

Final Report

On Farm Series | Cotton Research & Development Corporation

Part 1 - Summary Details

CRDC Project Number: **CRDC 260**

Project Title: The effectiveness of Lynx Spiders (*Oxyopes amoenus*) and Damsul Bugs (*Nabis kingergii*) at controlling Green Mirids (*Creontiades dilutus*) in Cotton

Project Commencement Date: July 2004 **Project Completion Date:** June 2005

CRDC Program: On- Farm

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Part 3 – Final Report Guide (due 31 October 2008)

Background

With the introduction of cotton containing the two Bollgard II[®] genes (*CryIAc* and *CryIIAc*), the need for cotton producers to spray their crops with pesticides to control the *Helicoverpa* spp. has been greatly reduced (Fitt, 2000). This has made cotton more amenable to Integrated Pest Management (IPM) strategies that are an ever increasing economically and environmentally sound approach to the control of secondary pests (Fitt *et al*, 2004). An effective IPM system involves chemical and biological controls, including the use of natural predators, parasites or pathogens to help control the numbers of individual pest species below an acceptable threshold (Sarre, 1999). IPM strategies have provided the grower with many benefits in terms of costs saved, and to the community in general in terms of lower levels of insecticide in the environment.

However, with the reduced sprays, secondary pests such as green mirids, which were inadvertently controlled by such sprays, can build up in numbers and have now become an ever increasing pest (Green *et al*, 1999). These insects have become an important mid to late season sucking pest causing considerable damage to areas on the cotton plant that are high in protein content, such as the tips, squares and young bolls (Khan *et al*, 2004a; Khan *et al*, 2003).

Mirids feed on young plant tissue by piercing it with their stylets and releasing pectinase enzymes that destroy the cells in the feeding zone (Khan *et al*, 2004a). They feed on the growing points of the young plants, especially those from the four-true-leaf stage to early flowering (Adams & Pyke, 1982), causing the destruction of vegetative buds and the abscission of flower buds (Foley & Pyke, 1985). Damage is also inflicted upon the young cotton bolls in the form of shiny black spots on the outside at the feeding site (Khan *et al*, 2004b).

One means of controlling this pest without resorting back to hard sprays is to follow IPM and use predators to a greater extent. In Texas, the striped Lynx spider (*Oxyopes salticus*) is the dominant predator of the mirid, *Pseudatomoscelis seriatus*, and is responsible for 15-18% of the mirids daily mortality rate (Nyffeler, Sterling & Dean, 1992a). It is also the most abundant predator in cotton constituting as much as 90% of all spiders collected in the fields (Young & Lockley, 1986). In Australia, Lynx spiders, including the species *Oxyopes amoenus*, are also very common in the cotton field. Damsel bugs (*Nabis kingergii*) are considered to be generalist predators that also attack mirids (Freeman, 1999).

The aim of these experiments was to determine the effectiveness of two naturally occurring predators, *Oxyopes amoenus* (hereafter referred to as lynx spiders) and *Nabis Kingergii* (hereafter referred to as damsel bugs) of the green mirid (*Creontiades dilutus*) in controlling mirid numbers and mirid damage. As part of this aim, we wanted to determine the preferred size of mirid prey and the maximum number of mirids each predator could consume per day. Both field and laboratory experiments were conducted.

Objectives

Experiment 1 was performed in the field using the Bt cotton variety Bollgard[®] Sicala 40B[®] and field cages as shown in figure 2. The aim was to determine (a) if Lynx spiders and/or Damsel bugs were able to control mirid numbers and damage inflicted upon the cotton and (b) whether the predators attached each other (intraguild predation) resulting in less mirid control.

Experiment 2 was conducted in the laboratory to determine the mirid size that small Lynx, adult female lynx and adult female damsel bugs preferred to consume. Once size preferences were determined then experiment three could be conducted.

Experiment 3, also conducted in the laboratory, examined predator satiation. It asked “how many mirids could a predator consume in a single sitting until it became satiated?” In this experiment I also determined the time it took for the predator to resume attacking and consuming mirids.

Experiment One: Predator Efficiency

Are lynx spiders and/or damsel bugs capable of controlling both mirid numbers and mirid damage and are their effects additive or non-additive in this control process?

Introduction

For a predator to be effective in controlling a pest it must control the pest's numbers and minimise the extent of damage that the pest causes (Beddington *et al*, 1978). Initially, the ideal predator was thought to be a specialist. That is, one that attacks only one pest, is highly effective in searching for this pest and is able to increase in numbers when required to stop an outbreak (Beddington *et al*, 1978). Unfortunately, Breene *et al* (1990) found that many predators in cotton were in fact generalist predators that are not highly synchronised with arthropod pests, and do not have a great potential for rapid increase in numbers when a pest outbreak occurs. They do not seem to demonstrate a numerical response to pest numbers (Breene *et al*, 1990) but are still capable of preventing severe outbreaks by maintaining a sympatric presence (Breene *et al*, 1989). In fact, some of the most effective agents of biological control are the generalist predators that are able to maintain a presence by being able to switch prey when numbers vary (Murdoch *et al*, 1985). Both Lynx spiders and Damsel bugs can be classified as generalist predators as they prey on other animals, including mirids.

In order to control outbreaks, predators need to be effective in the presence of other species, particularly other predators as they are working within an ecological community where interaction with other animals is always occurring (Townsend *et al*, 2000). Multiple natural enemies often interact to produce additive or non-additive effects on their prey or host populations (Rossi, 2004) often resulting in impaired pest control (Dinter, 2002). Additive effects are when predators combine to prey on a pest increasing the effectiveness of their control; while non-additive effects are when competition between predators, and even intraguild predation (where one predator attacks another predator) reduce control effectiveness.

The aim of this experiment was to test if the predators, lynx spiders and damsel bugs, could reduce mirid numbers and mirid damage in cotton and to see if any interaction between them caused an additive or non-additive affect on mirid control.

Methods

Five cages (Fig. 2), each of 0.5m³ volume, were set up over Bollgard[®] Sicala 40B[®] cotton plants in the field and 15 mirids (5 small, 5 medium and 5 large) were added to each cage except for one which was the control cage. Four lynx spiders and four damsel bugs were added to three cages in various combinations (Table 1). Prior to enclosing the plants in the cages, the plants were vigorously shaken in an attempt to remove any animals present. After one week, the cages with enclosed plants and animals were removed from the field and fumigated with chloroform. The plants were inspected for damage and all animals present were identified and counted. In particular, we counted the remaining mirids, lynx spiders and damsel bugs as well as any other prominent insect group. The experiment was replicated four times.

The mirids used ranged from small (1st or 2nd instar), medium (3rd or 4th instar) and large (5th instar or Adult).

Statistical analysis:

Statistical analysis was conducted using the Genstat 7 program (Payne, 2000). Wherever possible we used parametric techniques (in particular ANOVA) but when the data could not be normalised we used non-parametric techniques including the Friedman's Two-Way analysis of variance by rank, Chi-squared test or Fisher's exact test (in all cases our α value was 0.05)

Table 1 – Details of the four replicates of the five different treatments used in this experiment

Cage Type	1st Release	2nd Release	3rd Release	4th Release
Control	No insects added	No insects added	No insects added	No insects added
Mirid	Mirids (5 small, 5 medium, 5 large)	Mirids (5 small, 5 medium, 5 large)	Mirids (5 small, 5 medium, 5 large)	Mirids (5 small, 5 medium, 5 large)
Lynx	Mirids (5 small, 5 medium, 5 large) Lynx 2 adult female 2 large juveniles	Mirids (5 small, 5 medium, 5 large) Lynx 1 adult female 3 large juveniles	Mirids (5 small, 5 medium, 5 large) Lynx 2 adult female 2 large juveniles	Mirids (5 small, 5 medium, 5 large) Lynx 2 adult female 2 large juveniles
All	Mirids (5 small, 5 medium, 5 large) Lynx 2 adult female 2 large juveniles Damsel Bugs 3 adult female 1 large juveniles	Mirids (5 small, 5 medium, 5 large) Lynx 2 adult female 2 large juveniles Damsel Bugs 4 large juveniles	Mirids (5 small, 5 medium, 5 large) Lynx 2 adult female 2 large juveniles Damsel Bugs 2 adult female 2 large juveniles	Mirids (5 small, 5 medium, 5 large) Lynx 2 adult female 2 large juveniles Damsel Bugs 4 adult female
Damsel Bugs	Mirids (5 small, 5 medium, 5 large) Damsel Bugs 2 adult female 2 large juveniles	Mirids (5 small, 5 medium, 5 large) Damsel Bugs 1 adult female 3 large juveniles	Mirids (5 small, 5 medium, 5 large) Damsel Bugs 2 adult female 2 large juveniles	Mirids (5 small, 5 medium, 5 large) Damsel Bugs 4 adult female

Results

During the 4 weeks of experiments, no tip damage occurred to any of the plants in any of the combinations. Damage though was recorded to the squares and bolls of the plants with, in some cases, as much as 100% boll damage being inflicted in mirid only cages (Fig. 3). The squares though suffered far less damage than the bolls.

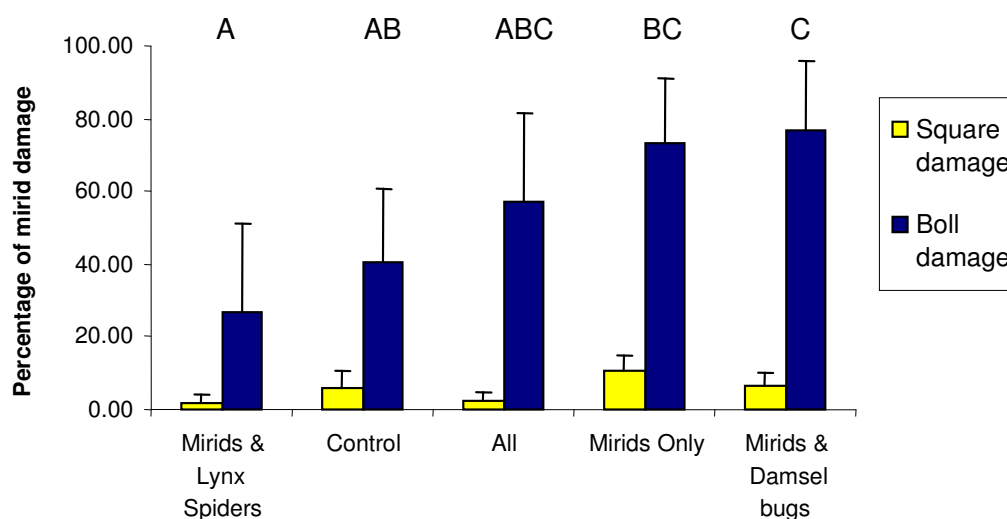


Fig. 3 – Average square and boll damage inflicted by green mirids in the 5 different field cages with standard error bars. Letters indicate treatment whose boll damage do not differ significantly.

Although there was no significant effect of treatments on square damage (ANOVA test: $F=3.10$, $df=4, 11$, $P=0.062$) there was a trend with the mirid only cages receiving the greatest amount of damage to the cotton squares (mean=10.96%, Fig. 3) while the least damage occurring in the cages containing mirids and lynx spiders, (mean=2.02%, Fig. 3).

There was a significant affect of treatment on boll damage (Friedman’s two-way analysis of variance by rank: $df=4$, mean rank=2.93, critical rank=8.80, $P=0.016$). After comparing the cage ranks with the critical rank of 8.80, we found that there was a significant difference between the mirid cages with lynx spiders and those without, but no difference between the mirid cages with and without damsel bugs (Fig. 3; total rank: Mirids & Lynx=19.0; Control=16.0; All=11.0; Mirids only=8.5; Mirids & Damsel bugs=5.5).

Boll damage between treatments followed a similar pattern to that of square damage. Cages containing mirids and lynx spiders fared the best with an average of only 26.59% while the cages with mirids and damsel bugs fared the worst with an average of 76.55%. As for the other three, the control cages suffered 40.30% damage, the cages with all animals (mirids, lynx & damsel bugs) received 57.19% damage and those with mirids only added ended up with an average of 73.08% boll damage.

I also noticed that the number of squares and bolls damaged and the extent of the damage that the mirids inflicted on the cotton increased as the season and experiment progressed (Fig. 4). The number of damaged squares was lower in the last release because by then it was late in the season and most of the squares had already flowered.

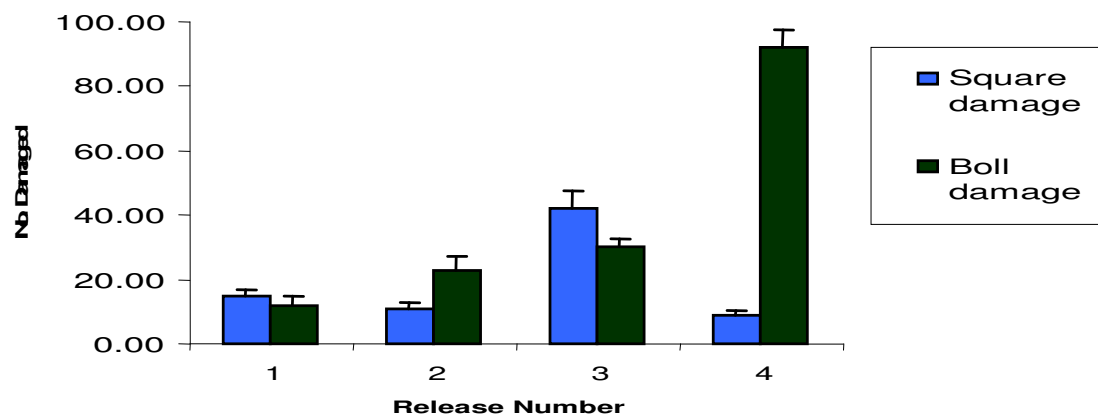


Fig. 4 – Increase in square and boll damage as the season progressed.

At the end of each repetition we counted the number of animals present in the cages, especially mirids, lynx spiders and damsel bugs (Fig. 5). The damsel bug treatment cages contained the greatest number of mirids at the end of the experiments with an average of 10.50 mirids out of 15 released or 70.0% surviving, slightly more than the mirid treatment cage (mean=9.75, n=4 (65.0%)). On the other hand, the lynx treatment cages had an average of only 3.25 mirids recaptured from the 15 released (21.67% surviving) while the All treatment cages had slightly higher mirid numbers (mean=4.00, n=4). The control cage had an average of 1.50 mirids at the end of the experiment indicating that although the plants were vigorously shaken prior to being enclosed, they still retained some invertebrates. This is also reflected in the lynx spider and damsel bug numbers found in the cages at collection, more so the lynx than the damsel bugs though. Twenty-one additional lynx spiders were collected from all of the cages over the 4 weeks but of these, only three were subadults, while 18 were spiderlings which were less than 4mm in body size. Two additional damsel bugs were found in the mirid only cages but both were very small nymphs that would not have had any effect on the adult mirids.

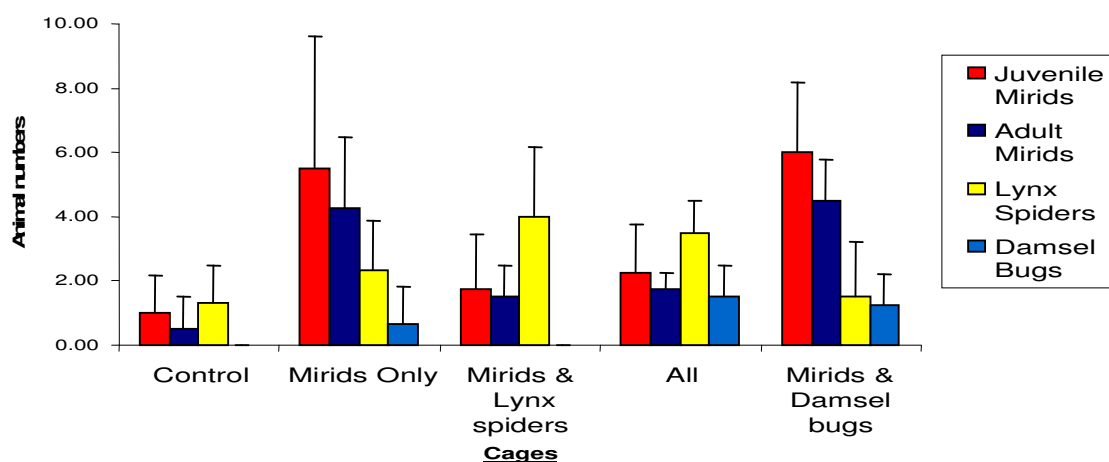


Fig. 5 – Average number of Juvenile mirids, Adult mirids, Lynx spiders & Damsel bugs captured from the 5 different field cages.

Other prominent animals found in the cages included jasids, thrips and brown smudge bugs. We found no significant difference in the number of thrips (ANOVA: $F=0.76$, $df=4,12$, $P=0.571$) nor jasids (ANOVA: $F=1.87$, $df=4,12$, $P=0.181$) but brown smudge bugs showed a trend to differ (ANOVA: $F=8.90$, $df=4,12$, $P=0.055$) with the highest numbers found in the All treatment cages and the lowest numbers found in the Damsel bug treatment cages.

Discussion

The experiment showed that the presence of female or large juvenile lynx spiders (*Oxyopes amoenus*) on cotton plants reduced the boll damage caused by mirids. However, the presence of female or large juvenile Damsel bugs did not reduce damage caused by mirids, and when damsel bugs were included with lynx and mirids, the effect of the lynx spiders on mirid damage was reduced to the extent that it was no longer significant. The same trend was seen with the squares, with less damage in the cages containing lynx and mirids and most damage in the mirid cages.

Lynx spiders are having an effect on the mirids possibly through two ways – predation and non-lethal predator risk. The numbers of mirids recaptured from the field cages each week show that the lynx cages always had the lowest numbers of mirids, with a slight increase in numbers in the all cages (Fig. 5). This suggests the lynx spiders are actively attacking the mirids in the field, thereby, reducing mirid numbers and the damage that they can cause to the plants. Another possibility is that the presence of the spider discouraged the mirids from feeding, and therefore reduced the damage inflicted. This type of effect upon a prey is called non-lethal predator risk (Danner & Joern, 2003). Experiment three shows that this behavioural pattern does exist between Lynx spiders and mirids and further examination of this action is required.

Damsel bugs were significantly ineffective in mirid control with the most amount of boll damage occurring within the Damsel bug cages (Fig. 3) and the highest number of recaptured mirids being recorded in the same cages (Fig. 5). This points to the possibility that damsel bugs, while generalist predators that do consume mirids, may not be effective hunters in the field. This point is supported by experiment two.

Perhaps the damsel bug's poor performance reflects a low preference for mirids as prey by damsel bugs. An ANOVA on the most abundant additional animals found in the cages; jasids, thrips and brown smudge bugs; resulted in no significant difference between the cages with respect to the jasids and thrips (P -values being 0.181 and 0.571 respectfully) but a trend did appear in the brown smudge bug numbers ($P=0.055$). The lowest number of brown smudge bug numbers consistently occurred in the cage containing mirids and damsel bugs while the highest average number of smudge bug numbers occurred in the cages holding all animals. This may indicate that the damsel bug prefers to prey on the smudge beetle instead of the mirid and interference by lynx spiders may reduce this predation pressure. As brown smudge bugs are a beneficial insect, their control by damsel bugs, may not be so useful.

There also appeared to be some form of interaction occurring between the two predators with an average of only 1.5 out of the 4 damsel bugs released each week recaptured while an average of 3.5 lynx spiders from the 4 released were re-caught inside the all cages. The fact that damsel bugs are considered a prey of the striped lynx spider, *Oxyopes salticus*, in America (Young & Lockley, 1985) and my visual sighting of an adult lynx spider consuming

an adult damsel bug (M Barnett vis.obs.) also emphasises this. This negative interaction is reflected in the Lynx spider's reduced effectiveness in controlling mirids (boll damage increasing from 26.59% to 40.31%) when they were combined with the damsel bugs in the all cages (Fig. 3). Once again, a further study of this non-additive effect is required.

One thing that I did notice in sorting the animals collected from the cages each week was the large number of small (< 4mm) lynx spiders within each cage. This reflects the fact that even with vigorous shaking of the plants prior to enclosing the cages, not all animals could be removed. The effect of the large number of small spiders though does not appear to be a factor when determining the effectiveness of adult lynxes in mirid control as they do not seem to contribute to controlling 4th instar or larger mirids (refer experiment 2), the mirid sizes that cause most damage (Khan *et al*, 2004a). This means that when checking cotton fields for spider numbers, only the larger Lynx spiders should be taken into account when trying to determine if the beneficials in the field are going to be able to control the pests that are currently present. Counting hundreds of little spiders will not give a meaningful picture of the effectiveness the Lynx spiders will have in controlling mirid numbers and damage, an important component of any IPM strategy.

Therefore, in summary, even with the occasional presence of additional lynx spiders within the cages which were usually less than 4mm in size and, thus unlikely to affect the activities of the adult mirids, the results from the experiment indicate that some mirid damage control, especially to the bolls of the cotton plants, appear to be achievable with the use of an integrated pest management system containing the Lynx spider while the effectiveness of the damsel bug appears to be highly questionable. The control mechanisms used by the lynx spider obviously include direct predation but may also involve non-lethal predator risk actions. Some negative interaction does appear to occur between the two predators, with the lynx spider possibly including the damsel bug as part of its food web while the damsel bug may find other animals, for example the brown smudge bug, a more preferable prey than the green mirid.

Experiment Two: Preferred prey size of the Lynx spider and Damsel bug

Introduction

Very few animals appear to be willing to attack prey that is greater in size than themselves. Spiders, for example, have a preference for prey that is commonly 50-80% of their own size (Hayes & Lockley, 1990; Nyffeler *et al*, 1992b). The purpose of this experiment was to determine what sized mirid is preferred as a prey for small lynx spiders, large lynx spiders and adult damsel bugs. Once established, this would give an insight into the predator’s feeding patterns and allow better integration of these predators into Integrated Pest Management strategies.



Green Mirid Adult Photo: C. Mares (CSIRO)

Fig. 6 – A green mirid on a cotton square

Methods

Ten small lynx spiders, ten large lynx spiders and ten damsel bugs were selected, weighed, and placed in cages (diameter:4cm, height:5.5cm) for the duration of the experiment. Weights of the small lynx spiders ranged from 2.3mg to 6.3mg, for the adult female lynx spiders the range was from 25.8mg to 60.7mg, while the damsel bugs ranged from 4.4mg to 6.9mg.

Each day over a period of four days, a mirid was added to each cage in accordance to the random feeding draw as shown in table 2. After 1 hour I recorded whether the predator had captured the prey or not. If the prey was not captured, the mirid was removed from the cage.

Table 2 – Randomised feeding draw used to determine predator’s prey size preference.

Feeding Draw	A	B	C	D	E	F	G	H	I	J
1st feed	4/5	A	3	A	1	1	A	3	1	1
2nd feed	3	3	4/5	4/5	3	A	1	1	A	4/5
3rd feed	1	4/5	A	3	4/5	4/5	4/5	A	3	A
4th feed	A	1	1	1	A	3	3	4/5	4/5	3

The average sizes and weights of the mirids, lynx spiders and damsel bugs that were used are listed in table 3.

Table 3. – Average weights and sizes of mirids, juvenile lynx spiders, adult lynx spiders and damsel bugs used to determine preferred prey size of predators.

		Mirids				Juvenile Lynx Spider	Adult Lynx Spider	Damsel bug
	1st instar	3rd instar	4/5 instar	Adult				
Average weight	0.1mg	1.4mg	4.1mg	7.4mg		4.6mg	42.2mg	5.8mg
Average size	1.9mm	3.1mm	5.6mm	7.2mm		4.3mm	16.6mm	10.0mm

Statistical analysis:

I used a Chi-Square test or a Fisher's exact test to determine if there was any significant difference in the predators preferring a particular prey size and, if so, if this differed between the predator types.

Results

I found that the small lynx spiders showed a preference for smaller mirids (Chi square: $\chi^2=12.62$, $df=3$, $P=0.006$) with 6 out of 9 capturing a 1st instar but none preying on the adults (Fig. 7). The adult female lynx spiders though showed a preference for larger mirids (Chi square: $\chi^2=15.83$, $df=3$, $P=0.001$) with 10 out of 10 taking an adult mirid, while only 3 out 10 capturing a 1st and 3rd instar mirid (Fig. 8). In fact, adult female lynx spiders were significantly more likely to take 4th instar to adult mirids than juvenile lynxes (Fishers exact test; $P<0.001$) while juvenile lynxes showed a trend to take more 1st to 3rd instar mirids in comparison to adult female lynx spiders (Fishers exact test; $P=0.052$). Only one damsel bug attacked a mirid, consuming a 4th instar (Fig. 9).

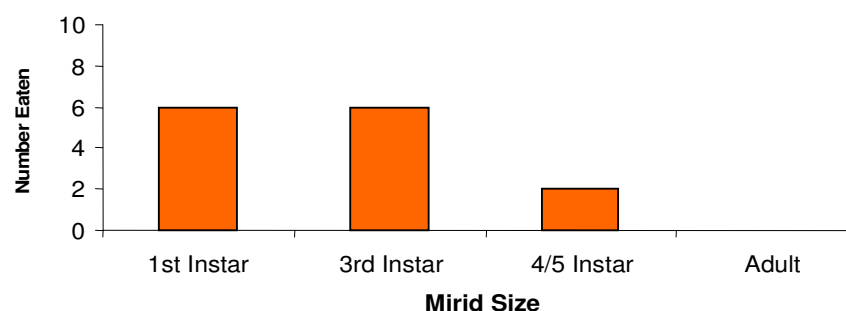


Fig.7 - Size of prey captured by small lynx spiders

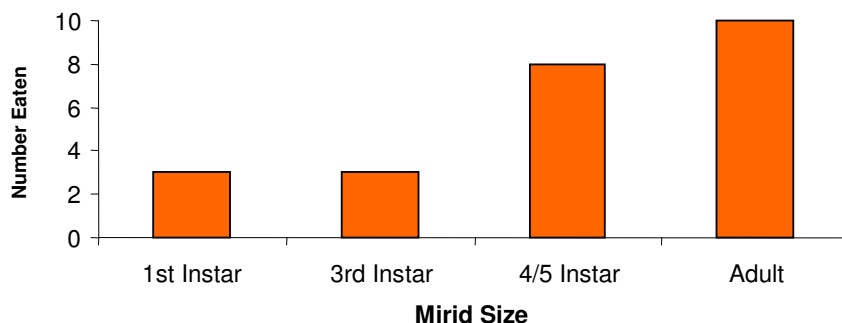


Fig.8 - Size of prey captured by adult lynx spiders

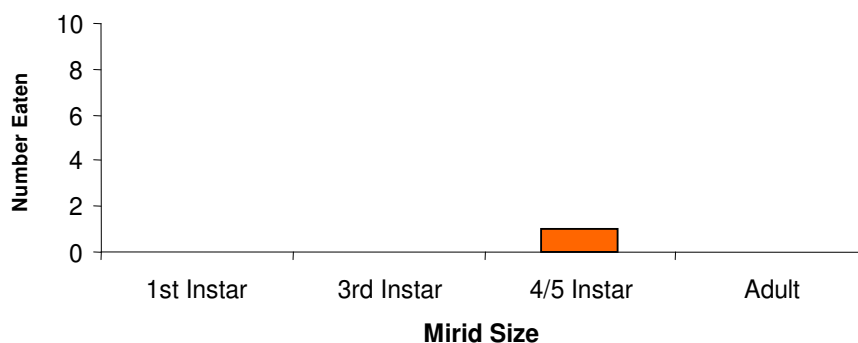


Fig.9 - Size of prey captured by Damsel bugs

Visual observations showed that the presence of the predators altered the mirid’s behaviour. When a mirid contacted a female Lynx spider, it would either be captured or instantaneously move away at a much faster than normal gate. The smaller lynx spiders altered the behaviour of the smaller mirids only (3rd instar or smaller) by causing them to move away at a faster than normal gait. The presence of the damsel bugs did not alter the mirid’s behaviour. Upon contacting this predator, the mirids would stop briefly then moved off at normal gait.

Discussion

The results show that the large female lynx spiders preferred the larger sized mirids as prey while the juveniles preferred the smaller sized mirids. Thus, the preferred size of mirid prey increases as spiders mature. This suggests that the adult spiders may find the smaller mirids (1.4mg or less) either too small in size to properly detect or they consider the prey to be too small to be worthwhile capturing. This last point is also supported by Nyffeler *et al* (1992b) who comments that lynx spiders attack prey usually between 50 and 80% of their body size. Spiders probably gauge body size in respect to both the length and weight of their prey. In comparison to female lynx spiders used, adult mirids were 43.4% of their length and 17.5% of their weight. Third instar mirids were 18.7% of their length and 3.3% of their weight. In respect to the juvenile lynx spiders used, the adult mirids were 167.4% of their length and 160.9% of their weight. The third instar mirids were 74.4% the length of the juvenile lynx

spiders and 30.4% their weight. Thus small mirids are too small for adult lynx spiders and adult mirids are too large for juvenile lynx spiders.

Damsel bugs are classified as generalist predators that will attack mirids (Johnson & Farrell, 2004). However, during this experiment they exhibited little willingness to attack the introduced mirids, attacking only 1 out of 40 mirids offered (Fig. 9). Observations of the mirid's behaviour in the presence of the damsel bugs suggests a lack of perceived threat from the damsel bugs, in contrast to the mirid's behaviour in the presence of the female lynx spiders which seem to alter the mirid's behaviour suggesting that lynx spiders cause non-lethal predator effects in mirids as discussed in experiment 1.

So, in summary, large adult female lynx spiders seem to prefer the largest mirid nymphs or adults while the smaller lynx spiders preferred the much smaller nymphs as prey. This is important as most damage is inflicted by the larger sized mirids (Khan *et al*, 2004a). Having the smaller lynx spiders preferring the small sized mirids, 1st to 3rd instar, they may also be a useful biological control agent of the green mirid by reducing the mirid's population before the pest reaches 4th instar, the size at which damage to the cotton plant starts to be the greatest. Damsel bugs, while generalist predators, appear to be rather ineffective in the control of mirid populations (reinforcing the findings in experiment one).

Experiment three: Lynx Spider Satiation

Introduction

When trying to understand the role of a beneficial in an IPM framework for the control of pests in cotton crops, it's always useful to determine not only its effectiveness in reducing damage caused by the pest but also the maximum number of pests that the predator may be able to kill. For example, if we know how many mirids, on average, a Lynx spider may consume per day we can determine whether a field population of Lynx spiders is large enough to potentially control a mirid infestation.

Larger mirids cause the most damage in cotton (Khan *et al*, 2004a). Adult lynx spiders have a preference for larger sized mirids while juvenile lynx spiders seem to prefer smaller mirids (Experiment Two). In addition, it is likely that adult Lynx spiders consume more mirids before being satiated than juvenile spiders. Consequently, I tested adult female lynx spiders using adult mirids as their prey.

I also wanted to know how a lynx spider would react if, after capturing a mirid, a second mirid came within its reach. Thus the aim of the experiment was to establish: 1) how many mirids could an adult lynx spiders consume until it becomes satiated; 2) how long after feeding does it take for Lynx spiders to recover their appetite again; and 3) what foraging methods does the spider adopt when more than one prey is available?

Methods

Five adult female lynx spiders ranging in weight from 37.2mg to 53.8mg were placed in individual petrii dishes and allowed to settle. Prior to the commencement of this experiment, the spiders were starved of food for 7 days in order to increase their appetite. I placed an adult mirid (average weight 7.4mg) into each dish and recorded the time until it was attacked by the spider. Five minutes after the first mirid was attacked a second mirid was placed into the dish and the spider's actions observed. The spider was given 1 hour after finishing the first mirid to attack the second mirid. If the second mirid was attacked within the hour, the process was repeated. If the next mirid was not taken up within the hour, the spider was assumed to be satiated.

Once satiated, the spiders were tested after 3 and 24 hours to see if they had regained their appetites. To do this the spider, still in the initial petrii dish, was offered an adult mirid. If the spider did not attack the mirid within 15 minutes it was assumed to be still satiated. If the spider did consume the mirid it was assumed to have regained its appetite.

Results

The spiders consumed an average of 4 mirids (range 0 to 7) over 12 hours before becoming satiated (Fig. 10).

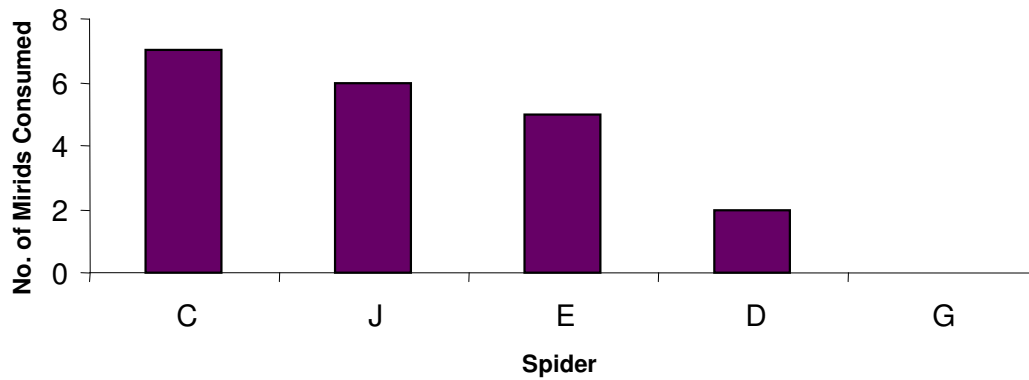


Fig.10 - No. of mirids consumed by each spider during satiation experiment

The average time that it took for each spider to consume a mirid was 1:55 hrs (with a standard deviation of 0.55 hrs) and ranged from 1:30 hrs for spider D to 2:05 hrs for spider E (Fig.11).

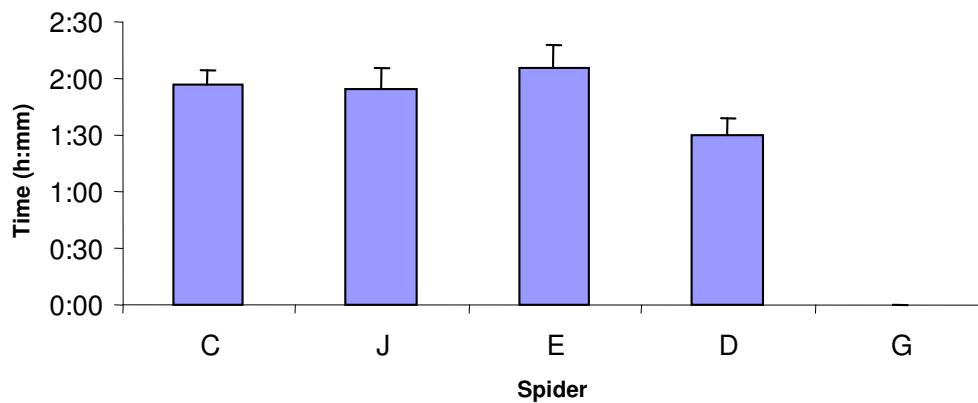


Fig.11 - Average time taken for each spider to consume a mirid

All satiated spiders ignored the mirid when tested after 3 hours but attacked and consumed the mirid after 24 hours. Spider G did not attack any mirids, not even after 3 or 24 hours.

Interactions between the mirids and the spiders were also observed primarily to determine the foraging habits adopted by Lynx spiders when faced with two or more mirids. Three of the 4 spiders which ate during the experiment consumed two mirids at the one time (spiders C and J both once and spider E twice). The reactions of the mirids when confronted with an adult female lynx spider was to either freeze immediately on touching the spider and then back away, or to move rapidly in the opposite direction to the spider.

Discussion

A maximum of 7 mirids were consumed by one of the smallest spiders in the experiment (37.2mg) over a period of 12hrs and within 24 hrs the spider, along with all the others, was once again keen to consume (Fig. 10). On average, it took almost 2 hours to digest each adult mirid and indications are that the adult female lynx spiders are highly capable of consuming two mirids at the one time. These results indicate that for each adult female lynx present in the cotton fields a maximum of 7 adult mirids can be biologically destroyed within a 36 hour period.

The reaction of the mirids in the presence of the spiders was also quite surprising. The mirids appeared to be agitated once they detected the spider. This suggests that the Lynx spider's non-lethal predator effect on the mirids may be an additional benefit in the pest's control, a point suggested in experiment one. An important non-lethal predator effect is that the mere presence of a predator can stop a pest from attacking a crop (Danner & Joern, 2003). This experiment suggests that the presence of a Lynx spider may agitate the mirids to such an extent that they are less likely to attack the cotton plants. This possibility needs to be further examined.

My preliminary findings with five female *Oxyopes amoenus* suggest that these spiders are ferocious predators of adult mirids. Not only did they have a high consumption rate of mirids (4 in 12 hours) and recovered their appetite within 24 hours, but their presence also disrupted the pest's behaviour. The results suggest that *Oxyopes amoenus* has the potential to be a formidable control agent of mirids. Work now needs to be done to see if this high consumption rate can occur and be maintained under field conditions.

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Part 4 – Final Report Executive Summary

The purpose of the experiments conducted were to determine whether the Australian Lynx spider, *Oxyopes amoenus*, and the Damsel bug, *Nabis kingergii*, had any potential in the control of the Green Mirid, *Creontiades dilutus*, in Bt cotton in Australia.

The predators and pests were firstly combined to try and determine if either of the predators was effective in mirid control. Secondly, the mirid size preference was determined for each predator and, finally, how many of the mirids the predators could eat before becoming satiated.

Field tests conducted along with associated laboratory tests revealed the following results:

1. Lynx spiders had a significant impact on the damage inflicted as well as the number of mirids present in the cotton
2. Direct predation and non-lethal predatory risk appear to be mechanisms by which the spiders reduce mirid damage
3. Damsel bugs created no significant impact on the control of mirids in Bt cotton. In fact, anecdotal evidence suggests a possible negative influence in mirid control
4. Intraguild predation, where lynx spiders attack damsel bugs, may reduce mirid control.
5. Damsel bugs seem to prefer alternative prey, such as Brown Smudge beetles, to mirids.
6. In the choice experiment, damsel bugs rarely attacked mirids.
7. Adult female lynx spiders seem to prefer larger mirids while the smaller lynx spiders prefer small mirids.
8. Adult female lynx spiders can consume up to 7 adult mirids within 12 hours before becoming satiated. Within 24 hours from completing the last mirid they are capable of regaining their appetite
9. It takes an average of 1:55 hrs to consume an adult mirid and the adult female spiders are capable of feeding on two at once

These results indicate that the lynx spider, *Oxyopes amoenus*, can contribute to mirid control within the Integrated Pest Management framework. As for the damsel bug, *Nabis kingergii*, a non-additive interaction with the lynx spider and a possible preference for alternative animals sees it as a poor addition to an IPM strategy concerning mirids in Australian Bt cotton. As mirids are significant pests in the Bollgard® II cotton landscape, *O. amoenus* may be a particularly important beneficial to maintain in cotton crops.

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