*: A feasible option?

M.D.Betts[1], P.C.Gregg[1], G.P.Fitt[2] and M.J.MacQuillan[3].

[1]University of New England, Armidale, NSW 2351

[2]CSIRO Division of Entomology, Narrabri, NSW 2390

[3]Dunluce International Pty.Ltd., Killara, NSW 2071.

Introduction.

The importance of *Heliothis* has grown with the advent of resistance in *H.armigera* to various pesticides. This, coupled with increasing public concern about the use of pesticides, has meant that the cotton industry needs to find alternative forms of control. One of the potential alternatives is mating disruption. This is achieved by releasing into the atmosphere sufficient amounts of pheromone to disrupt communication between the sexes, preventing mating and subsequent egg laying.

There are problems associated with the use of mating disruption. A method must be devised to maintain pheromone concentrations at sufficiently high levels for several weeks in an evenly distributed manner. This is difficult due to the volatility of most pheromone compounds. Mating disruption also requires some knowledge of the biology and ecology of the pest in order to determine the number of generations a year and the synchrony and predictability of the infestation. Much of this knowledge is still lacking for *Heliothis*. A further problem that may negate the beneficial effects of mating disruption is immigration of females which have mated elsewhere.

The most fundamental factor affecting success of this method is an understanding of the mechanism by which disruption works. Bartell (1982) proposed several possible mechanisms. These include sensory adaption and habituation, trail masking and false trail following. Knowledge of the mechanism is important for the design of appropriate formulations to achieve a more effective system of control.

The feasibility of mating disruption for the control of *Heliothis* has been studied for the American species (Mitchell *et al.* 1976, Hendricks *et al.* 1982). These trials employed pheromone traps to measure the level of disorientation of males caused by the pheromone application, and captive virgin females to measure the level of mating disruption. They found a significant lowering of pheromone trap catches and mating of captive females in sites treated with pheromones.

Few large scale trials have been undertaken on the utilisation of *H.armigera* pheromone in mating disruption. Here we summarise the findings of the first large scale mating disruption trial against *Heliothis* in Australia.

Materials and Methods.

The study took place during the 1990-91 season at Auscott, Narrabri. The site was located on the northern edge of the property and comprised two fields of cotton, a treated and a control field, of about 30 ha. They were separated by a field of *Dolichos lablab* and were surrounded mostly by fallow land. The trial was divided into three periods, pre-pheromone, during pheromone and post-pheromone. The pheromone was impregnated in Agrisense-BCS Ltd. Selibate^{R} rubber strips. The strips were placed at the top of bamboo stakes and placed manually in the field. The total pheromone rate was 40mg/ha.

A total of ten pheromone traps were run in each field. They were cleared daily. Reductions in the catch of traps in the treated field ("trap shut-down") indicated the extent to which the ability of males to find females was impaired. Light traps were also used to measure trends in the wild population and the level of mating of wild females. Captive virgin female *H. armigera* were placed in trays within the central sections of both fields. These were used to assess the level of mating of *H. armigera* within each field. This was done twice weekly during the pheromone and post-pheromone periods.

On two occasions during the pheromone period moth behaviour was observed in both fields using night vision glasses. Transects marked at 100m intervals were established in both fields. The number of moths and their flight behaviour was recorded for each section. Egg and larvae counts were made at regular intervals throughout the trial. Sampling followed the SIRATAC stratified random design.

Results and Discussion.

Pheromone Traps.

Catches of *H. armigera* and *H. punctigera* at the centre of both fields are shown in Figure 1. There was no significant difference between fields during the pre-pheromone period. Soon after pheromones were put in place catches for the treated field fell dramatically, while those in the control field increased for both species. There was a 99.8% reduction in pheromone trap catches for *H. armigera* for the treated field compared to the control, and 99.3% for *H. punctigera*. If it is accepted that suppression of pheromone trap catch provides a reliable means of estimating disruption (Doane and Brooks, 1981), then

effective prevention of mating in the treated field would have been maintained for the duration of the pheromone placement.

After the removal of the pheromone the *H. armigera* catches remained low (96.9% trap shut-down) while the *H. punctigera* increased to levels similar to the control field. This prolonged suppression may be due to plants taking up pheromone and re-emiting it later. Only the central site traps had a prolonged shut-down. Edge traps (situated further from the plants) quickly returned to levels of the control field.

Captive Females.

No mating of captive females occurred in the treated field during the pheromone period. During the same time there was a 25-40% mating of captive females in the control field. After the removal of the pheromone mating was detected amongst the captive females of the treated field but not to the same extent as the control field. This reflects the results from the pheromone traps.

Light Traps.

There were no significant differences between total light trap catches of the treated and control field for the entire duration of the trial. There were also no differences in the sex ratios or the percentage of mated females for either species. The likely reason is immigration of moths from surrounding areas.

Night Vision Studies.

Similar results were obtained for both nights on which moths were observed with night vision glasses. The number of moths sighted in the control field increased after midnight while the activity in the treated field decreased. A further distinction between the two fields was that moths in the control field were spread throughout, while in the treated field there was frequently a concentration at the perimeters, especially during the post-midnight period, when mating occurs.

Scarcity of moths in the central area of the treated field seemed to be due to a lack of males. Throughout the control field there were regular sightings of typical male searching flight, especially after midnight. This was not the case in the treated field, where this type of behaviour was only seen around the edges. The majority of moths seen in the centre of the treated field exhibited a fluttering vertical flight and appeared to be disturbed by the approaching observer. The bulk of these moths were probably female. The concentration of moths towards the edge and the comparative lack of typical male searching behaviour in the centre of the field suggests that pheromone disrupted mating by lowering the number of

males within the field. If this was the case the mechanism at work could have been repulsion rather than false trail following or habituation.

Egg and Larvae Counts.

There were no significant differences between the number of eggs and larvae in the two fields. Both fields exhibited similar trends for the entire period of the trial. The majority of eggs and larvae collected from both fields were *H. armigera*. Migration of mated females from surrounding areas may have been responsible for the similar numbers of eggs and larvae in the two fields.

Conclusions

This trial suggests that mating disruption has potential for *Heliothis* control. It is possible to prevent mating within a cotton field. Particularly encouraging is the fact that we were able to achieve almost total trap shut-down for both species with a single pheromone product. However, the question of interest to growers is: will this lead to reduced egg numbers?

Immigration of previously mated females into treated areas presents the greatest obstacle to reducing eggs. Walker *et al.* (1990) found a similar problem with the pink-spotted bollworm. Our study showed that, for *Heliothis*, a treated area of 30ha is much too small to prevent such immigration.

How large must a treated area be? The problem is that we do not know how far mated females move. *Heliothis* are capable of migration over very long distances, but we know that most such movement is by unmated moths. Some laboratory studies suggest that movement by mated females is much more restricted (Armes and Cooter 1991). Local movement of *Heliothis* is common, but most of the information we have comes from mark-recapture studies (Fitt and Pinkerton 1990). These studies involved only males, because males could be easily recaptured with pheromone traps.

Perhaps the easiest way to find out how far mated females move would be to conduct a large scale trial of mating disruption, extending over hundreds of hectares. At present we cannot do this because our methods of applying pheromones are not suitable for broad-acre use. We need an alternative formulation, such the micro-encapsulated sprayable one used against pink bollworm (Critchley *et al.* 1991). Technical problems are presently limiting the development of a similar formulation for *Heliothis* pheromone. Thus, we need more ecological understanding, particularly of mated females, before we can really assess

the potential for mating disruption. However, technical problems relating to formulation must be solved before the ecological ones can be tackled. Mating disruption might be a feasible option for *Heliothis* control - but not tomorrow!

Acknowledgements.

This study was jointly funded by AgriSense-BCS Ltd., the Cotton Research and Development Corporation, and the University of New England. We are grateful to the staff of the insectary at Narrabri Agricultural Research Station, and the Crop Protection Unit at the University of New England for their help during field and laboratory work, and to Auscott Pty. Ltd. for making the trial site available.

References.

Armes, N.J. and Cooter,R.J. (1991) Effects of age and mated status on flight potential of *Helicoverpa armigera* (Lepidoptera: Noctuidae). *Physiological Entomology* 16: 131-144.

Bartell,R.J. (1982). Mechanisms of communication disruption by pheromone in the control of Lepidoptera: A review. *Physiological Entomology* 7: 353-364.

Critchley,B.R., Chamberlain,D.J., Campion,D.G., Attique,M.R., Ali,M. and Ghaffar,A. (1991) Integrated use of pink bollworm pheromone formulations and selected conventional insecticides for control of the cotton pest complex in Pakistan. *Bulletin of Entomological Research* 81: 371-378.

Doane,C.C and Brooks,T.W. (1982) Research and development of pheromones for insect control with the emphasis on the pink bollworm. In Mitchell,E.R. (Ed.) *Management of Insect Pests with Semiochemicals: Concepts and Practices*. Plenum Press. New York. pp285-303.

Fitt,G.P. and Pinkerton, A. (1990) A mark-recapture study of Heliothis movement from a source crop in the Namoi Valley. In *Proceedings of the Fifth Australian Cotton Conference.* August 8th-9th. Broadbeach, Queensland. Australian Cotton Growers Research Organisation, Brisbane, pp. 283-293.

Hendricks,D.E, Perez,C.T and Guerra,R.J. (1982) Disruption of *Heliothis* spp. mating behaviour with chemical sex attractant components. *Environmental Entomology* 11: 859-866.

Mitchell,E.R, Baumhover,A.H and Jacobson,M. (1976) Reduction of mating potential of male *Heliothis* spp. and *Spodoptera frugiperda* in field plots treated with disruptants. *Environmental Entomology* 5: 484-486.

Walker,P.W, Zalucki,M.P and Twine,P. (1990) Disruption of sexual communication in the pink-spotted bollworm, *Pectinophora scutigera* (Holdaway), with synthetic pheromone. In *Proceedings of the Fifth Australian Cotton Conference.* August 8th-9th. Broadbeach, Queensland. Australian Cotton Growers Research Organisation, Brisbane, pp. 389-397.

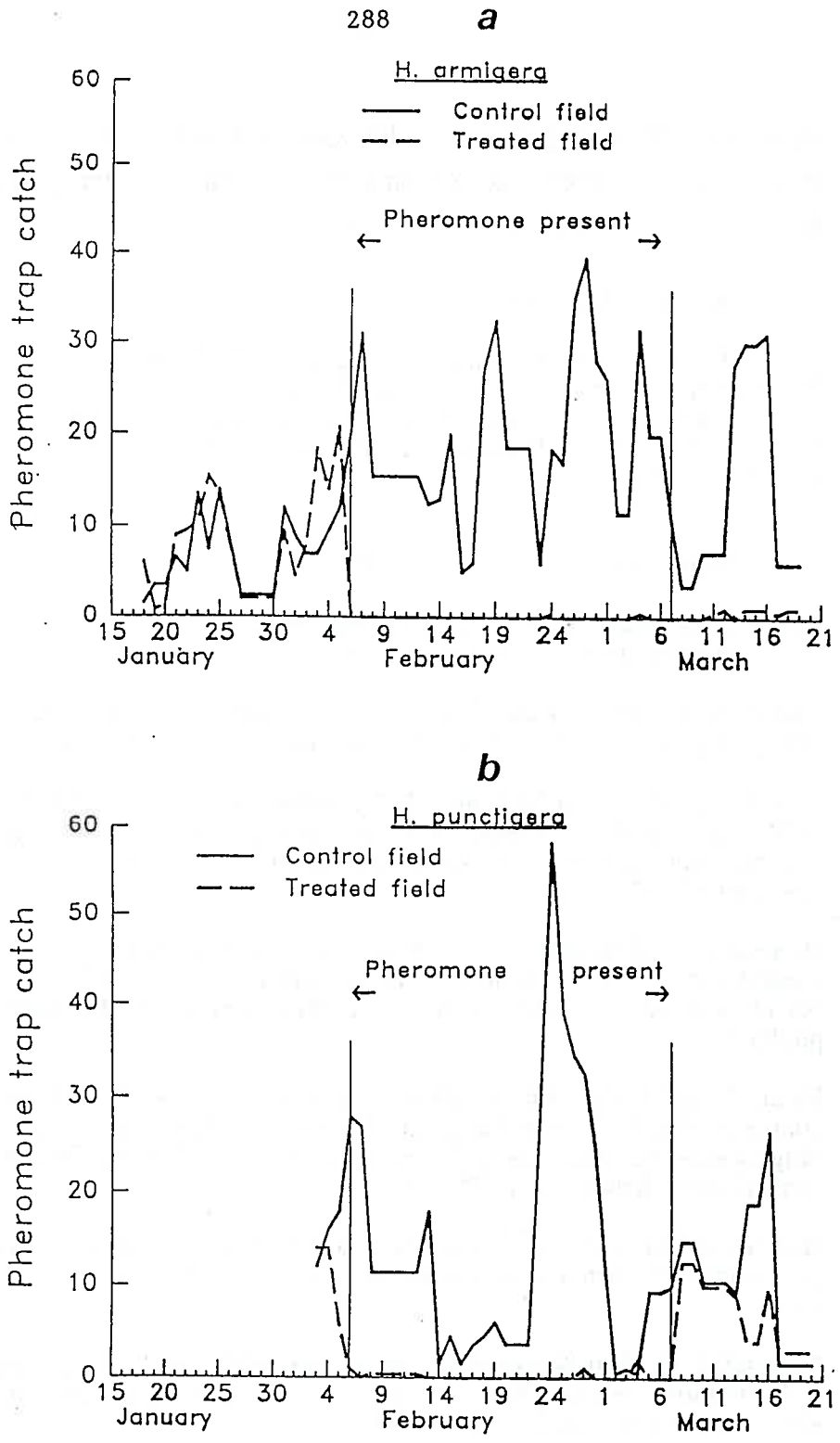

Figure 1: a) *H. armigera* and b) *H. punctigera* pheromone trap catches for the centre sites of the treated and control field. The period when pheromones were present is indicated by the arrows. Catches for the treated fields were very low during this time, indicating that mating was disrupted for both species