Habitat diversity: Implications for the conservation and use of predatory insects of *Helicoverpa* spp. in cotton systems in Australia

(*KEY-WORDS*: *Helianthus annuus, Carthamus tinctorius, Sorghum bicolor, Medicago sativa, Lycopersicon esculentum*, predators, monoculture, habitat, diversity, insect conservation)

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Abstract. Adoption of within-field monocultures of annual crops in modern farming systems is known to discriminate against and reduce the activity of predatory insects. In Australia, cotton fields are strictly monoculture and lack ecological diversity. This lack of diversity could be the major cause of pest problems in these agroecosystems. The utility of crops such as sunflower (*Helianthus annuus*), safflower (*Carthamus tinctorius*), sorghum (*Sorghum bicolor*), lucerne (*Medicago sativa*) and tomato (*Lycopersicon esculentum*) as refugia for predatory insects of *Helicoverpa* spp. when they were planted as strips in cotton fields was evaluated from 1993-1995. Densities of beneficial insects, mainly predatory beetles, bugs and lacewings, were higher in lucerne crops than any other crop tested. In an experiment where lucerne was planted in strips within commercial cotton, the number of predators was highest in the lucerne strip and declined with increasing distance from the lucerne strip to reach their lowest level 300 m away in the cotton crop. At the end of the study, 7.1, 6.1, 5.8 and 1.5 times more predatory beetles, bugs, lacewings and spiders per metre row respectively were recorded on the lucerne strips than on cotton. When lucerne was interplanted with commercial cotton to compare densities of predators on cotton with and without lucerne strips, 2.1, 2.5 and 1.2 times more predators were recorded on cotton with lucerne strips than cotton without lucerne strips. This indicated that the lucerne strips can serve as a refugia for predators which can then be moved into cotton fields. This study supports the findings of previous researchers that increased habitat diversity in monocultural crops by strip-cropping can increase population density of indigenous predators.

1. Introduction

Cotton crops (*Gossypium hirsutum*) in many parts of the world are attacked by a wide range of insect pests, the major ones being *Helicoverpa* spp. (Hardwick, 1965; Fitt, 1989). The management of these pests depends almost exclusively on synthetic insecticides; natural enemies of the pests are neglected due to lack of techniques to maximise their abundance and effectiveness. Modern farming systems which rely on within-field monocultures also discriminate against and reduce the activity of predatory insects because they lack ecological diversity (Hagen and Hale, 1974). Increased habitat diversity of crop systems through strip cropping is known to conserve and enhance the efficacy of natural enemies of crop pests by providing food sources for adults, alternative prey at times of scarcity, and shelter for overwintering or for unfavourable situations within the crop system (De Loach, 1971; Hagen and Hale, 1974).

In Australia, cotton fields are strictly monoculture, and the lack of ecological diversity could be the major cause of pest problems because the food, hosts, prey, and hibernating or overwintering sites of most of the natural enemies of the pests are reduced thereby limiting natural biological control (Beirne, 1967; De Loach, 1971; Hagen and Hale, 1974). This can result in pest outbreaks, because abundant food is available to the pest and they need not waste time searching for food or a mate or unduly expose themselves to their natural enemies (Beirne, 1967; Hagen and Hale, 1974). *Helicoverpa* spp., which are the major pests of cotton crops in Australia, are highly migratory and can therefore rapidly infest cotton crops and lay their eggs. Unless natural enemies are present and well established in high numbers before the pests arrive, they cannot respond rapidly enough to control them (Fitt, 1989; Mensah and Harris, 1994, 1995).

The development of a strategy that may conserve and maximise the abundance and effectiveness of natural enemies of *Helicoverpa* spp. in cotton fields will be crucial to enhance the control of these pests. There are many examples to show that increased habitat diversity in crops can increase population densities of indigenous predators to enhance biological control of pests on different crops ((Risch *et al.*, 1983; Herzog and Funderburk, 1989; Russell, 1989; Andow, 1991; Bugg *et al.*, 1987; Fye, 1972; Corbitt, 1991; Wetzler and Risch, 1984; DeLoach, 1971; Southwood and Way, 1970; Pimentel, 1971; Hagen and Hale, 1974; Van Emden and Williams, 1974; Andow and Risch, 1985; Van Leteren, 1987; Van Emden, 1990; Mensah and Madden, 1994; Way and Heong, 1994; Conlong, 1990, 1994, 1995; Mensah and Khan, 1997). However in Australia, no definitive studies have been undertaken to determine if.increased habitat diversity in and around cotton fields would conserve and maximise the abundance of populations of natural enemies of *Helicoverpa* spp.

The aim of this study was to quantify the impact of habitat diversity by strip-cropping on the abundance of natural enemies of *Helicoverpa* spp. in cotton fields as a step towards the development of strategies to conserve and establish these natural enemies in cotton fields early in the cotton season before the pest arrive. Specifically the objectives were to: (1) evaluate the utility of locally grown alternative crops as refugia for predatory insects of *Helicoverpa* spp. in cotton, (2) determine the best refuge crop for strip-cropping, and (3) determine whether the abundance of natural enemies in commercial cotton fields are greater with strip-cropping present than it would be without it.

2. Materials and methods

2.1. Responses of predatory insects to different alternative crops interplanted in cotton

The study was conducted on a 3 ha irrigated cotton field at the Australian Cotton Research Institute (ACRI)(30° 13'S, 149° 47'E) at Narrabri, New South Wales between September 1993 and April 1994. The alternative crops evaluated were sunflower (*Helianthus annuus* L.), safflower (*Carthamus tinctorius* L.), sorghum (*Sorghum bicolor* L.), lucerne (*Medicago sativa* L.), tomato (*Lycopersicon esculentum* Miller) and cotton. Most of these crops are grown in monoculture in the district. Each of the crops was planted in strips, 8 m (or rows) wide and 100 m long adjacent to and separated by cotton strips 20 m (or rows) wide and 100 m long. In total three strips of each crop were planted across the cotton field. The alternative crops were planted on 5 September 1993 and cotton was planted on 10 October 1993. All crops were irrigated at the same time as cotton; irrigation depended on the soil moisture level.

Predatory insects were sampled from each crop once every week from 3 November 1993 to 11 March 1994 by using a small portable suction sampler, D-vac (Homelite Textron Inc., NC, USA). On each sample date, one sample was taken from each crop strip. The D-vac has a 120 mm diameter cone and a nozzle speed of approximately 10 m per second. A gauze bag (25 cm deep) was inserted into the suction tube to collect insects sucked from the plants. The sample was collected from a single pass of the tube of the vacuum sampler along the tops of the plants in 20 metre of row. After each sampling, the contents of the D-vac were transferred to a plastic bag, chilled, taken to the laboratory, and frozen until the contents were counted and identified.

2.2. Effect of lucerne strips on numbers of predatory insects on adjacent cotton fields

Following the results of the above experiment, a study was conducted within lucerne/cotton interplants to determine whether the lucerne strip within the cotton crop is acting as a sink or source of predatory insects to cotton. Experiments were conducted in irrigated cotton fields at Auscott in Narrabri in New South Wales (30° 13'S, 149° 47'E). Lucerne strips 12 m wide and 710 m long, were planted as borders to sandwich 89 ha of cotton. This was repeated 4 times in four cotton fields. One half of the lucerne strips (4 m wide) was slashed alternately every 4 weeks to stimulate new growth and prevent the lucerne from haying or drying off (Mensah and Harris, 1995; Mensah and Khan, 1997).

Predatory insects were sampled weekly from 2 November 1993 to 2 January 1994 by taking a 20 m row vacuum sample from cotton, as previously described at 10, 50, 100, 200 and 300 m away from the edge of the lucerne strip. A sample was also taken in the lucerne at the same time. These were repeated 4 times at each distance. The predators were separated into predatory beetles, bugs, lacewings and spiders and data expressed as numbers per metre per sample date.

2.3. Abundance of populations of predatory insects in lucerne/cotton interplant

Based on the results of the above experiments, an experiment was conducted on lucerne/cotton interplants on a 170 ha commercial irrigated cotton field at Alcheringa near Boggabilla (29° 36', 150° 20') in New South Wales in the 1994-95 season. The goal of the study was to determine whether planting lucerne as strips within commercial cotton can conserve predatory insects within the agroecosystem. Lucerne strips 12 m (or rows) wide and 900 m long, were planted in cotton. For every 300 m (or rows) of cotton, one strip of lucerne was planted; this was repeated six times across the field. The lucerne was planted on 7 September 1994 and cotton on 15 October 1994. The lucerne strips were irrigated at the same time as cotton, depending on the soil moisture level. Alternate 6 m wide bands of each lucerne strip were slashed every 4 weeks and the slashings baled as hay. The 4-week slashing sequence stimulates new growth and prevents the lucerne from haying or drying off before the end of the study (i.e. end of the cotton season) (Mensah and Khan, 1997).

Predatory insects of *Helicoverpa* spp. were sampled weekly from 11 November 1994 to 16 January 1995 by taking a 20 m row vacuum sample from lucerne and cotton plants as previously described.

2.4. Comparison of numbers of predatory insects on cotton crops with and without interplanted lucerne

The experiment was conducted in two irrigated cotton fields at Norwood (29° 28', 149° 50'), near Moree in New South Wales, Australia from 30 October 1995 to 20 December 1995. The sizes of the two cotton fields were 53 ha (field 9) and 60 ha (field 16), respectively, and they were adjacent to each other, separated by 30 m natural vegetation. In the first field (field 9), lucerne strips 12 m (or rows) wide and 709 m long; were planted within the cotton. For every 300 m (or rows) of cotton, one strip of lucerne was planted. In total, six lucerne strips wewre planted across the field. Alternate 6 m wide bands of each lucerne strip were slashed every 4 weeks to stimulate growth and prevent the lucerne from drying off. The second field (field 16) had no lucerne planted within the cotton; the field was divided into six subplots (2a, 2b, 2c, 2d, 2e and 2f), and each subplot (10 ha cotton) was considered as cotton without lucerne strips. The two fields (fields 9 and 16) were left unsprayed with synthetic insecticide until after the early cotton season (i.e. 20 December 1995), when field 16 was sprayed with synthetic insecticides to prevent crop damage by *Helicoverpa* spp. and *Creontiades dilutus* and this resulted in the termination of the trials.

Predatory insects were sampled from 30 October 1995 to 13 December 1995 by taking a 20 m row vacuum sample, as previously described, separately from each of the six lucerne strips and the cotton in field 9 and also from each of the subplots in field 16.

2.5. Analysis of data

All experimental data were analysed using repeated measures analysis of variance (Graphpad Instat Software Inc. Version 2.03, San Diego, California) on transformed data (X = log (X+1). Treatment and sample dates were the independent variables. Tukey-Kramer Multiple Comparisons tests were used to separate means. Arithmetic rather than transformed means are given in the text.

3 Results

3.1. Responses of predatory insects to different alternative crops interplanted in cotton

Predators of *Helicoverpa* spp. identified from the study plots are given in Table 1. Significant differences ($P<0.001$) in numbers of predators were found among the crops tested (Figs 1 - 3). Significantly higher ($P<0.001$) numbers of predatory beetles were found on lucerne than any of the crops with the exception of *Adalia bipunctata* (Fabricius) where numbers recorded on the lucerne crops were the same as those on sunflower, safflower and sorghum (Fig. 1). The lowest numbers of predatory beetles were recorded on cotton and tomato crops (Fig. 1). Among the predatory bugs sampled, *Geocoris lubra* (Kirkaldy), *Nabis capsiformis* (Germar) and *Cermatulus nasalis* (Westwood) were most abundant on lucerne, whereas *Oechalia schellenbergii* (Guerin-Meneville) and *Coramus triabeatus* (Horvath) were more abundant on safflower and sunflower respectively (Fig. 2). There were greater numbers of predatory lacewings on safflower, and the highest numbers of spiders were recorded on lucerne crops (Fig. 3). Overall, more predators were recorded on the lucerne crop than any of the crops (Figs. 1-3).

3.2. Effect of lucerne strips on numbers of predatory insects on adjacent cotton

Populations of predatory beetles, bugs and lacewings recorded on the lucerne strips were significantly higher ($P<0.001$) than on the adjacent cotton and seemed to decline with increasing distance from the lucerne strip to reach their lowest level 300 m away (Fig. 4). A similar trend was shown by spiders, but numbers recorded on the lucerne strips and the cotton crops 50 m away were not significantly different ($P>0.05$) (Fig. 4). In general, the predator numbers recorded on cotton at different distances away from the lucerne strip were lower and not significantly different ($P>0.05$) from each other with the exception of the predatory bugs and spiders, indicating that the lucerne strip with higher number of predators was acting as a reserviour or refugia to conserve the insects (Fig. 4).

3.3. Abundance of populations of predatory insects in lucerne/cotton interplant

Predatory beetles, bugs and lacewings were more abundant on lucerne than cotton with the exception of spiders where populations on both crops were the same (Fig. 5). Predatory beetle numbers recorded on lucerne from 25 November 1994 until 6 January 1995 were significantly higher ($P<0.01$) than cotton, but after 6 January numbers on both crops were not significantly different ($P>0.05$) (Fig. 5). Populations of predatory bugs were higher on lucerne than cotton from 11 November through to 16 December and again from 23 December until 6 January 1996, thereafter populations on both crops were not significantly different ($P>0.05$)(Fig. 5). Predatory lacewing numbers were significantly higher ($P<0.05$) on lucerne than on cotton on all the sample dates with the exception of 28 November, 23 December, 29 December and 6 January where the lacewing numbers recorded on both crops were not significantly different (P>0.05) (Fig. 5). In contrast, numbers of spiders recorded on both lucerne and cotton were not significantly different (P>0.05) on most of the sampling dates with the exception of 25, 28 November and 5th December when spider numbers were significantly different (P<0.05). At the end of the study 7.1, 6.1, 5.8 and 1.5 times more predatory beetles, bugs, lacewings and spiders per metre row respectively were recorded on lucerne strips than on cotton (Fig. 5).

3.4. Comparison of numbers of predatory insects on cotton crops with and without interplanted lucerne

Significant diferences (P<0.01), with the exception of spiders, were found between the numbers of predatory beetles, bugs and lacewings recorded on cotton with and without lucerne strips (Fig. 6). The highest numbers of predatory beetles, bugs and lacewings were recorded on the lucerne strips, followed by cotton with lucerne strips with the least on cotton without lucerne strips (Fig. 6). In contrast, the number of spiders recorded from the lucerne strips and cotton with and without lucerne strips were not significantly different (P>0.05) (Fig. 6). At the end of the study 2.1, 2.5 and 1.2 times more predatory beetles, bugs and lacewings per metre row respectively, were recorded on cotton with lucerne strips, in comparison with cotton without lucerne strips. Also, within the lucerne/cotton interplanting, 1.7, 2.2 and 2.4 times predatory beetles, bugs and lacewings per metre row respectively, were recorded on the lucerne strips compared with the cotton.

4. Discussion

The study clearly showed that interplanting lucerne in cotton fields by strip-cropping can conserve and increase the densities of predatory insects of *Helicoverpa* spp. in cotton.

In an experiment where lucerne was planted within cotton field as strips, the densities of predators were higher in the lucerne crop than in cotton. In another study where lucerne was planted as borders to cotton fields, the number of predators in the lucerne crop were again higher in the lucerne crop than in cotton with predator numbers declining with increasing distance from the lucerne strip to reach their lowest level 300 metres into the cotton crop. This could mean that within a lucerne/cotton interplant, the lucerne crop may act as a refugia or reserviour to conserve predatory insects. However, when lucerne was interplanted with commercial cotton, to compare densities of predators on cotton with and without lucerne strips, 2.1 and 2.5 times more predatory beetles and bugs per metre row respectively were recorded on cotton with lucerne strips than cotton without lucerne strips. This indicated that the interplanted lucerne crop may be acting as a source of the predators to the cotton crop. The refugia or source function of the lucerne strips may be attributed to the abundance of floral nectar and alternate prey, shelter, mating and oviposition sites etc harboured in the lucerne crop (Bugg *et al.* 1987), compared to the monocultural cotton. These resources may have enhanced the establishment of the predators within the lucerne strips. The magnitude of these effects will depend on whether the lucerne strips were well established and colonized by predatory insects long before the cotton crop germination and also the mobility of the predators themselves (Corbett and Plant, 1993). According to Corbett and Plant (1993), an interplanted vegetation may act as a source of natural enemies when natural enemies colonize strip vegetation before crop germination, but may act as a sink when crop and interplanted vegetation germinate at the same time. In this study though, the lucerne crop was established before the cotton crop germinated, the role of the lucerne strip as a source of predators to the cotton crop, however, was minimal looking at the higher numbers of predators recorded in the lucerne strip compared with the numbers in the cotton crop within the lucerne/cotton interplant. Thus given the abundance of food resources, shelter, mating, oviposition sites etc within the lucerne strips (Bugg *et al.* 1987), higher numbers of the predators may not have been inclined to move from the strips to forage the adjacent cotton crop. The movement of the predators can be improved by either applying natural enemies food attractants to the cotton crop to attract predators especially the predatory beetles, bugs and lacewings onto the cotton (Mensah and Harris, 1994, 1995; Mensah, 1997) or by using smaller lucerne strips less than 12 m wide or slashing all the lucerne strips or allowing the lucerne crop to hay off (Mensah and Harris, 1995). The last three options may also force *C. dilutus* another pest of cotton which found mostly in the lucerne strips to move from lucerne to cause damage in cotton (Mensah and Khan, 1997).

The use of lucerne as strips in cotton to generate beneficial insects in cotton systems especially early in the season as indicated in this study, is very important to the management of *Helicoverpa* spp.(Fitt, 1989; Mensah and Harris 1995). This is because *Helicoverpa* spp. can rapidly infest cotton crops through migration from other sources, especially early season, and unless natural enemies are present and well established before the pest arrives they cannot respond rapidly enough to achieve control (Fitt, 1989; Mensah and Harris, 1995). The presence of the lucerne crop within the cotton system will enable the establishment of a high population of beneficial insects in the cotton fields on time prior to the arrival of *Helicoverpa* spp.

However, the study did indicate that planting lucerne crop 300 metres apart within cotton could increase the abundance and spread of predatory insects in cotton systems.

In conclusion, increased habitat diversity in cotton fields using lucerne strips can be a useful tool in using indigenous predators in an integrated pest management program in cotton in Australia.

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Table 1. Major predators identified from study plots within commercial cotton farms at all study sites, 1993-96.

Order	Family	Species	Group
Coleoptera	Coccinellidae	*Coccinella transversalis* (Fabricius)	Predatory
		Adalia bipunctata (Linnaeus)	beetles
	Melyridae	*Dicranolauis bellulus* (Guerin-Meneville)	
Hemiptera	Nabidae	*Nabis capsiformis* (Germar)	Predatory
	Lygaeidae	*Geocoris lubra* (Kirkaldy)	bugs
	Pentatomidae	*Cermatulus nasalis* (Westwood)	
		Ochelia schellenbergii (Guerin-Meneville)	
	Reduviidae	*Coranus triabeatus* (Horvath)	
Neuroptera	Chrysopidae	*Chrysopa* spp.	Predatory
	Hemerobiidae	*Micromus tasmaniae* (Walker)	lacewings
Araneida	Lycosidae	*Lycosa* spp.	Spiders
	Oxyopidae	*Oxyopes* spp.	
	Salticidae	*Salticidae* spp.	
	Araneidae	*Araneus* spp.	

This will enhance the efficacy of the beneficial insects and enable their use as basic components in a practical integrated pest management system. The beneficial arthropods also may aid in the management of spider mites and other pests (Corbett et al. 1991; Godfrey and Leigh, 1994) provided the lucerne strips are not sprayed with synthetic insecticides which may disrupt the activity of the beneficial arthropods resulting in the resurgence of the spider mite population (Mensah and Singleton, Unpublished data). The lucerne strips also serve as trap crop for the green mirid, *Creontiades dilutus* Stål which are major pests of cotton (Mensah and Khan, 1997). It should therefore be managed to remain attractive to the green mirids by maintaining new regrowth throughout the cotton season (Mensah and Khan, 1997). This could be done by slashing half of each strip every 4 weeks (Mensah and Khan, 1997).

Several studies have indicated that increased habitat diversity in crops leads to increase population densities of indigenous predators and other arthropods and this can enhance biological control. For example, Conlong (1995) intercropped sugarcane with sorghum and maize and this increased the population density of indigenous predators and arthropods in the intercrops as compared to pure stands of sugar cane. Corbett (1991) also found that the predatory mite *Metaseiulus occidentalis* was enhanced in abundance immediately adjacent to alfalfa interplants in cotton. Greenbug populations on strips of sorghum interplanted in cotton were found by Fye (1972) to support large populations of *Hippodamia convergens* and other predators. These studies suggest that the presence of abundant resources can increase the residence time of natural enemies on vegetation providing these resources and by diversifying agroecosystems by adding such vegetation could enhance natural enemy abundance and effectiveness.

Cotton is grown in Australia as a short lived annual monoculture and so the predatory insects fly periodically to new host locations as the crop matures and is then harvested. The surrounding natural vegetation in most of the cotton areas in Australia especially in the Northern New South Wales where most of the cotton is grown is very sparse and sometimes bare with no natural vegetation at all. By artificially increasing the habitat diversity in the cotton system by interplanting the cotton with lucerne strips, the predatory insects were given a permanent refugia for feeding, oviposition and possible overwintering sites during and after the cotton season enabling them to be carried over from one season to another. This study did not seek to determine whether strip cropping with lucerne will produce predators enough to reduce damage of *Helicoverpa* spp.in cotton since cotton growers are reluctant to leave cotton fields unsprayed against *Helicoverpa* spp.

Figure 1. Responses of predatory beetles to alternative crops interplanted in commercial cotton in the Australian Cotton Research Institute farm at Narrabri, NSW, 1993-94 (Means of treatments followed by the same letter are not significantly different ($P > 0.05$) (Tukey-Kramer Multiple Comparisons Test). Error bars represent standard errors.

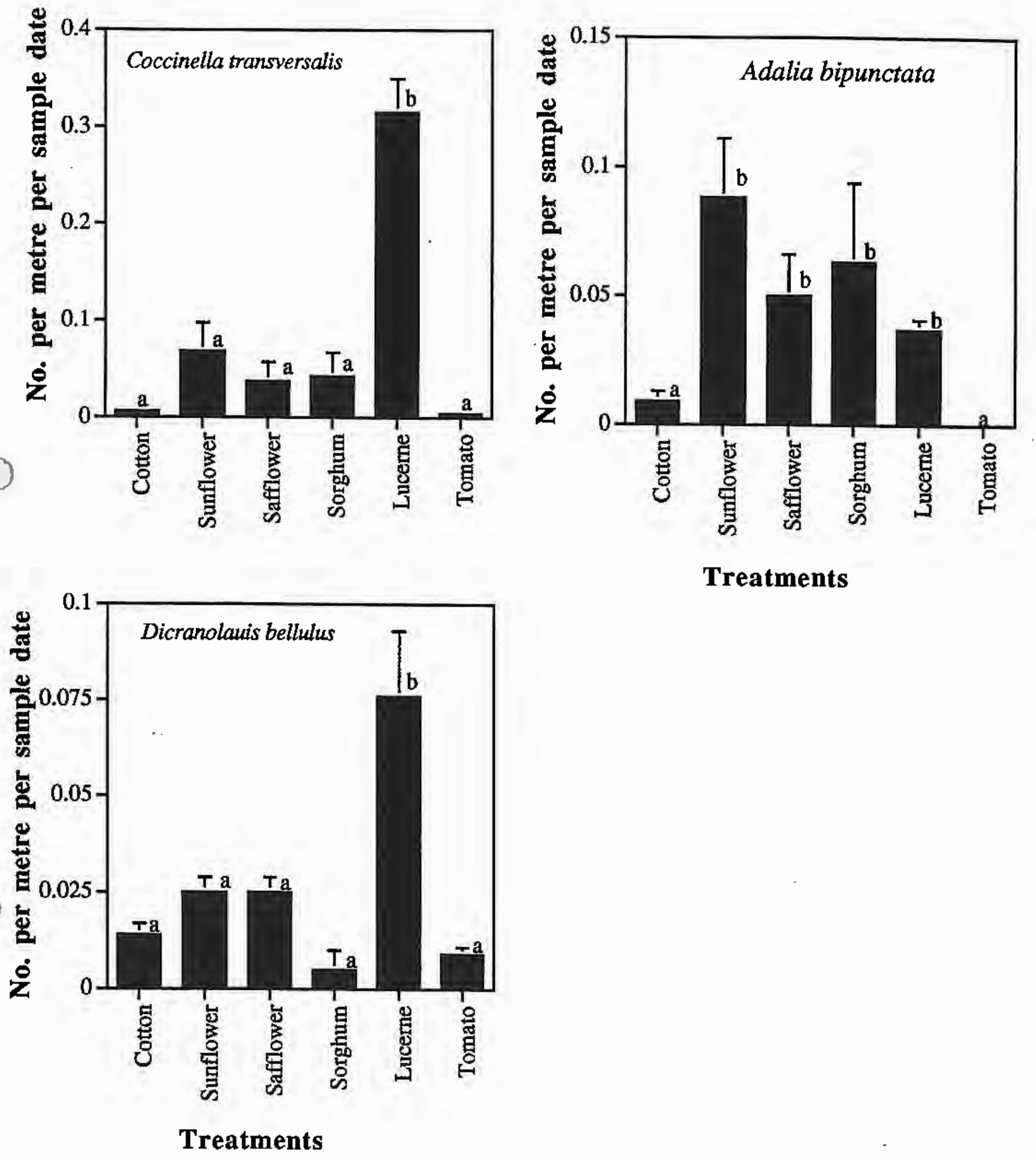
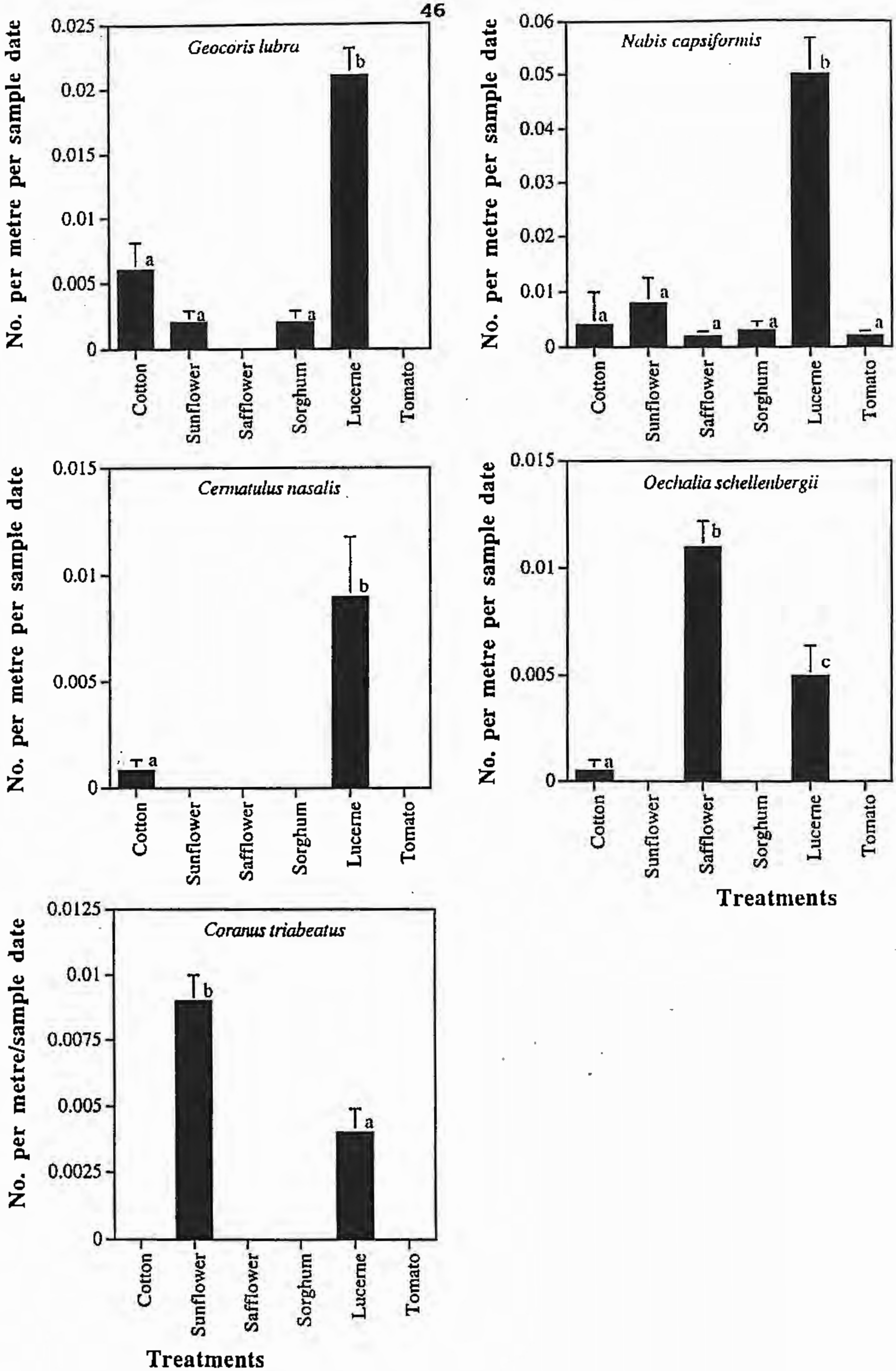

Coccinella transversalis
No. per metre per sample date
0.4
0.3
0.2
0.1
0
Cotton
Sunflower
Safflower
Sorghum
Lucerne
Tomato
Adalia bipunctata
No. per metre per sample date
0.15
0.1
0.05
0
Treatments
Dicranolauis bellulus
No. per metre per sample date
0.1
0.075
0.05
0.025
0
Treatments

Figure 2. Responses of predatory bugs to alternative crops interplanted in commercial cotton in the Australian Cotton Research Institute farm at Narrabri, NSW, 1993-94 (Means of treatments followed by the same letter are not significantly different ($P > 0.05$) (Tukey-Kramer Multiple Comparisons Test). Error bars represent standard errors.



Geocoris lubra
Nabis capsiformis
Cermatulus nasalis
Oechalia schellenbergii
Coranus triabeatus
No. per metre per sample date
No. per metre/sample date
Cotton
Sunflower
Safflower
Sorghum
Lucerne
Tomato
Treatments
0
0.005
0.01
0.015
0.02
0.025
0.03
0.04
0.05
0.06
0.0025
0.0075
0.0125
a
b
c

Figure 3. Responses of predatory lacewings and spiders to alternative crops interplanted in commercial cotton in the Australian Cotton Research Institute farm at Narrabri, NSW, 1993-94 (Means of treatments followed by the same letter are not significantly different ($P > 0.05$) (Tukey-Kramer Multiple Comparisons Test). Error bars represent standard errors.

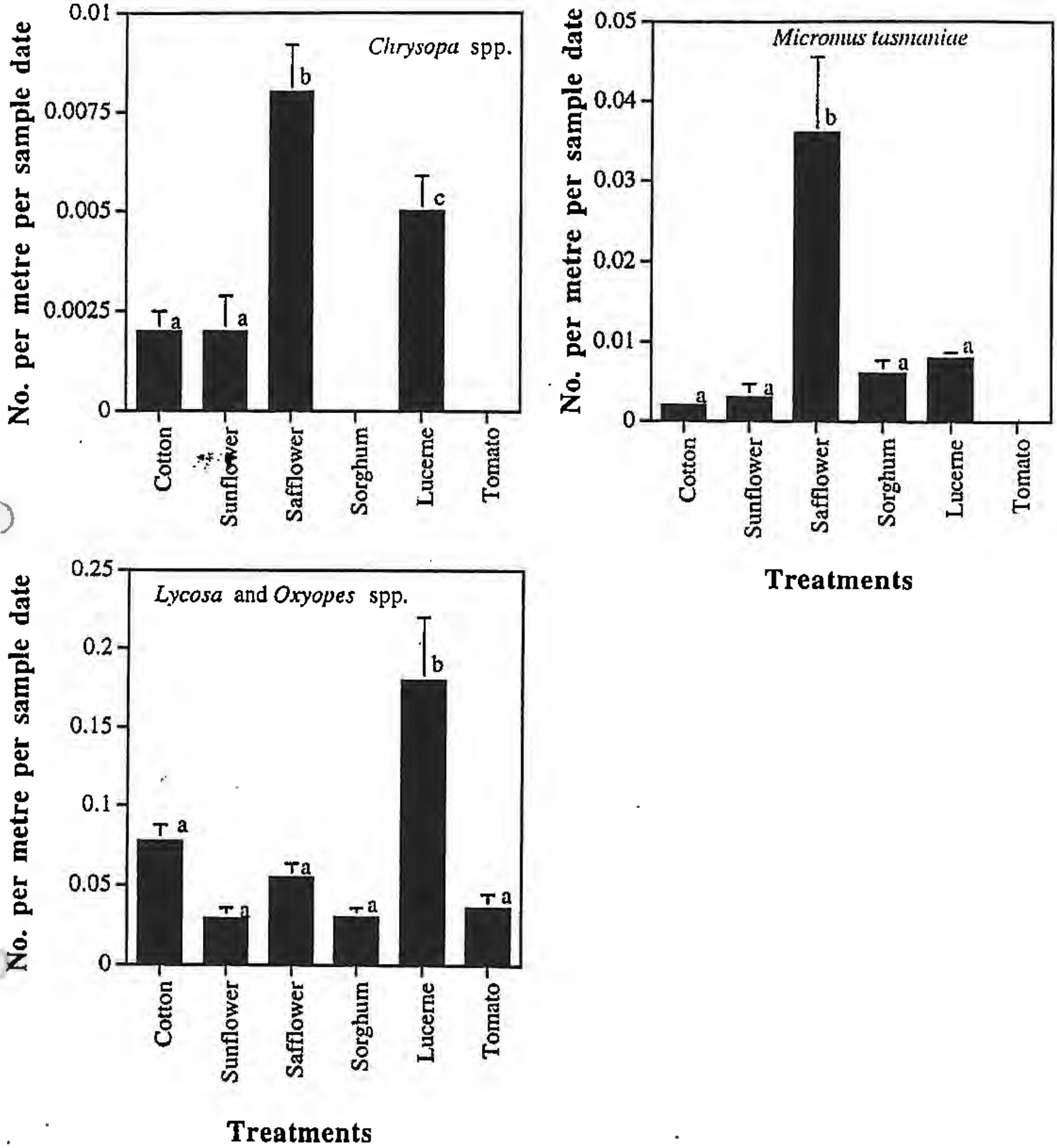
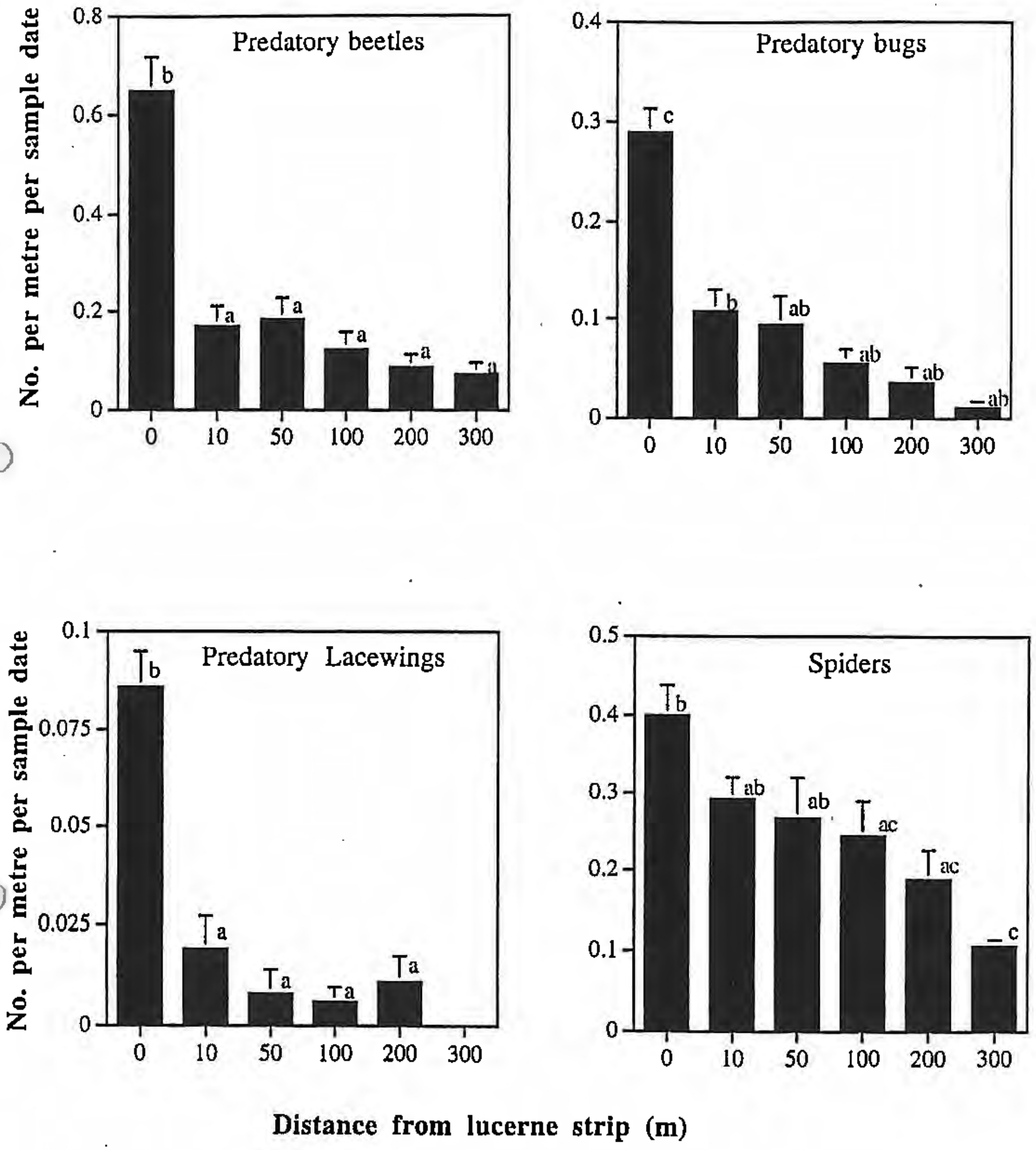

Chrysopa spp.
No. per metre per sample date
0
0.0025
0.005
0.0075
0.01
Cotton
Sunflower
Safflower
Sorghum
Lucerne
Tomato
a
a
b
c
Micromus tasmaniae
No. per metre per sample date
0
0.01
0.02
0.03
0.04
0.05
Cotton
Sunflower
Safflower
Sorghum
Lucerne
Tomato
a
a
b
a
a
Treatments
Lycosa and Oxyopes spp.
No. per metre per sample date
0
0.05
0.1
0.15
0.2
0.25
Cotton
Sunflower
Safflower
Sorghum
Lucerne
Tomato
a
a
a
a
b
a
Treatments

Figure 4. Effect of lucerne strips on numbers of predatory beetles, bugs, lacewings and spiders in adjacent cotton crop in Auscott at Narrabri, NSW, 1993-94. (Means between treatments followed by the same letter are not significantly different ($P > 0.05$) (Tukey-Kramer Multiple Comparisons Test). Error bars represent standard errors.



Predatory beetles
Predatory bugs
Predatory Lacewings
Spiders
No. per metre per sample date
0
10
50
100
200
300
Distance from lucerne strip (m)

Figure 5. Comparison of numbers of predatory beetles, bugs, lacewings and spiders in lucerne strips and in cotton at Alcheringa near Boggabilla NSW, 1994-95. Error bars represent standard errors.

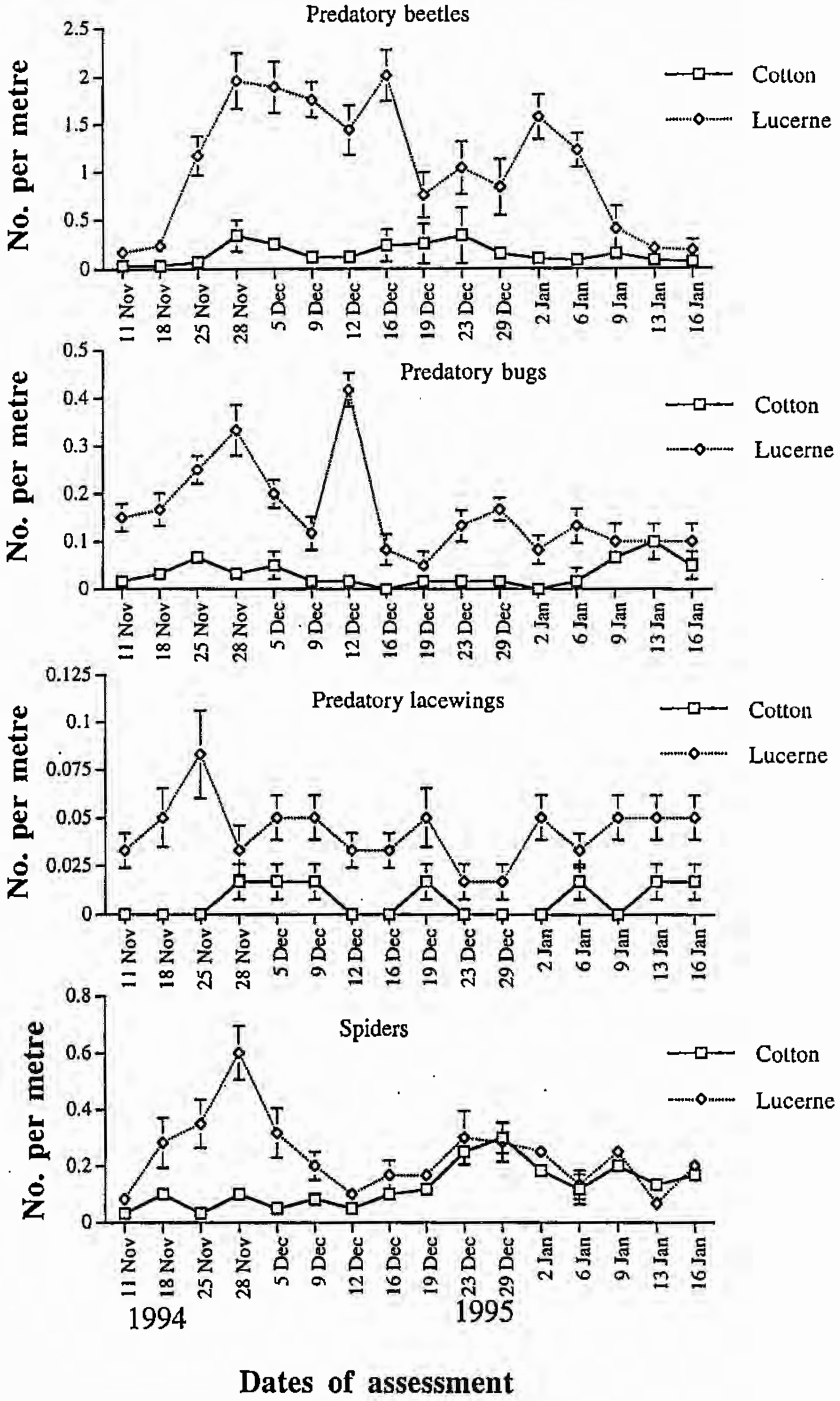
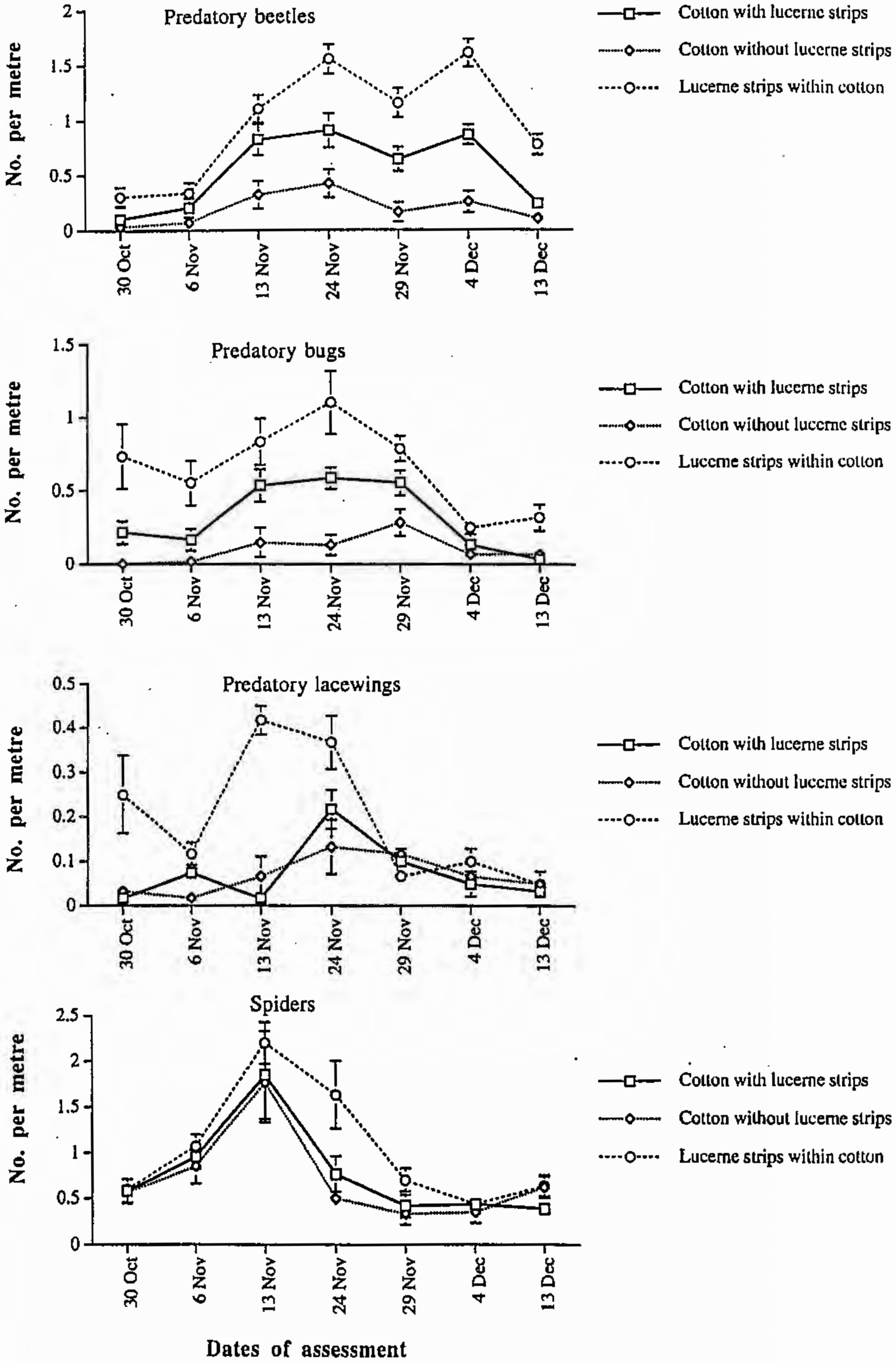

Predatory beetles
No. per metre
Cotton
Lucerne
Predatory bugs
No. per metre
Cotton
Lucerne
Predatory lacewings
No. per metre
Cotton
Lucerne
Spiders
No. per metre
Cotton
Lucerne
11 Nov
18 Nov
25 Nov
28 Nov
5 Dec
9 Dec
12 Dec
16 Dec
19 Dec
23 Dec
29 Dec
2 Jan
6 Jan
9 Jan
13 Jan
16 Jan
1994
1995
Dates of assessment

Figure 6. Comparison of numbers of predatory beetles, bugs, lacewings and spiders in lucerne strips, cotton with and without lucerne strips at Norwood near Moree NSW, 1995. Error bars represent standard errors.


Predatory beetles
No. per metre
Cotton with lucerne strips
Cotton without lucerne strips
Lucerne strips within cotton
30 Oct
6 Nov
13 Nov
24 Nov
29 Nov
4 Dec
13 Dec
Predatory bugs
No. per metre
Cotton with lucerne strips
Cotton without lucerne strips
Lucerne strips within cotton
Predatory lacewings
No. per metre
Cotton with lucerne strips
Cotton without lucerne strips
Lucerne strips within cotton
Spiders
No. per metre
Cotton with lucerne strips
Cotton without lucerne strips
Lucerne strips within cotton
Dates of assessment

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