January, August & Final Reports

Part 1 - Summary Details A2001

REPORTS

Please use your TAB key to complete part 1 & 2.

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January Report:	☐	Due 29-Jan-01
August Report:	☐	Due 03-Aug-01
Final Report:	☒	Due within 3 months of project completion

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The points below are to be used as a guideline when completing your final report.

1. Outline the background to the project.

Australian cotton production is in the process of adopting new transgenic (INGARD) technology for managing heliothis and other caterpillars. INGARD technology has no effect on sucking insects such as green mirids, and under the low insecticide use patterns envisaged using INGARD cotton, the status of sucking pests in general will increase. In the past, most insecticides applied to control heliothis inadvertently controlled sucking pests. As these are removed from operations, sucking pests will survive in the crop.

Conventional cotton producers also have an awareness of the need to adopt a more selective approach to early season pest management. Both these approaches highlight the need to develop sound management practices for sucking pests in general, and green mirids in particular, as current insecticide treatments against these pests are invariably disruptive to beneficial fauna. Some of the new, more selective insecticides for green mirids (e.g., fipronil, imidacloprid) will be more expensive than organophosphates and pyrethroids, further highlighting the need for careful consideration about when and how to control green mirids.

Green mirid control is usually required during early squaring (November to December) when the foundations are being established for the conservation of beneficial fauna in the cotton crop. While lucerne strips have been employed successfully for green mirid control under the Envirofeast IPM approach, lucerne strips do not suit all situations and are difficult to maintain in an attractive state under rain-grown conditions. Green mirid management will depend on insecticides for the foreseeable future. The challenge is to use the least disruptive approach available. Current thresholds for green mirids on cotton are poorly defined. They range from 1 per 10 metres (barely detectable levels) to 4 per metre. As a consequence of these poorly defined thresholds, controls are sometimes applied when they are not necessary and *vice versa*. As new insecticides for cotton pests are developed, it is important that the Cotton Industry has its own independent assessment of their effect on beneficial fauna.

2. List the project objectives and the extent to which these have been achieved.

<u>Evaluate protocols for green mirids threshold trials</u>

A trial to test possible techniques for their efficiency, reliability and ease of use showed that the general sampling measures used were effective at assessing mirid densities. Weekly applications of omethoate were highly effective at removing mirids from the crop, but re-invasion of the crop by adult mirids could occur within a week if north-westerly winds brought large populations of immigrants. They probably inhabited new foliage that had not been present at spraying the previous week. These adults were not escapees as no nymphs appeared in the sprayed part of the crop. However, safety considerations precluded more frequent spraying of the product. The current plant mapping technique used to assess fruit retention was unable to properly map the fate of a plant's fruit production and a new, fully binary system developed.

Conduct a series of green mirid threshold trials in INGARD cotton

Four threshold trials were conducted during the 2000/01 season. While mirid densities were lower than ideal, cotton crops situated near sunflowers and lucerne had higher densities than general and provided good experimental sites. The data show that the current threshold (0.5/m) is slightly high for an established mirid population, and should be reduced substantially for immigrant populations.

Screen new insecticides against beneficial in a series of small plot trials

A number of products, either brand new for the Australian market, or being extended for use in cotton, were tested in 7 small plot trials. Green mirids were present in most of the trials. The same beneficial groups were common to most trials, but allowed a range of products to be tested against common cotton beneficials. Some of these products have had their registrations extended to cover control of other pests (e.g., apple dimpling bugs). Steward and Affirm show promise of delivering an ideal product for mirid control, namely, effective control of green mirids with minimal imapct on beneficial fauna.

Conduct large plot trials to evaluate products under commercial usage

Two large scale trials using Steward in 2000 and one in 2001 were conducted in collaboration with Dupont. The trials in 2000 involved sampling twice after a single spray; that in 2001 involved twice weekly sampling. Beneficials and green mirids were counted in each trial.

3. How has your research addressed the Corporations three outputs: Sustainability, profitability and international competitiveness, and/or people and community?

The results of the experiments conducted in this project can be used by consultants to improve the confidence of their green mirid population assessments and damage potential of green mirids to further reduce the impact of controlling green mirids on early season IPM development. The low impact of some new insecticides like Steward and Affirm on beneficials will also go some way to achieving this aim. These results should also help to more cost effectively manage green mirids by better ensuring that only crops truly requiring treatment receive same.

4. Detail the methodology and justify the methodology used.

Evaluate protocols for green mirids threshold trials

A trial to test techniques was established in a commercial INGARD cotton crop. The trial site was split into two areas with one section sprayed weekly with omethoate and the other unsprayed. The trial was at one end of the crop; this permitted the farmer to avoid spraying the site when treating his crop. Samples (5) for green mirids were taken weekly from each section of the trial with a suction sampler using the top, forward sampling method. Different rows were used each week. Plant mapping to estimate the fruit retention of 30 plants from each section was done at the same time. The rows used for the fruit retention studies were different to the rows used for the mirid population estimates. The crop was then sprayed to remove any mirids that had entered the crop and to give some protection for the next few days. The experiment commenced just prior to the crop commencing squaring, and ran weekly to late December.

Conduct a series of green mirid threshold trials in INGARD cotton

Four threshold trials were conducted in INGARD cotton during the 2000/01 season. Insufficient mirids occurred in cotton in 1999/2000 to test the techniques established in the 1998/99 preliminary trial. Mirid densities in 2000/01 were less than ideal, but crops situated near sunflowers and lucerne had higher densities than general and provided good experimental sites.

Each site was divided into an unsprayed plot and a sprayed plot. The sprayed plot was treated with a pyrethroid weekly to remove mirids similar to the technique used in the evaluation trial. Fruit retention was estimated from 20 plants (top 5 first position fruit), and mirid densities from five 20 metre suction samples in each plot. Mirid counts were corrected for sampling efficiency as a function of plant height using functions developed from previous research prior to analyses.

Screen new insecticides against beneficial in a series of small plot trials

A number of products being registered, or reduced rates of registered products, were tested for their effects on beneficial fauna, apple dimpling bugs and green mirids in 7 small plot trials. These trials were randomised block trials using 6 treatments (including untreated control) over 4 blocks. Plots were sampled prior to spraying, then at 2, 4, and 7 days after treatment, for all beneficials and pests. Analyses were done on groups that had sufficient numbers to give a meaningful result. Table 1 shows the products and rates tested in each trial.

Conduct large plot trials to evaluate products under commercial usage

Trials 1, 2: Two trials designed to test Dupont's new insecticide indoxacarb (Steward) against bifenthrin (Talstar) and spinosad (Tracer) were established at Brookstead and Byee. Each trial was established as an unblocked design with 3 treatments. Treatments were applied by the respective farmers and included dimethoate (500 mL/ha of Rogor) with all test treatments for aphid control at Brookstead. The treatments were:

Brookstead

Steward @ 650 mL/ha for 90 rows (Steward 650);
Steward @ 850 mL/ha for 90 rows (Steward 850);
Talstar @ 800 mL/ha + Gemstar @ 200 mL/ha for rest of field (Talstar).

Byee

Steward @ 650 mL/ha for 90 rows (Steward 650);
Steward @ 850 mL/ha for 90 rows (Steward 850);
Tracer @ 150 mL/ha + Gemstar @ 200 mL/ha for rest of field (Tracer).

Table 1. Products tested in the small plot trials, 1999 to 2001.

QDPI Trial number	Product (g a.i. / L)	Rate (mL/ha)
K1-99	Untreated control	
	Methoxyfenozide (240) + D-C-Tron	1680
	Chlorfenapyr (360)	1100
	Chlorpyrifos methyl (500)	1000
	Chlorpyrifos methyl (500)	2000
	Beta-cyfluthrin (25)	600
K2-99	Untreated control	
	Emamectin (19)	700
	Indoxacarb (150)	850
	YRC2894	105
	Amitraz (200)	2000
	Beta-cyfluthrin (25)	600
G1-00	Untreated control	
	Novaluron (100)	750
	Chlorpyrifos methyl (500)	1000
	Chlorpyrifos methyl (500)	2000
	Beta-cyfluthrin (125)	80
	Beta-cyfluthrin (25)	400
G2-00	Untreated control	
	Azadirachtin (15) + Synertrol	2000
	Novaluron (100)	750
	Fipronil (200)	30
	Naled (900)	550
	Beta-cyfluthrin (25)	600
G3-00	Untreated control	
	Fipronil (200)	62.5
	Fipronil (200)	125
	Imidacloprid (200) + Pulse	250
	Omethoate (800)	70
	Omethoate (800)	280
G1-01	Untreated control	
	Lufenuron (50)	2000
	Emamectin (19)	700
	Indoxacarb (150)	650
	Indoxacarb (150)	850
	Bifenthrin (100)	800
G2-01	Untreated control	
	S1812 (500)	200
	S1812 (500)	400
	Novaluron (100)	1000
	Emamectin (19)	700
	Bifenthrin (100)	800

Each treatment was sampled 10 times, with 5 samples being taken from each of 2 rows 10 rows apart. Sample locations were spaced approximately evenly so that the length of each row was sampled. Each sample consisted of a 20 m length of row sampled by a Stihl BG72 suction machine using the side, zigzag sampling method. Samples were placed into 70% ethanol for later counting in the laboratory. Sampling occurred 3 or 4 and 7 days after spraying (DAS), using different rows on each occasion. Fauna were selected for analysis based on the numbers found at each site:

brown smudge bugs (*Deraeocoris signatus*);

ladybird larvae (larvae of various Coccinellidae);

other beetles (beetles other than adult or larval Coccinellidae, but mainly fungus beetles (Mycetophagidae));

total beetles (all Coleoptera);

lynx spiders (Oxyopidae);

other spiders (all spiders not grouped into one of the main cotton families of Araneae);

total spiders (all spiders);

wasps (various families of small, parasitic Hymenoptera) and

flies (various families of Diptera).

Data were analysed by comparing the Steward treatments to the standard by means of a *t*-test for selected beneficial arthropods. A variance ratio test firstly showed that variances of each group were not significantly different between treatments. An equal-variance *t*-test then determined treatment differences. For each test significance was based on a 5% probability.

Trial 3: This trial evaluated indoxacarb (Steward) in a commercial situation (i.e., spray the field when required). It was established at Brookstead as an unreplicated trial with 5 sub-plots (2 rows x 20 m) arranged diagonally across field. Treatments were applied by the farmer when pest densities warranted economical control. The trial did not have a control sub-plot. Each sub-plot was sampled regularly twice per week, using different rows on each occasion. Each sample consisted of a two 20 m lengths of row sampled by a Stihl BG72 suction machine using the side, zigzag sampling method. Samples were placed into 70% ethanol for later counting in the laboratory. Fauna were selected for analysis based on the numbers found at each site, and included various bugs, beetles, small wasps, flies and brown lacewings.

Data were analysed by comparing numbers for each faunal group before and after a spray. Endosulfan applied to the whole farm (including the trial site) reduced numbers such that Steward treatments appeared to have no effect on the groups studied.

5. Detail results including the statistical analysis of results.

Evaluate protocols for green mirids threshold trials

The trial showed that omethoate effectively removed mirids. Mirids were present in the untreated section of the trial for its duration. However, some adults reinfested the treated area following migratory flights. They probably inhabited new foliage that had not been present at spraying the previous week. These adults were not survivors from the spraying as nymphs were absent. Problems were experienced with the plant mapping technique as it could not distinguish between, for example, 0 fruit retained on 1 fruiting position or 0 fruit retained on 2 positions. Square retention in the unsprayed section of the trial, where adults counts had been from 5 to 8 per 20 metres, was 67% that of the undamaged area at the end of the trial.

Conduct a series of green mirid threshold trials in INGARD cotton

The background fruit loss (the difference between treated and untreated retention) was estimated to be 5%. Assuming that 65% retention is the aim when growing cotton, the threshold was a mirid density sufficient to cause a 30% ((100 – 65) - 5).

No mirids were collected from the treated plots. In the untreated plots, most mirids collected were adults, with 2 or 3 first instars collected in early collections. The nymphs were neglected in the damage estimates as there were so few and damage from first instar nymphs is low. A regression of weekly fruit losses against the estimated green mirid densities for suction samples corrected for plant height showed that 8.5 mirids per 20 m was sufficient to cause a 30% fruit loss. Those who use suction samplers to estimate mirid densities can correct their counts for plant height and use updated control decision tables to decide if control is warranted. A similar regression for estimated densities for the standard shake sampling method gave a threshold of 1.9 mirids per 5 m for a 30% fruit loss. These values are close to the current threshold of 0.5 per metre.

Screen new insecticides against beneficial in a series of small plot trials

Some of the following information is *Commercial-in-Confidence.*

Trial K1-98: All products except methoxyfenozide controlled green mirids, and all controlled loopers, after 2 days. Loopers were still controlled to some extent after 7 days, with methoxyfenozide possibly displaying looper egg toxicity or a longer residual activity killing looper neonates.

Methoxyfenozide and chlorfenapyr had the least disruption to beneficials, with no group differing from the control after 2 days, and similarly for most groups after 7 days. While chlorpyrifos methyl controlled loopers and green mirids, it displayed undesirable toxicity to all beneficial groups except microhymenoptera (wasps). No clear rate effects were observed with this chemical. Chlorpyrifos methyl should be considered further if green mirid control without regard to disruption to beneficials is desired.

Trial K2-98: All products except amitraz had controlled green mirids after 2 days, with control achieved by amitraz after 4 days, although not as good as the pyrethroid. Amitraz lost its effect by day 7, with all other products still effective. Loopers were controlled by all products after 2 days, with more pronounced effects after 4 and 7 days. Emamectin and indoxacarb were especially effective after 4 and 7 days, with YRC2894 showing a stronger effect by 7 days.

No products significantly reduced brown smudge bugs during the trial, although the means for emamectin and YRC2894 suggest that prolonged use of these products would reduce the numbers of brown smudge bugs.

All products reduced at least one group of beneficials, although amitraz was the only test product to reduce wasps within 7 days. YRC2894 appeared to attract spiders, with counts greater than the control at 2 and 7 days, and equal to the control at 4 days. This product had the least disruption to beneficials, with counts for all beneficial groups being similar to the control on each sampling occasion.

YRC2894 controlled green mirids and showed promise of little disruption to beneficials. Although not statistically significant, the means for the predatory mirids (apple dimpling bugs and brown smudge bugs) indicate that regular use of YRC2894 could reduce their numbers.

Trial G1-00. Novaluron had the least disruption to beneficials. While chlorpyrifos methyl controlled loopers and green mirids, it displayed undesirable toxicity to many beneficial groups. No clear rate effects were observed with this chemical. Chlorpyrifos methyl should be considered further if green and brown mirid and looper control is desired without regard to disruption of beneficials. An SC formulation of beta-cyfluthrin showed similar effects to its EC formulation, although neither product affected spiders, wasps or small black ants, and had at least as many brown smudge bugs as the control. Both products controlled green and brown mirids.

Trial G2-00. Azadirachtin had the least disruption to beneficials, only affecting wasps, but did not control loopers or green mirids. Of the products controlling loopers, novaluron had the least disruption to beneficials. Its severe effects on night stalker spiders is reduced to some extent by the rarity of this group in the trial, with dissimilar trends being shown to some other spiders. It failed to control green mirids after 2 days, while numbers subsequently were too low to show any definite trends.

Apart from the standard, only naled controlled both green mirids and loopers, but adversely affected 4 groups of beneficials – apple dimpling bugs, night stalker spiders, wasps and flies. The low rate of fipronil reduced counts relative to the control for 4 beneficial groups, without controlling green mirids. Most products failed to give adequate control of loopers while disrupting beneficials.

Trial G3-00. Although there were no significant differences in means for most beneficials between the reduced and full rates of fipronil and omethoate, the full rates tended to have lower means. Whether this would be sustained over a few sprays using whole field treatments is doubtful, since recruitment into sprayed areas would be difficult under this scenario. The area of the trial site consisted of 160 rows of cotton, of which 50 were used per trial. This gave a buffer from which the sprayed area could be invaded by beneficials or pests. Single sprays of any product (especially if using the reduced rate) might be acceptable for its impact on beneficials, assuming good control of the target pest is obtained. However, these data suggest that the use of a less disruptive product would be easier to justify for controlling a pest without the disruption to beneficials caused by the products used in this trial.

Trial G1-01: Low densities of fauna (mainly bugs, spiders, wasps and flies) were recorded in this trial. All products except lufenuron significantly reduced green mirid numbers at 2 DAT. Both rates of indoxacarb had minimal effect on predatory bugs, spiders, wasps and flies. Lufenuron was disruptive to predatory bugs but not to spiders, wasps and flies. Emamectin reduced bug numbers and had minimal impact on spiders, wasps and flies.

Trial G2-01: As with Trial G1-01, low densities of fauna were recorded in this trial. As expected, bifenthrin was extremely disruptive to all sampled groups. S1812 showed minimal adverse effect on predatory bugs, spiders and wasps. Novaluron had only minor effect on spiders, wasps and flies, but appeared to have some detrimental effect on predatory bugs. Emamectin adversely affected all bug species. Numbers of wasps and flies were reduced 2 DAT with emamectin, but numbers recovered quickly.

<u>Conduct large plot trials to evaluate products under commercial usage</u>

Trials 1, 2: Applying dimethoate at the Brookstead trial reduced counts for all faunal groups except flies to levels unsuitable for analyses. Flies were more numerous in both Steward rates than in Talstar 3 and 7 days after spraying (DAS). There was a hint that spiders were more numerous in Steward 850 (0.8 / 20 m) than Talstar (0.2 / 20 m) (P = 0.084) at 7 DAS, but the numbers were low and subject to high variation. Steward 650 did not differ from Talstar (0.4 / 20 m). No differences were present at 3 DAS.

More groups were analysed from Byee, but few showed any significant differences between the Steward treatments and Tracer. Tables 2 and 3 show the differences between the Steward treatments and Tracer for the selected faunal groups 4 and 7 DAS respectively. By 3 DAS only flies differed significantly between treatments, with Steward 650 having more than Tracer. This difference was still apparent 7 DAS. There was a hint that spiders may have been affected by these treatments by 3 DAS (P = 0.063), as Steward 650 had more than Tracer. By 7 DAS Steward 650 had more brown smudge bugs and other beetles than Tracer. However, these differences were not significantly different for Steward 850.

Conclusions are difficult to draw from the Brookstead trial as dimethoate had been applied with all test treatments and few fauna were found. Given that the Byee trial had many more arthropods than the Brookstead trial where dimethoate was not applied, and that the two trials were sampled at about the same time in January, it would appear that applying dimethoate to the Brookstead trial site was responsible for the low faunal counts recorded.

The Byee trial showed that Steward 650 had more arthropods in a number of beneficial faunal groups than did Tracer. Only for some of these were the results significant. Steward 850 did not show the same result, with no groups differing from Tracer. It is difficult to assess Steward 650 absolutely, as no control treatment was provided at the Byee trial. However, relative to Tracer the lower rate of Steward had less effects on beneficial fauna than Steward at the higher rate or Tracer. If the 650 mL/ha rate of Steward performs satisfactorily against its target pests then it may have a limited place in IPM programs. The higher rate could not be justified based on these data.

Trial 3: No definite conclusions can be drawn from this trial as Steward was not the sole insecticide applied. Numbers of the faunal groups studies decreased after applying endosulfan and were not of sufficient numbers to allow confident analyses after Steward applications.

6. Discuss the results, and include an analysis of research outcomes compared with objectives.

The industry now has a well defined damage threshold for green mirids in INGARD cotton that can be extended to conventional varieties. Combined with the powerful, easy to use and robust sampling technique developed in another project (DAQ72c), growers and consultants can confidently assess their crops for green mirids and have faith in their decisions. Decisions for control or otherwise are more reliable, being based on sound ecological principles. The chances of making a wrong decision for control with expensive consequences (not spraying when required or applying insecticides when not required) have been vastly reduced with this work and that from the previous project. The difference in thresholds currently recognised between south and central Queensland (0.5/m and 1/m, respectively) needs to be investigated to see if it holds true. This difference is a relatively recent change to the threshold and was not derived from experimental data.

Growers now have a range of relatively new insecticides, or reduced rates of older products, to control green mirids. Their worth has been proven in small plots trials, with some also having been tested in large plot trials. A few of these products provide some measure of limited impact on some or most groups of beneficial fauna. This improves the prospects for early and mid season IPM programs developed to control other minor pests. The interaction of these insecticides with other beneficial faunal groups not commonly encountered in Darling Downs cotton, but perhaps more important in other locations, should be investigated before large scale adoption of the newer insecticides occurs.

An understanding of the distribution, abundance and species of beneficial fauna occurring in cotton and other nearby crops such as sunflowers will help growers and consultants to make better decisions regarding control of pests in cotton. The value of sunflowers as early season nurseries for some beneficial fauna has been shown with many of these fauna likely to depart maturing sunflowers to invade neighbouring young and actively growing cotton crops. Once in cotton many of these beneficial are able to establish if not disrupted by insecticides, and the work from this project lays a valuable foundation for future studies of beneficial fauna in cotton, having shaved at least two years from future projects. The knowledge of the biology and ecology of some species was established in other projects, but there is still a long way to go to thoroughly understand the cotton fauna and how it may be better protected and encouraged as early and mid season predators or parasites of various pests.

The knowledge of the biology and ecology of green mirids has been improved during the project, with the in-crop distribution and abundance over the season now documented. Improved sampling techniques for green mirids have been devised, both to improve the reliability of decisions made regarding pest management, and for more reliable data collection by researchers. Many other studies on green mirids could flow from the results and questions generated from the current and previous projects. We have circumstantially proved the thoughts of consultants over the past few decades that green mirids emigrate from cental Australia to Queensland on north-westerly winds and invade cotton as it is an actively growing crop at the time of migration. It would also appear that green mirid females have mated before emigrating or do so on the wing. A greater understanding of green mirids just before, during and just after emigration would help in our understanding of green mirids. Every increase in knowledge of this insect would allow better management decisions to be made.

7. Provide an assessment of the likely impact of the results and conclusions of the research project for the cotton industry. Where possible include a statement of the costs and potential benefits to the Australian cotton industry and future research needs.

The data generated from the small plot insecticide trials have been used by industry and in part contribute to the IPM Guidelines Support Document 1 - Impact of insecticides and miticides on predators in cotton.

Better management decisions for green mirids should result from this project. Educational costs will increase in the short term as advice and demonstrations are given to growers and consultants on the new thresholds. Longer term benefits will outweigh these costs with a better understanding of the pest among all stakeholders, reduced insecticides costs or crop loss from incorrect control decisions and a more uniform assessment of green mirid densities in cotton areas. The value of the latter should not be underestimated as the range of techniques used to estimate mirid densities mean that correlating data within or across areas is risky. More useful information could result if the data generated each year on green mirid populations was more widely useable.

8. Describe the project technology (eg. commercially significant developments, patents applied for or granted licenses etc).

The researchers in the project (David Murray and Gordon Simpson) gave input to a television segment by Nufarm for the work done on Rimon (novaluron). The input showed trial sites and "real life" examples of pest insects in action. Novaluron gives growers an additional product that can control target pests without greatly disrupting early season beneficial populations.

Other insecticide companies have applied to extend their registrations to include other minor pests using the results from the small plot trials to support their applications to NRA. Additional pests able to be controlled by any given product will help growers to minimise insecticide usage by allowing one product to be applied to control a number of pests, reducing costs and environmental damage.

9. Provide a technical summary of any other information developed as part of the research project. Include discoveries in methodology, equipment design, etc.

Distributions of beneficial fauna in cotton

The distributions of green mirids in cotton were established in previous research, where it was shown that they tended to be randomly distributed, regardless of stage or instar. With the move towards using beneficial fauna, particularly allowing them to develop useful early populations for IPM, a knowledge of their distributions, abundances over time and variation in abundances within and across fields assumes greater importance. The distributions for some common beneficial faunal groups was established in 1999/2000 using random samples to determine the larger scale spatial variation in abundance, and in 2000/01 by sampling consecutive rows to determine spatial variation on a smaller scale.

Distributions and abundances of green mirids and beneficial fauna in sunflowers

Cotton and sunflowers can be neighbouring crops in spring on the Darling Downs, with sunflowers planted in late winter and cotton in mid spring. The sunflowers begin maturing when the cotton plants are beginning their floral development. Hence, sunflowers potentially can be a source of the pest mirids for the cotton.

Sunflowers also host a range of beneficial fauna, the same species of which help to manage early season pests in cotton. Managing early season pests by their natural enemies allows a delay to early season insecticide sprays which is important in cotton as it allows crop managers to form a valuable fauna for integrated pest management. These fauna presumably also help to control some pests of sunflowers. Sunflowers can therefore act as a reservoir of beneficial fauna for cotton, allowing densities to increase prior to migration to neighbouring cotton crops once the sunflowers mature. Budding sunflowers were sampled for green mirids, apple dimpling bugs, broken backed bugs, transverse, striped and minute two-spotted ladybirds and brown lacewings to assess their population dispersion and to determine sample sizes for a predetermined level of sampling precision.

Green mirids and broken backed bugs tended to be randomly distributed in sunflowers, although the first two instars of green mirids tended to be more strongly clumped than the other instars or adults. Apple dimpling bugs, particularly adults, tended to be clumped. Sample sizes of 15 would be adequate for the mirids, except apple dimpling bug nymphs, and for minute two-spotted ladybirds and brown lacewings. These species would require about 30 samples.

<u>Distribution of green mirid eggs on cotton</u>

A knowledge of the egg distributions on plants will help to provide better management decisions by giving researchers a better understanding of green mirid behaviour. Mirids insert eggs into plant tissue leaving only a small cap visible, so counting eggs on plants in the field to obtain advanced estimates of populations is unwarranted. However, the distribution of eggs will allow better understanding of where nymphs may reside, giving better results from sampling for nymphs or a smaller target for more efficient application of insecticides.

Field collected green mirid females (10) were caged on potted cotton plants commencing to square and left for a few days to oviposit. Females were assumed to have mated prior to caging, as there is no known method to determine the mated status of live female mirids. Plants were examined for eggs and the distribution of eggs mapped into various plant locations (e.g., leaf petiole top or underside, stem, square, etc). The frequency of eggs in each location was determined for all plants assessed. Leaves (200 per collection) from field collected plants were examined to check the findings of the above experiments.

Oviposition occurred on all nodes, with about 25% in the bottom tercile, 30% in the top, and the remainder in the middle. Eggs were laid individually (a few millimetres apart), or, on the petiole, in line clusters (eggs laid 0.5 to 1 mm apart in a line, approximately parallel with the petiole) or irregular clusters (eggs laid closely to each other in one location). Most (70%) eggs were distributed along the length of the petiole, with 70% of these laid dorsally. About 75% of eggs laid in the petiole were laid in the final 20% of the petiole's length, especially with in a few millimetres of (but not in) the pulvinus. Remaining locations, with similar distributions, were the underside of the main leaf vein, with eggs distributed evenly along the vein from the pulvinus to a few millimetres past the nectary, the floral structures, and the stem, with most eggs located close to the petiole with the greatest number of eggs.

Occasionally eggs were not inserted into the plant tissue and were fully exposed on a surface; these were assumed to have resulted from females being disturbed during the egg laying process. Green mirids eggs are relatively large and eggs not inserted into plant tissue were obvious to the eye. Eggs not inserted into plant tissue desiccated before hatching. Should this be aberrant behaviour it is of no practical consequence as so few eggs were laid in this manner.

Field collected leaves showed a similar distribution of eggs, although only one egg cluster was observed. The number of egg clusters on caged plants probably resulted from a number of females laying in the same location. A density of 10 mirids per plant is very high compared to field densities. This provides confidence in the technique to assess egg distributions and perhaps to allow an accurate estimate of nymph distributions. Follow up work should investigate the distribution of first instar nymphs to match egg distributions to those of nymphs. If nymphs follow a similar distribution to eggs, the current suction sampling techniques, which sample some proportion of the plant's surface area, would appear to be efficient for whole plant sampling.

10. Detail a plan for the activities or other steps that may be taken;

(a) to further develop or to exploit the project technology.

Easy to use and reliable sampling techniques were developed in a previous project (DAQ72c). Well defined damage thresholds have been developed in this project. Currently control for green mirids relies on insecticides, some of which show promise for excellent IPM development with low impact on beneficial fauna. However, both projects have shown that a virulent fungal pathogen of green mirids might have a place in controlling green mirids if developed. A future project, perhaps collaborating with Carrie Hauxwell and David Holdom (QDPI, Indooroopilly) should investigate the use of pathogens for mirid control. That project could make use of the sampling techniques and thresholds already developed and in use.

Educational campaigns showing the correct use of the sampling techniques, with an explanation of the aim of the new damage thresholds, should boost the adoption of the project's outcomes. Such expenditure would be rewarded with better management decisions for controlling green mirids, reduced impact on early and mid season IPM programs, and a more uniform estimation of mirid densities across the industry.

(b) for the future presentation and dissemination of the project outcomes.

Extension articles will be written for publication in *The Australian Cottongrower*. These will detail work from the project not published in previous articles. Good data exist in the 2000/01 small plot trials and will be made available through *The Australian Cottongrower* to farmers and consultants for products showing promise for IPM development in the farming system. The industry eagerly awaits the newly developed thresholds as current thresholds are poorly defined and subject to change almost yearly with no reasons given for their change. Current control decisions tables that have been published annually in *The Australian Cottongrower* will need to be updated to reflect the changed threshold.

More scientific results will be presented in the scientific literature. The distribution of eggs on plants and distribution of beneficial fauna in vegetative and squaring cotton will be of interest to other entomologists, particularly those working with other mirids or pests of cotton.

Hugh Brier and Kristen Knight (QDPI Kingaroy) are using some of the ideas developed and used in this project to develop better management plans for green mirids in pulse crops for south Queensland and northern New South Wales.

Results will be added to the department's project management database (Promis). Yearly summaries are taken from this database and added to the Australian Rural Research In Progress (ARRIP) database for public distribution.

Poor uptake of this work and its application by some of the key stakeholders in the project is hampering the ability of growers to become more profitable by making better informed decisions regarding management of green mirids. The results from this project and their implications will be discussed with consultants at meetings, workshops, etc., when the opportunity arises to further emphasise the worth, and obligations to their clients, of making competent, informed decisions.

11. List the publications arising from the research project.

<u>Conference papers</u>

Cornford, R. and Simpson, G.B. (1998) Bioassay of new insecticides for the control of the green mirid *Creontaides dilutus* (Stål). Proceedings of the 9th Australian Cotton Conference.

Simpson, G.B. and Cavallaro, B. (1998) Activity of heliothis egg parasites in late season INGARD cotton. Proceedings of the 9th Australian Cotton Conference.

Simpson, G.B., Lloyd, R.J. and Murray, D.A.H. (2000) Effects of some insecticides on pests and beneficials in cotton. Proceedings of the 10th Australian Cotton Conference.

<u>Extension articles</u>

Simpson, G., Murray, D. and Lloyd, R. (1998) Managing green mirids. *The Australian Cottongrower* 19(5): 73-76.

Simpson, G., Murray, D. and Lloyd, R. (1999) New ideas on sampling for green mirids in cotton. *The Australian Cottongrower* 20(5): 22-24.

Simpson, G., Murray, D. and Lloyd, R. (2000) Affirm and Steward: Minimal impact on beneficial fauna in cotton. *The Australian Cottongrower* 21(4): 20-23.

Simpson, G., Khan, M., Brier, H. and Knight, K. (2000) Beware the green veggie bug. *The Australian Cottongrower* 21(5): 17-23.

Simpson, G., Murray, D. and Lloyd, R. (2000) Will lower insecticide rates have less impact on IPM in cotton. *The Australian Cottongrower* 21(5): 36-39.

<u>Draft publications</u>

Simpson, G.B., Murray, D.A.H. and Lloyd, R.J. Sampling green mirids (*Creontiades dilutus* (Stål)) (Hemiptera: Miridae) in cotton. *Australian Journal of Entomology*.

Simpson, G.B. and Murray, D.A.H. Dispersion of mirids (Hemiptera: Miridae) and some beneficial fauna in sunflowers on the Darling Downs, Queensland. *Australian Journal of Entomology*.

Anticipated publications
1. Subject: the past season's insecticides trials
Authors: Lloyd, R.J., Simpson, G.B. and Murray, D.A.H.
Journal: *The Australian Cottongrower*
2. Subject: Damage thresholds for green mirids in cotton
Authors: Simpson, G.B. and Murray, D.A.H.
Journal: *The Australian Cottongrower*
3. Subject: Distributions of beneficial fauna in cotton
Authors: Simpson, G.B. and Murray, D.A.H.
Journal: *Australian Journal of Entomology*
4. Subject: Distribution of green mirid eggs on cotton
Authors: Simpson, G.B. and Murray, D.A.H.
Journal: *Australian Journal of Entomology*

12. Are changes to the Intellectual Property register required?

No.

Part 4 – Final Report Plain English Summary

Provide a half to one page Plain English Summary of your research that is not commercial in confidence, and that can be published on the World Wide Web.

Following from this research the cotton industry has a well defined damage threshold for green mirids in INGARD cotton that can be extended to conventional varieties. Combined with the powerful, easy to use and robust sampling technique developed earlier, growers and consultants can confidently assess their crops for green mirids and have faith in their decisions. Decisions for control or otherwise are more reliable, being based on sound ecological principles. The chances of making a wrong decision for control with expensive consequences (not spraying when required or applying insecticides when not required) have been vastly reduced with this work and that from the previous project.

Growers now have a range of relatively new insecticides, or reduced rates of older products, to control green mirids. Their worth has been proven in small plots trials, with some also having been tested in large plot trials. A few of these products provide some measure of limited impact on some or most groups of beneficial fauna. This improves the prospects for early and mid season IPM programs developed to control other minor pests.

An understanding of the distribution, abundance and species of beneficial fauna occurring in cotton and other nearby crops such as sunflowers will help growers and consultants to make better decisions regarding control of pests in cotton. The value of sunflowers as early season nurseries for some beneficial fauna has been shown with many of these fauna likely to depart maturing sunflowers to invade neighbouring young and actively growing cotton crops. Once in cotton many of these beneficials are able to establish if not disrupted by insecticides, and the work from this project lays a valuable foundation for future studies of beneficial fauna in cotton.

The knowledge of the biology and ecology of green mirids has been improved during the project, with the in-crop distribution and abundance over the season now documented. Improved sampling techniques for green mirids have been devised, both to improve the reliability of decisions made regarding pest management, and for more reliable data collection by researchers. Many other studies on green mirids could flow from the results and questions generated from the current and previous projects. We have circumstantially proved the thoughts of consultants over the past few decades that green mirids emigrate from cental Australia to Queensland on north-westerly winds and invade cotton as it is an actively growing crop at the time of migration. It would also appear that green mirids females have mated before emigrating or do so on the wing. A greater understanding of green mirids just before, during and just after emigration would help in our understanding of green mirids. Every increase in knowledge of this insect would allow better management decisions to be made.