Use of Predator to Pest Ratio As Decision making tool in Integrated Pest Management (IPM) in Cotton.

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Introduction

Elsewhere in this proceedings I have stated that the cotton industry in Australia is undertaking a journey towards the adoption of a true IPM. The industry has come a long way from indiscriminate use of synthetic insecticides to realising the major role natural enemies of cotton pests particularly predatory insects play in cotton IPM.

Many beneficial insects such as predatory beetles, bugs, lacewings, spiders and parasitoids have been recorded in cotton crops in Australia. However, the potential value of these beneficial insects have not been fully exploited in cotton pest management. This is due to the lack of understanding of the efficacy of these beneficial insects, lack of techniques to maximise their abundance and effectiveness, and the continuous use of broad-spectrum insecticides on cotton crops against major pests.

Cotton fields across Australia are strictly monoculture and can affect the activities of beneficial insects. In such agro-ecosystems, pest populations increase, minor pests become major pests and non-pests become pests. This is because the food, hosts, prey, and hibernating or overwintering sites of the natural enemies are reduced thus affecting biological control (Mensah, 1997, 1999). Natural enemies of cotton pests usually have different food requirements in the larval and adult stages to develop and survive through the season. In contrast, adult pests particularly *Helicoverpa* spp. can normally lay their eggs without any feeding, relying only on food reserves transferred from their larval stage. *Helicvoverpa* spp. are highly migratory and can rapidly infest cotton crops and lay their eggs. Unless natural enemies are present and well established in high numbers before the pest arrive, they cannot respond rapidly enough to control these pests (Fitt, 1989; Mensah, 1997, 1999). This paper focuses only on predatory insects and how to incorporate them in pest management decisions.

Insect sampling for pest management decisions

Insect scouting or sampling enables the cotton grower or farmer to know the number of pests and beneficial insects on his crops at the time of sampling. Knowledge of pest and beneficial insect numbers allows the grower or consultant to make appropriate pest management decisions on a particular farm. The appropriate methods of sampling and the number of times per week one has to sample are given in the IPM guidelines (Entopak, Mensah and Wilson, 1999).

Within the cotton industry insects on cotton crops are sampled using D-vac (vacuum sampling), sweep net, beat cloth or visual counts. All these sampling techniques have their own limitations and none of them provide a 100% accuracy.

D-vac, sweep net and visual sampling provide the grower an information about the proportion of insects on the particular crop at that point in time (relative value of insects present). Beat cloth may provide an information closer to the total insects present on the crop (absolute value). Appropriate pest management decisions can be made using a proportion of insects (relative values) or total insects in the crop (absolute values). Sampling methods which gives information on the proportion of insects on the crop is as good as the ones giving information about the total insects on the crop.

All insect thresholds currently used in the cotton industry are based on visual or D-vac sampling methods which gives a proportion of insects on the crop. With the introduction of beat cloth technique which may give an information closer to total insect population in the crop, we need to have a conversion rate from beat cloth to visual, D-vac or sweep net. Failure to do this, may result to panic spraying by growers. For example if a visual or D-vac sampling gives a result of 0.4 mirids per metre and beat cloth 4 per metre, the question is should the grower control the pest or hold off. Decision based on visual counts or D-vac will recommend no action taken provided fruit retention is not lower than 50%. With high numbers using beat cloth, the grower will be tempted to control the pest. Additionally, high numbers of predators obtained using beat cloth will create a false impression of a high numbers of predators. There is therefore the need to develop a conversion rate for beat cloth to D-vac to avoid panic spraying against sucking pests.

One of the biggest limitation of beat cloth is that beat cloth cannot be used after irrigation or rain even if the foliage is dry. Should growers be introduced to beat bucket rather than beat cloth since growers should sample for beneficial insects anytime they visual check for Helicoverpa spp. Beat bucket can be undertaken when the ground is wet. A conversion factor for beat bucket or cloth should be developed before these sampling methods are introduced into the industry.

What is a predator to pest ratio?

The predator to pest ratio is a threshold which incorporates the activity of predators in pest management decisions. The decision to control *Helicoverpa* should be based on pest threshold and the ratio of predators to pests in the crop as indicated by your visual counts (see IPM guidelines).

How was the predator to pest (*Helicoverpa* spp.) ratio determined

This study was conducted in irrigated cotton fields at Norwood (29° 28'S, 149° 50'E) near Moree in New South Wales from 11 October 1993 to 14 April 1994 and at Bellevue (31° 48'S, 147° 59'E) near Warren in New south Wales from 18 November 1994 to 29 March 1995. The size of the cotton field at Norwood was 53 ha and at Bellevue 70 ha.

The fields used for this trial were treated with food sprays (Envirofeast®) and biological insecticides, Gemstar (NPV and foliar Bt), from October until the first week in January to avoid disruption to the activity of predatory insects. Thereafter fields were treated with synthetic insecticides when *Helicoverpa* spp. numbers exceeded 2 (1st-3rd stage) larvae per metre of row of cotton (recommended pest threshold) (Deutscher and Wilson,1999). Foliar application of Envirofeast® was commenced when the cotton crop was at the 4-true leaf stage and thereafter at 14 day intervals until the completion of the experiments.

Visual counts of *Helicoverpa* spp. eggs, larvae and predatory insects were made on cotton plants in 10 randomly selected one metre lengths of row i.e. 10 metres per field. Data for *Helicoverpa* spp. were expressed as numbers of eggs (E), very small plus small larvae (VS+S) and medium plus large larvae (M+L) per metre as in experiment 2.1. The survival rates of *Helicoverpa* spp eggs to very small and small larvae and medium and large larvae per metre were calculated from the field data using the method of Richards (1940) and Watmough (1968a). The predatory insects were separated into predatory beetles, bugs, lacewings and spiders. In calculating the predator to pest ratio, all the predators were grouped as one unit (total predators). The predator to pest ratio per metre was calculated for each sample date by dividing the total number of the predators per metre by the number of *Helicoverpa* spp. eggs plus very small and small larvae per metre (i.e Total predators ÷ *Helicoverpa* spp. (E + VS+S). Numbers of medium and large larvae were not included in the calculation as at that stage they were too big for the predators to effectively capture as food (Mensah and Singleton, 1998).

A comparison was made between the predator to pest ratio and *Helicoverpa* spp. larval survival rate by plotting the predator to pest ratio per metre per sample date at a minimum with larval survival rate. This enabled the determination of the minimum ratio at which *Helicoverpa* spp. larvae can survive to reach, exceed or remain under the threshold of 2 larvae per metre in the study sites. *Helicoverpa* spp. larval survival rates were calculated from field data using the method of Richard (1940) and Watmough (1968a). The method considers that the number of each instar found in a series of samples corresponds with the time spent in that instar, any deviation from this representing the magnitude of mortality and or survival in that instar (see Mensah, 2002).

Results

Determination of predator to pest ratio required to manage *Helicoverpa* spp. in cotton crops

A predator to pest ratio of 0.5 or higher reduced the survival rate of *Helicoverpa* spp. larvae (Figure 1). A ratio lower than 0.5 resulted in higher survival of the larvae to exceed the pest threshold particularly at Norwood study site (Figures 1).

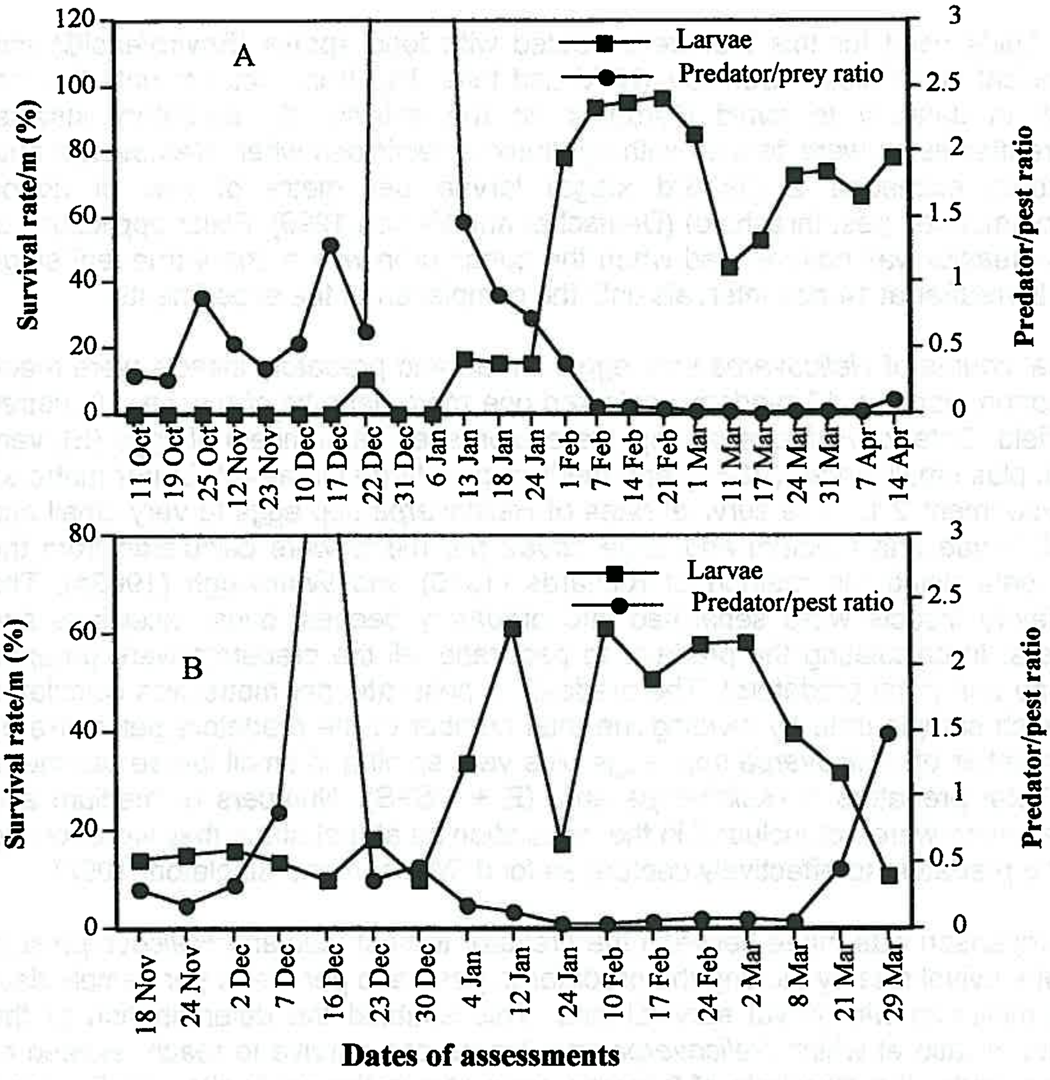

Figure 1. Comparisons of predator to pests (*Helicoverpa* spp.) ratio to the survival rates of *Helicoverpa* spp. larvae in commercial cotton farms at (A) Norwood, 1993-94 and (B) Bellevue, 1994-95 seasons.
Source: Mensah (2002). International Journal of Pest Management 48, 85-94).

At Norwood, a high predator to pest ratio of 0.5 and higher was recorded from 10 December 1993 until 24 January 1994 and this maintained egg and larval numbers below the threshold (Figure 1A). The predator to pest ratio fell from 0.5 to 0.40 on 1 February 1994 and crashed on the 7 February 1994 (Figures 1A). This resulted in a drastic increase in the survival rate and densities of *Helicoverpa* spp. eggs and larvae to a peak of 12.0 per metre requiring an insecticide treatment on 21 February 1995 to clean it up (Figure 1A). It was observed that the reduction of predator numbers and their subsequent crash coincided with the application of synthetic pyrethroid spray against *Helicoverpa* spp. from neighbouring growers.

At Bellevue, the increase in *Helicoverpa* spp. survival rate commenced on 4 January when the predator to pest ratio fell below 0.5 (Figure 1B) indicating that control of *Helicoverpa* spp. should commence when the predator to pest ratio falls below 0.5. The predator to pest ratio crashed at Bellevue on the 24 January 1995 and did not recover until 21 March 1995 (Figure 1B). The recovery of the predator to pest ratio at Bellevue to 0.5 or higher from 21 March 1995, resulted in the subsequent reduction in the populations of *Helicoverpa* spp. to as low as 0.35 per metre on the 29 March 1995.

Table 1. Predators of cotton pests identified from study plots from 1992 - 1998.

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.	

Calculation of the predator to pest ratio:

The predator to pest ratio is calculated as; predators per metre divided by Helicoverpa eggs + larvae (very small (VS) + small (S)) = 0.5 or higher. Total predators per metre should be used in the calculation of the predator to pest ratio. This is because a concerted action of total predators bring a pest population down not individual predator species. However, to be confident in the ratio, ***at least 3 insects of the most common predators (see table 1) within the families Coccinellidae, Melyridae, Hemerobiidae and Pentatomidae should be present in your checks.***

Decision making protocol - conventional cotton

The accepted predator to pest threshold is 0.5 or higher (see IPM guidelines, CottonLogic, EntoPak)

- When the ratio is 0.5 or higher and *Helicoverpa* numbers are below threshold it means the IPM system is functioning well.
- When the ratio falls below 0.5 but is higher than 0.4 and *Helicoverpa* numbers are below threshold and the population is mostly eggs, a predator food attractant should be applied to attract predators into the crop to feed on the eggs.
- If the predator ratio falls below 0.5 but it is higher than 0.4, and *Helicoverpa* numbers are below threshold and the population is predominantly larvae (rather than eggs) then a sugar or yeast- based food sprays or UV-protected petroleum spray oil mixed with biopesticides should be applied to restore the predator to pest ratio to 0.5 or higher.
- If *Helicoverpa* larvae levels are above threshold in your next check following the food spray/biopesticide or UV-protected petroleum oil/biopesticide mixture sprays and the predator to pest ratio is 0.4 or lower use one of the soft option insecticides to correct the insect pressure situation and then return to predatory insect management strategies. (see IPM guidelines for more details and also Decision making protocol for transgenic cotton).

Discussion

Pest management programs usually have decision support tools on which decisions to control pests are based. Most pest control decisions are made on the basis of the pest numbers rather than the ratio of natural enemies to the pests. With the increasing adoption of IPM worldwide, the use of both pests and natural enemies, especially predator to pest ratios, as threshold in pest management program is becoming increasingly important. The question as to how many predators to pests are required to maintain pests such as *Helicoverpa* spp. below thresholds is frequently being asked. Thus knowledge of predator to pest ratio is crucial to enable the activities of predators to be incorporated into decision making protocols in pest management programs.

This study indicated that the most acceptable predator to pest ratio is 0.5 or higher per sample date. A ratio lower than 0.5 could result in a higher survival of *Helicoverpa* spp. larvae to exceed the recommended pest threshold of 2 larvae per metre in Australian cotton (CottonLogic, 1999). Calculation of the predator to pest ratio was based on visual counts of the total predators per metre divided by *Helicoverpa* spp. eggs and early stage larvae. The calculation of the ratio excluded *Helicoverpa* spp. medium and large larvae since at this stage in the life cycle of the pest they were too large for the predators to capture as food (Mensah and Singleton, 1998). The predator population need to include a mixture of predators (beetles, bugs, lacewings etc) and not be dominated by one type of predator (eg spiders). ***At least 3 insects of the most common predators (see table 1) within the families Coccinellidae, Melyridae, Hemerobiidae and Pentatomidae should be present in your checks.***

The application of supplementary food on commercial cotton crops can mediate changes in the predator to pest ratio by aggregating predatory insects to the area (Mensah *et al.*, 2000), arrestment of predatory insects in the area following contact and subsequent feeding on the food attractant (Mensah and Harris, 1995), increased consumption rate by predators (Mensah and Singleton, 1998), and decreased oviposition activity of *Helicoverpa* spp. due to the physical presence of the food attractant (Mensah, 1996; Mensah *et al.*, 2000). Any or all of the above changes can either affect the total number of predators and or pests or both to alter the ratio of predators to pests in favour of predators. It is therefore important that IPM practitioners using the predator to pest ratio as a decision support tool sample their cotton fields regularly to determine any changes in the predator to pest densities so that appropriate measures can be undertaken to maximise the abundance and effectiveness of the predatory insects to manage the pests.

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