

Yellow traps can be used to monitor populations of *Coccinella transversalis* (Fabricius) and *Adalia bipunctata* (Linnaeus) (Coleoptera: Coccinellidae) in cotton crops

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**ABSTRACT:** Squares (30 x 30 cm) sticky traps of various colours were used on a commercial cotton farm to trap adults of *Coccinella transversalis* and *Adalia bipunctata* which are both major predators of *Helicoverpa* spp. during 1992 to 1994. Both insects were attracted most to yellow traps which also reflected the most visible light between 500 nm and 600 nm (where green foliage reflects most light). When yellow was diluted with white to produce yellow-white hues, the light reflected between 500 nm and 600 nm was reduced and the numbers of *C. transversalis* and *A. bipunctata* adults caught on these traps was also significantly reduced. This suggests that *C. transversalis* and *A. bipunctata* adults can discriminate foliage-hues (500 to 580 nm) from non foliage-hues (<500 nm and > 580 nm) and are attracted to colours that suggest the foliage of host plants that may harbour their prey. Yellow sticky traps placed 25 to 50 cm above ground caught significantly more *C. transversalis* and *A. bipunctata* adults than those placed at 75 to 150 cm and are the most appropriate traps to monitor populations of *C. transversalis* and *A. bipunctata* adults in cotton farms.

### Introduction

*Coccinella transversalis* (Fabricius) and *Adalia bipunctata* (Linnaeus) (Coccinellidae) are major predators of *Helicoverpa* spp. (Noctuidae) in cotton in Australia (Room and Wardhaugh, 1979) (Mensah and Harris unpublished data). Both adults and larvae of the coccinellids feed on the eggs and early stage larvae of the noctuids and if high densities of *C. transversalis* and *A. bipunctata*, are established especially early in the cotton season, *Helicoverpa* spp. can be controlled in cotton farms (Mensah & Harris unpublished data). However, *Helicoverpa* spp. are highly migratory and can rapidly infest crops from other sources, so, unless predatory insects are present and well established in high numbers in the

cotton crops early in the season before *Helicoverpa* spp. arrive, they cannot respond rapidly enough to control *Helicoverpa* spp. Currently, cotton growers rely solely on visual observation to determine the presence of *C. transversalis*, *A. bipunctata* and other predatory insects in cotton, especially early in the cotton season. Therefore, there is a need to develop a quick and effective trapping technique to monitor populations and to help to evaluate the disruptive impact of insecticides on beneficial insects. Developing such a technique requires a better understanding of the role of colour stimuli in the detection of food or host plants that harbour the prey of these coccinellid species. The role of colour stimuli in host detection is becoming more widely recognised (Prokopy and Owens, 1983) and coloured traps have been used to monitor populations of many flying insects, especially phytophagous insects in field crops (Kennedy *et al.* 1961; Ridgway and Mahr, 1986; Adams and Los, 1989; Economopolous, 1989; Mensah and Madden, 1992). However, studies of the responses of entomophagous insects (*viz.* predators and parasitoids) to different colours are rarer (Weseloh, 1981; Disney *et al.*, 1982; Kirk, 1984) and no studies have been made of *C. transversalis* and *A. bipunctata*.

The questions to be asked in such a study are:

- (1) do *C. transversalis* and *A. bipunctata* adults respond to yellow colour like many other phytophagous insects;
- (2) if they do, can yellow sticky traps be used to monitor their population in cotton farms;
- (3) what is the optimum height above ground level to place these coloured traps and
- (4) can these two coccinellid species discriminate foliage hues from non-foliage hues?

To answer these questions, I tested traps with different colours and shades placed at different heights above ground level in commercial cotton farms.

### Materials and methods

**Responses of *C. transversalis* and *A. bipunctata* to yellow and other enamel colours.** The colour response studies of *C. transversalis* and *A. bipunctata* adults were conducted in a cotton farm at Auscott near Narrabri using field trapping techniques similar to those described by Prokopy (1972). The traps consisted of aluminium squares (30 x 30 cm) painted on both sides with the test colour, coated with a thin layer of adhesive glue (Bird Tangletrap®, The Tangletrap Company, Grand Rapids, Michigan, USA), and attached to a vertical steel rod in the ground at 50 cms above the ground.

The reflectance characteristics of the colours were measured with a Field Spec™.UV/VNIR

## Results

**Responses *C. transversalis* and *A. bipunctata* to yellow and other enamel colours.** Yellow traps caught significantly more *C. transversalis* and *A. bipunctata* adults than any other trap (Table 1). Green and orange traps were the next most effective and true blue, deep blue, red, magenta and black traps were the least effective (Table 1). There was a significant and positive correlation between the amount of light reflected by each colour between 500nm and 600 nm region and the capture rates of *C. transversalis* ( $r^2 = 0.93$ ;  $P < 0.001$ ) and *A. bipunctata* ( $r^2 = 0.94$ ;  $P < 0.001$ ) (Table 1).

**Responses of *C. transversalis* and *A. bipunctata* to different hues of yellow.** Significantly more *C. transversalis* and *A. bipunctata* adults were caught on the full yellow (Y) and 3Y:1W traps than on any of the other hues tested (Fig. 1). The white traps were the least effective. On the yellow traps the most *C. transversalis* adults were caught in November and the most *A. bipunctata* in February. As the same population trends were seen when both species were sampled visually, colour preference was not affected by season.

The maximum reflectances of the yellow and the white and the intermediate shades occurred between 500 nm and 600 nm. The light reflected between 500nm and 600 nm by yellow, white and the three intermediate colours tested was positively correlated with the mean daily trap catches of *C. transversalis* ( $r^2=0.68$ ,  $P < 0.001$ ) and *A. bipunctata* ( $r^2=0.84$ ,  $P < 0.001$ ) (Fig. 3).

**Determination of optimum trap height for maximum capture of *C. transversalis* and *A. bipunctata* adults.** The optimum height to place a yellow coloured trap in the field to maximise *C. transversalis* and *A. bipunctata* adult catches was 25 cm or 50 cm above ground (Table 2). At these heights significantly higher numbers ( $P < 0.05$ ) of *C. transversalis* and *A. bipunctata* adults were captured than at 75-150 cm (Table 2). Fewest insects were caught at 150 cm above ground.

## Discussion

*C. transversalis* and *A. bipunctata* adults are more responsive to yellow traps than to any of the other colours tested. When full yellow was diluted, the amount of visible light reflected between 500 nm and 600 nm dropped, and presumably, caused the reduction in the number of

*C. transversalis* and *A. bipunctata* adults captured thus indicating the degree to which these insects respond to light reflected in the 500-600 nm region.

This positive response of both *C. transversalis* and *A. bipunctata* adults to yellow suggests that these insects can discriminate foliage hues (500-580 nm) from other hues (<500 nm and > 580 nm) and would therefore be attracted to the colours of the foliage of host plants that harbour their prey. Leaves, reflect little visible energy below 500 nm and much between 500-600 nm, the yellow range. In northern New South Wales, Australia, where short-lived annual crops, including cotton, are grown seasonally, the habitat provided by these crops for phytophagous insects which are preyed upon by *C. transversalis* and *A. bipunctata* will be ephemeral. Such differences in host permanence means that the coccinellids fly periodically to new host locations when their prey's host plant are harvested and so they may use colour stimuli frequently in flights to distinguish foliage that harbours food and thereby ensure their survival.

Many phytophagous insects respond positively to yellow (Wilde 1962; Kring, 1967; Prokopy and Boller 1971, Greany *et al.*, 1977; Ferro and Sychak, 1980; Coombe, 1981; Adams *et al.*, 1983) and yellow coloured traps have been used to monitor their populations (Meyerdirk and Oldfield, 1985; Adams and Los, 1989; Mensah and Madden 1992). Entomophagous insects that are not particularly associated with foliage such as predators and parasitoids would be expected to show the positive response to yellow if this enabled them to locate the leaf-feeding insects on which they prey. The present study has indicated that *C. transversalis* and *A. bipunctata* adults respond to yellow in this way. This could suggest that traps for prey will catch beneficial insects as well and make it possible to monitor populations of both prey and predator using one trap. However, in studies using yellow traps to monitor populations of a specific phytophagous insect where one wishes to avoid the capture of *C. transversalis* and *A. bipunctata* adults, the traps should be located at a height higher than 50 cm above ground.

In conclusion, yellow coloured traps placed between 25 to 50 cm above ground in cotton farms could be used to monitor populations of *C. transversalis* and *A. bipunctata*.

**Table 1.** Response of *Coccinella transversalis* and *Adalia bipunctata* adults to yellow colours and reflected light emitted between 500-600 nm region on traps in a cotton crop at Auscott, Narrabri 1992-1993.

Colour enamels	Mean catch per trap per day <sup>1</sup>		Per cent total reflected light emitted in the 500-600 nm region
	<i>C. transversalis</i>	<i>A. bipunctata</i>	
Yellow	0.35 a	0.23 a	26.8
Orange	0.17 b	0.08 b	13.9
Green	0.23 b	0.11 b	17.1
Red	0.09 c	0.03 c	11.8
Deep blue	0.10 c	0.02 c	7.0
Magenta	0.08 c	0.02 c	5.2
True blue	0.11 c	0.03 c	8.7
Black	0.06 c	0.02 c	7.7

<sup>1</sup> Means based on counts of 19 dates between November 1992 and May 1993; Three replications of each colour per sampling date.

Means between treatments within rows followed by the same letter are not significantly different ( $P > 0.05$ ) using the least significant difference test (LSD).

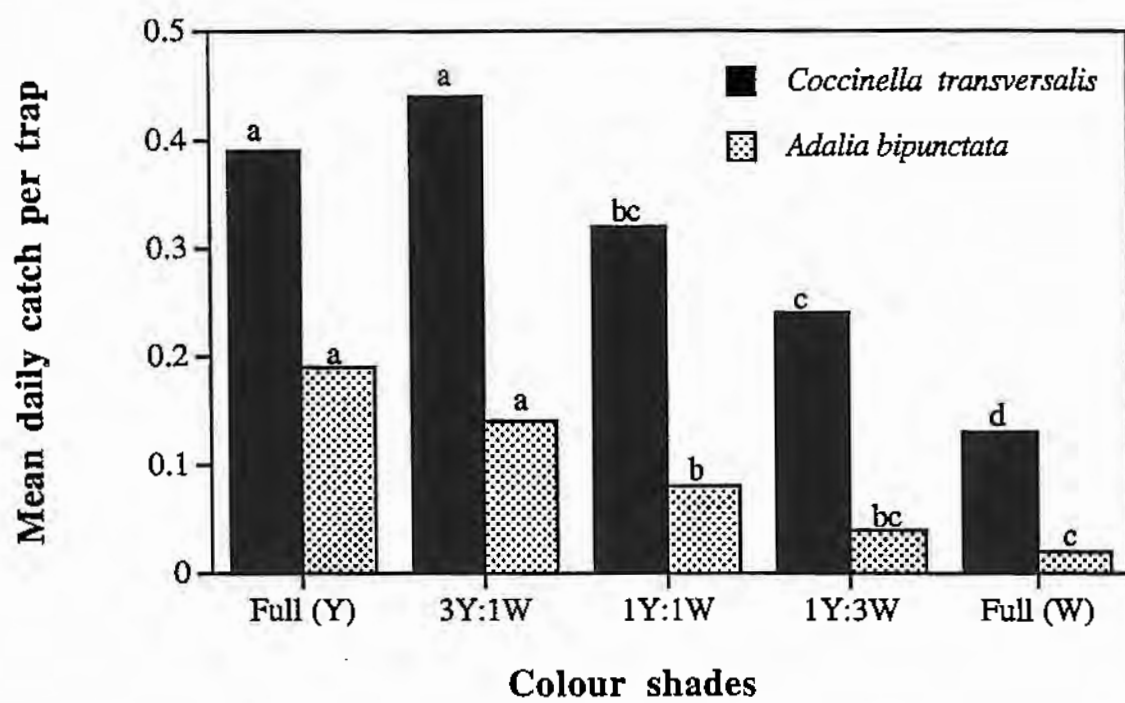
**Table 2.** Yellow trap captures of *Coccinella transversalis* and *Adalia bipunctata* adults at different heights between 25-150 cm above ground level in a cotton crop at Auscott in Narrabri, 1992 - 1993.

Trap height (cm)	Mean catch per trap per day <sup>1</sup>	
	<i>C. transversalis</i>	<i>A. bipunctata</i>
25	4.64 a	2.37 a
50	3.08 ab	1.79 b
75	2.74 bc	0.92 c
100	1.22 c	0.55 cd
125	0.82 c	0.32 d
150	0.53 c	0.13 d

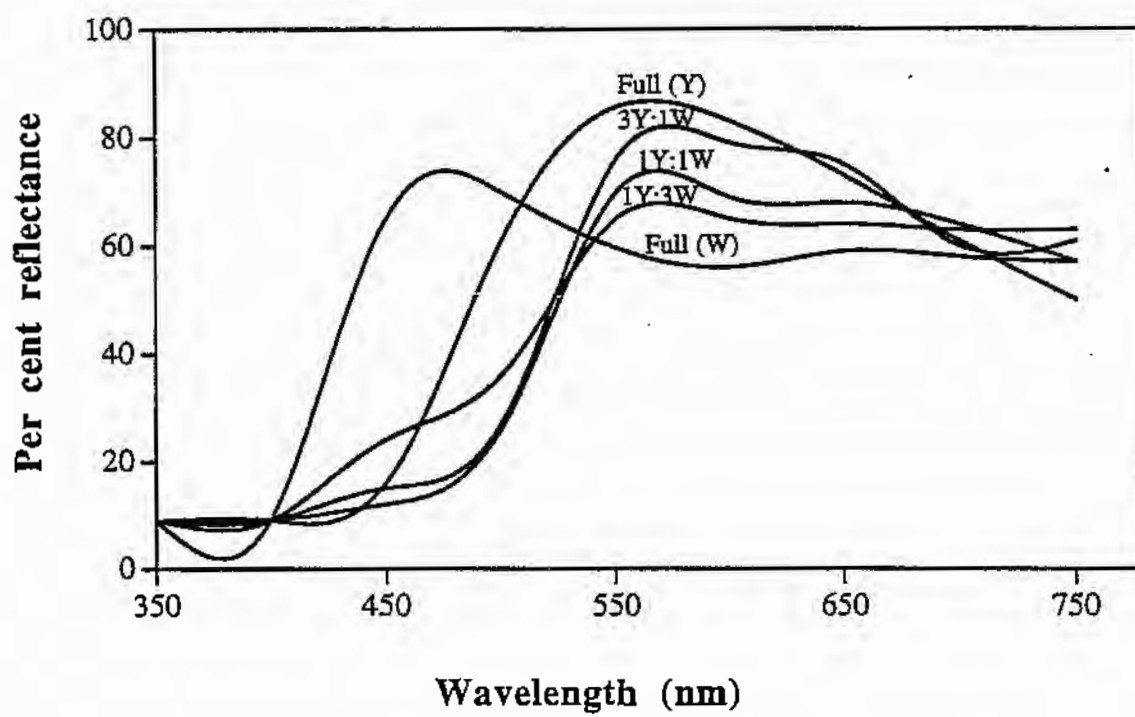
<sup>1</sup> Means based on counts of 19 dates between November 1992 and May 1993; Three replications of each colour per sampling date.

Means between treatments within rows followed by the same letter are not significantly different ( $P > 0.05$ ) using the least significant difference test (LSD).

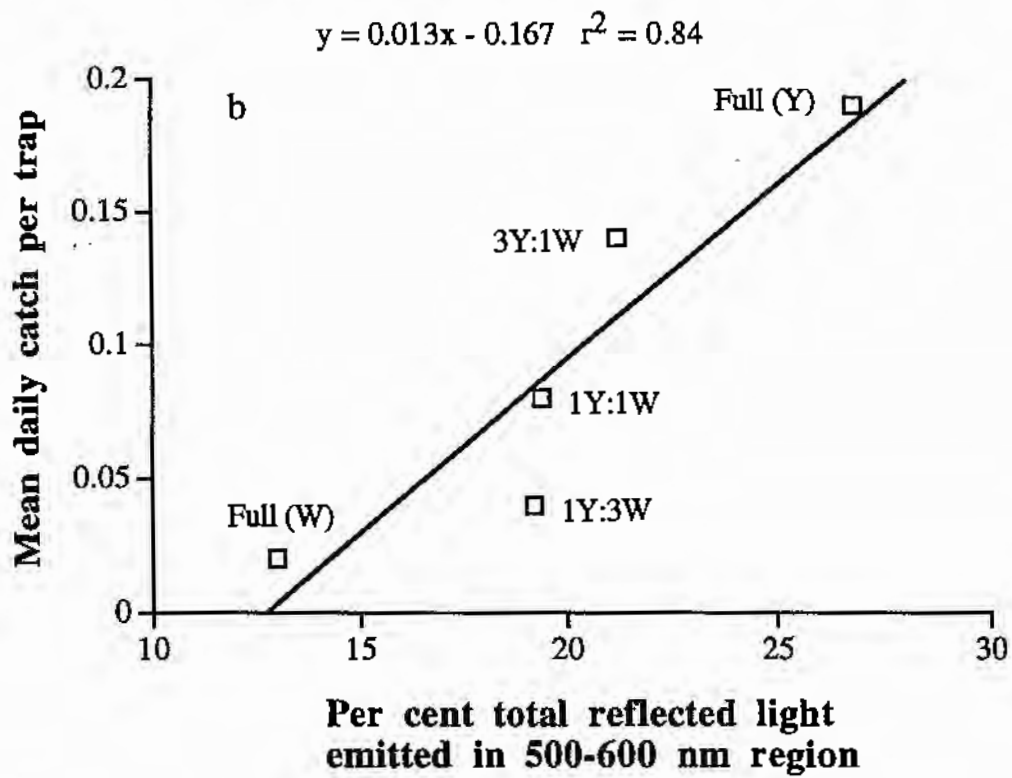
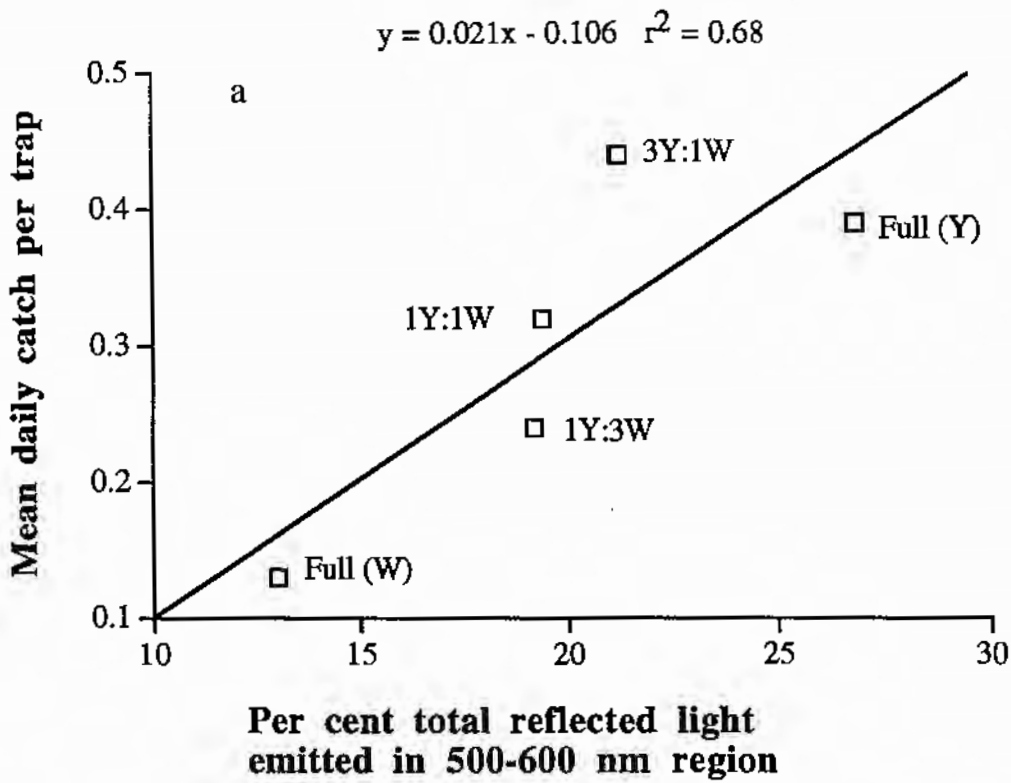
**Fig. 1.** Captures of *Coccinella transversalis* and *Adalia bipunctata* adults on different hues of yellow coloured traps in commercial cotton at Auscott in Narrabri from November 1993 until April 1994. (Means between treatments for each coccinellid species followed by the same letter are not significantly different ( $P>0.05$ ) using the least significant difference (LSD) test).



**Fig. 2.** Reflectance spectra of yellow and white colour enamels and shades. Y = yellow; W = white and Y:W = various mixtures of yellow and white colour enamels.



**Fig. 3.** Relationship between the per cent total reflected light emitted in the 500-600 nm region by each of the test colours and the mean daily trap catch of *Coccinella transversalis* (a) and *Adalia bipunctata* (b) in commercial cotton at Auscott in Narrabri from November 1993 until April 1994.



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### References

- ADAMS, R. G., DOOMEISEN, C. H. and FORD, L. G. (1983). Visual trap for monitoring pear psylla adults on pears. *Environ. Entomol.* 12: 1327-1331.
- ADAMS, R. G. and LOS, L. M. (1989). Use of sticky traps and limb jarring to aid in pest management decisions for summer populations of the pear psylla (Homoptera : Psyllidae) in Connecticut. *J. Econ. Entomol.* 82: 1448-1554.
- COOMBE, P. E. (1981). Wavelength specific behaviour of the whitefly, *Trialeurodes vaporariorum* (Homoptera : Aleurodidae). *J. Comp. Physiol.* 144: 83-90.
- DISNEY, R. H. L., ERZINCLIOGLU, Y. Z., HENSHAW, D. J. C., HOWSE, D., UNWIN, D. M. WITHERS, P. and WOODS, A. (1982). Collecting methods and the adequacy and attempted fauna surveys, with reference to the Diptera. *Field Studies* 5: 607-621.
- ECONOMOPOULOS, A. P. (1989). Use of traps based on colour and or shape. *In* Robinson, A. S. and Hooper, G. (eds.) *World Crop Pests, Fruit Flies, their biology, natural enemies and control* 3B: 315-328. Elsevier Sci. Publs. B. V.: Amsterdam.
- FERRO, D. N. and SYCHAK, G. J. (1980). Assessment of visual traps for monitoring the asparagus miner, *Ophiomyia simplex*. *Entomol. exp. appl.* 28: 177-182.
- GREANY, P. D., AGEE, H. R., BURDITT, A. K. and CHAMBERS, D. L. (1977). Field studies on colour preferences of Caribbean fruit fly, *Anastrepha suspensa* (Diptera : Tephritidae). *Entomol. exp. appl.* 21: 63-70.
- KENNEDY, J. S., BOOTH, C. O. and KERSHAW, W. J. S. (1961). Host finding of aphids

- in the field. III. Visual attraction. *Ann. Appl. Biol.* 49: 1-21.
- KIRK, W. D. J., (1984). Ecologically selective coloured traps. *Ecol. Entomol.* 9: 35-41.
- KRING, J. B., (1967). Alighting aphids on coloured cards in a flight chamber. *J. Econ. Entomol.* 60, 1207-1210.
- MENSAH, R. K. and MADDEN, J. L. (1992). Field studies on colour preferences of *Ctenarytaina thysanura* in Tasmanian boronia farms. *Entomol. exp. appl.* 64: 111-115.
- MEYERDIRK, D. E. and OLDFIELD, G. N. (1985). Evaluation of trap colour and height placement for monitoring *Circulifer tenellus* (Homoptera : Cicadellidae). *Can. Entomol.* 117: 505-511.
- PROKOPY, R. J. (1972). Response of apple maggot flies to rectangles of different colours and shades. *Environ. Entomol.* 1: 720-726.
- PROKOPY, R. J. and BOLLER, E. F. (1971). Response of european cherry fruit flies to coloured rectangles. *J. econ. Ent.* 64: 1444-1447.
- PROKOPY, R. J. and OWENS, E. D. (1983). Visual detection of plants by herbivorous insects. *Ann. Rev. Entomol.* 28: 337-364.
- RIDGWAY, N. R. and MAHR, D. L. (1986). Monitoring adult flight of *Pholetesor ornigis* (Hymenoptera : Braconidae), a parasitoid of the spotted leafminer (Lepidoptera : Gracillariidae). *Environ. Entomol.* 15: 331-334.
- ROOM, P. M. and WARDHAUGH, K. G. (1979). Seasonal occurrence of insects other than *Helicoverpa* spp. feeding on cotton in the Namoi Valley of New South Wales. *J. Aust. Ent. Soc.* 16: 165-174.
- WESELOH, R. M. (1981). Relationship between coloured sticky panel catches and reproductive behaviour of forest tachinid parasitoids. *Environ. Entomol.* 10: 131-135.
- WILDE, W. H. A., 1962. Bionomics of the pear psylla, *Psylla pyricola* in pear orchards of Kootenay Valley of British Columbia. *Can. Entomol.* 94: 845-849.