Soil Arthropod Predators at "Doreen" for 1995–96 Season

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Introduction

Rapid changes in cotton farming practices and the introduction of new synthetic insecticides and control strategies over the last 10–15 years are likely to have led to significant changes in the species diversity and abundance of beneficial crop canopy insects, soil fauna and soil microflora. However, there have been no studies investigating the effects of these changes in Australian cotton farming practices on beneficial soil fauna since the 1970s and early 1980s (Bishop and Blood 1977; Room 1977; Bishop and Blood 1980). As the Australian cotton industry strives to develop more viable, sustainable and environmentally responsible farming and crop protection practices, detailed and up to date knowledge of the key functional groups of soil fauna and their respective contributions to the cotton agroecosystem performance becomes increasingly essential.

The objectives of this baseline research project, which started late in the 1993–94 growing season, were to: (a) develop a soil fauna sampling protocol for cotton agroecosystems, (b) enumerate the principal ecological groups of soil fauna present and (c) for chosen groups, characterise and compare the resultant short–term changes in soil fauna biodiversity under different farming and crop protection practices. For the 1995–96 cotton growing season the effects of cotton production on the biodiversity of surface–active soil meso– and macrofauna were studied using pitfall traps and soil cores in single irrigated cotton fields at "Doreen" and at the Australian Cotton Research Institute (Environfeast demonstration field). Here we report on the results for the soil predators component of the 1995–96 season at "Doreen".

Study area for 1995–96 Namoi Valley Bt trial

Fieldwork for the 1995–96 cotton growing season was conducted at the Namoi valley Bt field site at "Doreen" (30.00S and 149.17E), located approximately 61 km north–west of Narrabri. Experimental plots (see Fig. 1) were established in the conventionally sprayed and unsprayed cotton treatments of block 10, the conventionally sprayed block 8, and in the adjoining native vegetation. Block 10 was 86 ha in size and developed for irrigated cotton production in 1994. The adjoining block 8 was developed in 1984, and had a cropping history of seven cotton and four faba bean crops. The management operations used for each block for the 1995–96 growing season are given in table 1.

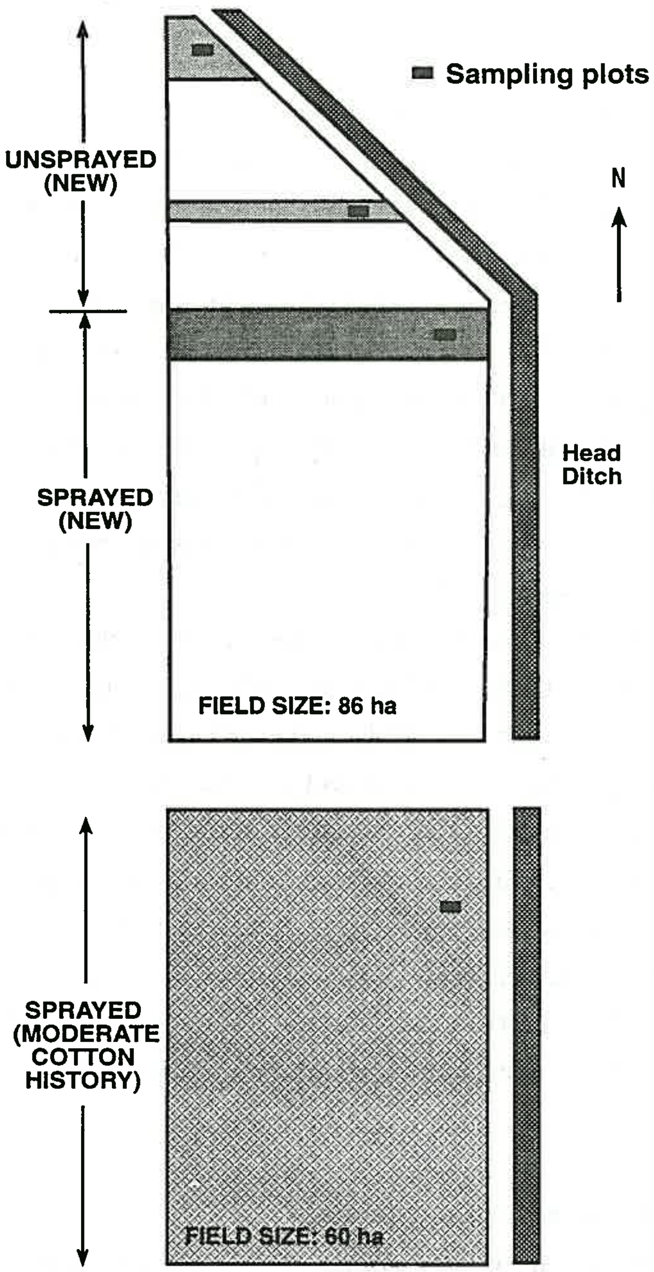

Fig. 1: Field plans for 1995–96 cotton season at "Doreen".

Table 1: Farming System Management at "Doreen".

	Cotton Field		
	Block 10	**Block 8**	**Chemical group**
Herbicides			
Fallow	Sandoban	Sandoban	
Pre–plant	Treflan Cotoran Diuron	Treflan Diuron	
Post–plant	Roundup	Roundup	
Variety	Sicala V2	Siokra V–15	
Sown	13–10–95	5–10–95	
Cultivations	6–11–95 13–12–95	8–11–95 14–12–95	
Irrigations			
Watered–up	15–10–95	8–10–95	
Full irrigation	18–2–96 5–3–96	30–12–95 11–2–96 28–2–96	
Insecticides	*Sprayed treatment*		
Stage I			
6/8–11–95	Endosulfan	Endosulfan	Organochlorine (OC)
13/14–12–95	Endosulfan	Endosulfan	Organochlorine (OC)
Stage II			
22–12–95	Endosulfan	Endosulfan	Organochlorine (OC)
1–1–96	Endosulfan	Endosulfan	Organochlorine (OC)
12–1–96	Endosulfan	Endosulfan	Organochlorine (OC)
20–1–96	Bifenthrin–Dimetholate	Deltamethrin	Pyrethroid (P)–OC & P
29–1–96	Thiocarb	Thiocarb	Carbamate (C)
Stage III			
7–2–96	Bifenthrin	Bifenthrin	Pyrethroid (P)
19–2–96	Thiocarb	Thiocarb	Carbamate (C)
1–3–96	Deltamethrin	—	Pyrethroid (P)
5–3–96	Profenofos	Profenofos	Organophosphate (OP)

Results and discussion

General trends and field observations

The two fields sampled collectively contained a relatively large proportion of all the ant and ground beetle species with a predatory feeding habit collected throughout the 3 year duration of this project (see table 2). Species totals for the Carabid beetles are also given in table 2 since species belonging to this family are likely to be the most aggressive ground beetle predators of cotton insect pests. Also of note, was that by the end of the 1995–96 cotton season a grand total of 149 beetle species had been collected in irrigated cotton fields using pitfall traps.

Table 2: Comparative species totals of soil fauna predators at Doreen and all sites.

Taxa	"Doreen" spp. total	Spp. grand total
Beetles	43	66
Carabids	23	30
Earwigs	2	2
Ants	4	6

The common earwig and ground beetle predators are nocturnal; generally show little indication of food preference; appear unaffected by regular applications of irrigation water; raise their offspring within the ground floor habitat; move very quickly on the soil surface when disturbed; and reside within surface cracks or crevices, under the canopy of broadleaf weeds (eg *Triblis terrestris* and *Rapistrum rugosum*), amongst decomposing residues that aggregate in the furrows, and in their own burrows during the daylight hours. A significant proportion of the important soil arthropod predators identified at "Doreen" and the other sites sampled during this study are therefore unlikely to have been seen in cotton fields by crop scouts and growers, and entomologists that use only daytime sampling techniques (eg suction sampling). Larval and adult growth stages with the capacity to burrow (eg *Lapidura riparia truncata* and *Geoscaptus laevissimus*) are the most common soil arthropod predators during stage I when the cotton hill surfaces are most exposed, dry, scarce of prey (springtails for example) and crop residues, and the furrows frequently cultivated.

In unsprayed fields, the soil arthropod predators likely to be most capable of contributing significant *Heliothis* spp. (egg, larval or pupal stages) mortality during at least one of the three crop stages (I, II, &/or III) were the earwig *Lapidura riparia truncata* (I and II); the Carabid beetles, *Calosoma schayeri* (III) and *Geoscaptus laevissimus* (I); the *Lycosa* spp. spiders (III), and the *Rhytidoponera metallica* (I) and *Iridomyrmex vicinus* (I) group ant species. *Calosoma schayeri* is a potentially important Carabid beetle for irrigated cotton because it is reported to be an aggressive predator of *Heliothis* spp. larvae. Ground floor spiders, a group not identified to genera or species level during this study, were observed to be particularly abundant in the unsprayed field plots of block 10. Despite pitfall trapping generally being regarded as an unsatisfactory method for monitoring ground spider biodiversity, the pitfall samples did show comparatively large spider catches for the unsprayed plots.

For sprayed fields, the greatest incidence of mortality (as indicated by their absence) was evident for Carabid beetle species with a body length greater than 1 cm (eg *Calosoma schayeri*, *Rhytisternus* sp., *Helluo insignis*, and *Geoscaptus laevissimus*); and those predator species with a very active night flying behaviour (Staphylinid beetles). Of the 11 Carabid beetles found in cotton fields with a body length greater than 10 mm, *Geoscaptus laevissimus* was the only species to be repeatedly caught in either of the sprayed field plots during stage II or III, and the potentially important species, *Calosoma schayeri*, was completely absent during all sampling periods of the same sprayed plots.

Seasonal changes in soil predator surface activity

In sprayed plots the insecticides (see table 1: five organochlorines, single pyrethroid–organochlorine and organophosphate sprays, and two pyrethroids and carbamates) applied during the evening hours of November–March clearly contributed to significant reductions in the biodiversity of beneficial soil arthropod predators. The seasonal mean abundance and species diversity of Carabid beetles remained low throughout stages II and III in the sprayed field of moderate cotton history (see Fig. 2). The locomotive activity of the Carabid beetles, spiders and predatory ant spp. for stage III were also substantially reduced by insecticides in the sprayed plot of block 10 (first season of cotton) (see fig. 2). The peaks in soil predator surface locomotive activity for each plot (most pronounced in the unsprayed, first season field) after their respective irrigations in mid–February is a phenomenon commonly observed in previous seasons. Adult and larval catches of *Calosoma schayeri* dominated the distinct Carabid beetle peak shown in fig. 2 for the unsprayed plot of block 10, and their combined mean abundance for stage III was greater than the entire seasonal abundance of the two most common Carabid species found in block 8 (sprayed, moderate cotton history). The larvae of *Calosoma schayeri* had also never been previously found in irrigated cotton anywhere in Australia.

The suppression of predatory ant and beetle spp., leading to significantly greater earwig abundances (compared to unsprayed new season plots) in stages I and II is perhaps indicative of a cumulative effect. The common brown earwig, *Lapidura riparia truncata* was consistently the most abundant species caught in stages I and II. This earwig species remains on the ground floor to feed during the night hours, and has been reported to have greater survival and colonisation in fields cropped for at least 10 years, and where their predators (carnivorous ants, Carabids and spiders) have been removed by insecticides (Gross and Spink 1969; and Price and Shepard 1977).

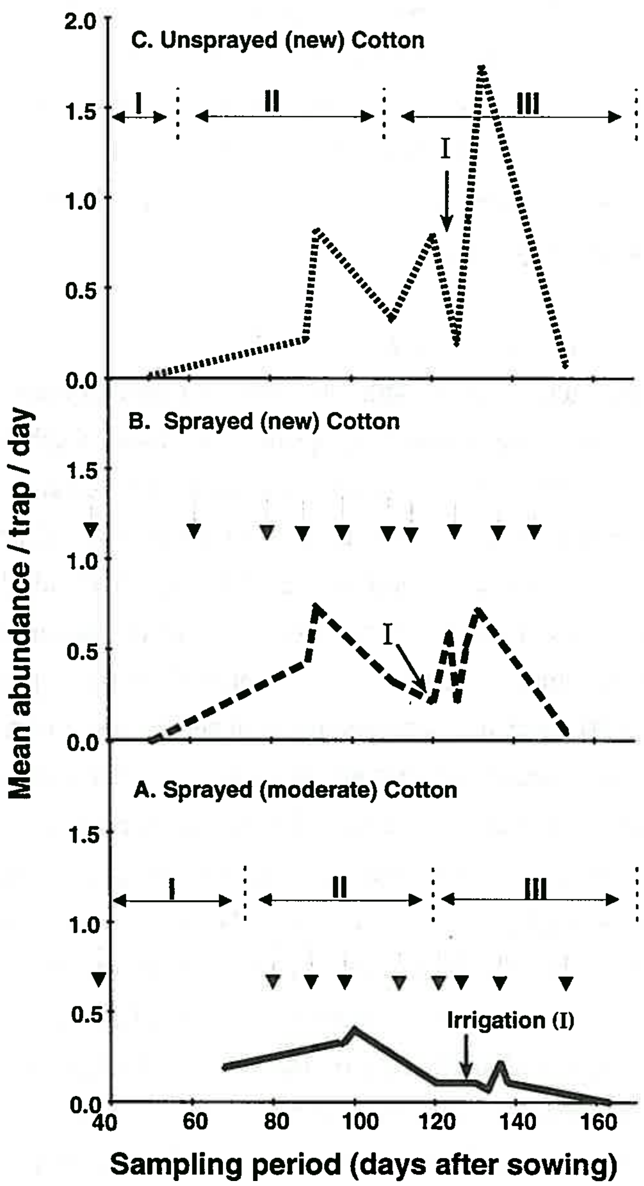

Fig. 2: 1995–96 seasonal abundance of Carabids in pitfall traps at "Doreen".

The predacious ant species, *Rhytidoponera metallica*, was present in all plots of the newly developed field (block 10) in significantly large abundances prior to the application of the first irrigation. Significant and prolonged waterlogging incurred in the northern most unsprayed replicate plot after the watering–up irrigation in late

October did however cause *Rhytidoponera metallica* to be completely absent from this area during the remainder of the growing season. The sensitivity of this species to waterlogging was also evident in the environfeast field at the ACRI where large abundances quickly disappeared from the cotton plots (did however remain relatively steady in lucerne plots) after heavy rains in late December and January were followed by a regular 14–day interval between irrigations. The 5 inches of rain that came in late January–early February reduced the locomotive activity of ant predator spp. to exceptionally low abundances for all plots at "Doreen" during early February. By mid–March, the unsprayed, first cotton season plot of block 10 was the only treatment to support ant predator catches similar to the relatively large abundances previously observed in stage I.

Factors influencing the mortality rates of beneficial soil arthropod predators caused by insecticides might include: the time of day, dosage rate, chemical toxicity and selectivity, and application method; the leaf shape of the cotton variety (okra leaf allows greater insecticide penetration to ground floor and more effective mortality); the crop canopy density and stature during stage II and III when most 'hard' synthetic insecticides are applied; and the proximity to, and/or protection of, a given field to the spraying regime of neighbouring cotton fields and/or farms. Likely secondary factors affecting the populations of beneficial soil arthropod predators include: drought seasons, quantity and availability of surface cover (past and current decomposing residues and weeds) during all three crop phenological stages, the application of early season systemic soil insecticides, and cotton field size and design.

Conclusions

Conventionally sprayed cotton production has a pronounced effect on beneficial soil arthropod predators, suppressing the ants and beetles, and resulting in significant increases in the relative abundance of earwigs. Early in the season when the ground floor is most exposed, decomposing residues and weeds located in the furrows were the principal refugia sites for soil arthropod predators. At this time of the growing season, Carabid beetle surface activity was very much restricted, leaving the control of insect pests at seedling emergence largely in the hands of the earwigs and for unsprayed, well drained fields, the predatory ant spp. The particularly large catches of larval and adult *Calosoma schayeri* in the unsprayed field plots of block 10 during stage III, whilst indicative of encouraging prospects for consumption of *Heliothis* spp. larvae, may only be capable of contributing genuine benefit in fields that remain unsprayed during the January–February period. Sampling protocols designed to monitor beneficial soil arthropod populations will need to incorporate both day and night sampling methods if they are to be truly representative. Soil arthropod predator–pest field studies investigating the consumption rates of *Heliothis* spp. (eggs, larvae, and pupae) are required in order to begin to utilise the predatory activity of soil fauna in sustainable IPM systems.

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