PYRETHROID RESISTANCE IN PUPAL AND ADULT *HELIOTHIS ARMIGERA*

Joanne C. Daly[1], Gary P. Fitt.[2] and Jennifer H. Fisk[1]

CSIRO Division of Entomology
[1] Canberra, ACT and [2]Narrabri, NSW

The frequency of resistance to synthetic pyrethroids in *Heliothis armigera* has been monitored in the Namoi Valley since the introduction of the insecticide resistance management strategy in 1983. During this time the frequency has varied cyclically. Although the magnitude of the changes varies from year to year, the same pattern is evident each cropping season: the frequency increases in stage 2 (the six week period during which pyrethroids are used), continues to increase in stage 3 (autumn) and then falls by stage 1 (spring and early summer) of the following cropping season (Forrester and Cahill 1987).

We have undertaken a series of experiments to determine the important factors involved in this cyclical variation. Although most of this work has focused on larvae this paper considers some factors which are important in adults and pupae.

DIAPAUSING PUPAE

For about six months of the year (May-October) *Heliothis armigera* are present in the Namoi Valley as diapausing pupae. One possible explanation for the decline in the frequency of resistance between autumn and the following spring is that resistant pupae are less able to survive this period than are susceptible ones. We tested this hypothesis of selective mortality last winter. Details of the other aspects of the study are given elsewhere in these proceedings (Fitt and Daly 1988).

Pupae were collected on seven different occasions from a single site (Yarral block 19) near the Myall Vale Research Station from early July until mid-November. Emergence cages placed over the pupal beds indicated that the moths emerged from late October through November. The collected pupae were transferred to the Canberra laboratory where diapause was broken by placing the pupae at 27°C and 14 h day-length. During November and December eight samples of H. armigera larvae were collected throughout the Narrabri/Wee Waa region from wheat (3 samples), weeds growing in cotton stubble of Yarral 19 (1), maize (2), twiggy mullein, Verbascum virgatum (1) and evening primrose, Oenothera stricta (1). The larvae were placed on artificial diet and reared to adults.

To determine the frequency of resistance in these collections, adults were placed into a scintillation vial coated with 0.009 ug of fenvalerate. This dose was known to kill 99% of susceptible

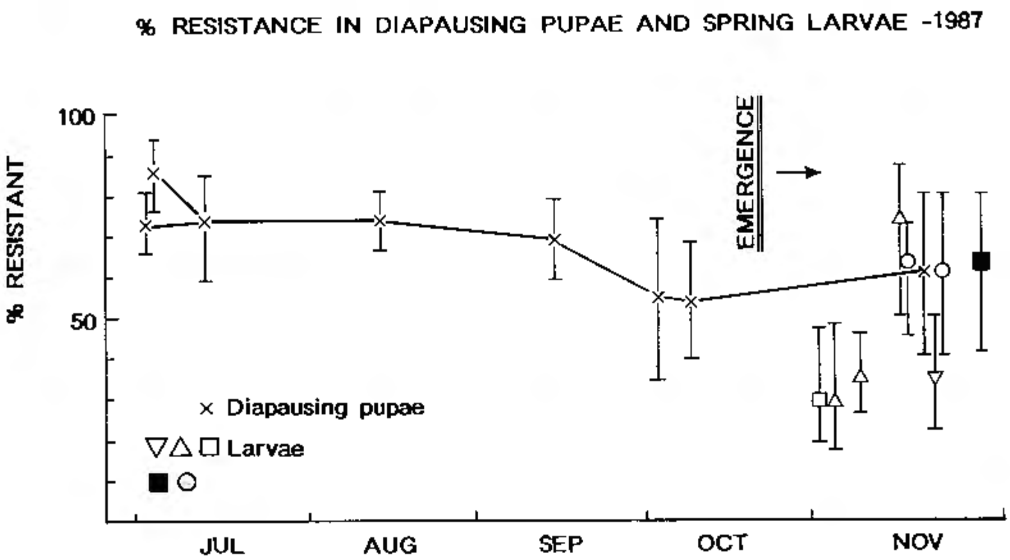

Figure 1. The frequency of resistant adults (95% C.I.) reared from diapausing pupae and from larvae present in spring.

adults but < 5% of resistant moths (both heterozygotes and homozygotes). A record was kept of pupae which failed to emerge or which were parasitised.

During September, there was a small but non-significant drop in the frequency of resistant adults reared from overwintering pupae, from 69% to 55% (Figure 1). The drop may have resulted from selective mortality of resistant versus susceptible insects because associated with the drop was an increase in the proportion of pupae that failed to emerge, 1%-12% (Table 1).

Table 1. The frequency of resistance in Yarral 19 samples and the proportion of pupae that did not emerge in 1987.

Collection Date	Number Collected	Proportion Resistant	Proportion Unemerged
7.7	145	0.74	0.08
7.7	63	0.87	0.05
16.7	56	0.74	0.04
7.8	155	0.75	0.01
15.9	103	0.69	0.12
2.10	27	0.55	0.22
9.10	54	0.54	0.23
19.11	21	0.62	0.00

In spring 1987, the frequency of resistant adults reared from larvae collected from various host plants fell into two groups (Figure 1). Two samples from wheat (△), one from weeds in the cotton stubble (□), and one from twiggy mullein (▽) all had a frequency of resistance between 30-35%. This frequency is below that found in local pupae diapausing under cotton stubble (54-87%) but is of similar magnitude to that observed by N.W. Forrester in larval infestations in cotton crops during stage 1 of 1987/88, 19% (the adult vial test leads to an estimate of resistance about 10% higher than that from the larval resistance test.)

The third sample from wheat, the two maize samples (○) and the sample from evening primrose (■) were grouped between 63-74%, a frequency similar to that in the local populations of over-wintering pupae.

We conclude from these results that the spring decline in the frequency of resistance cannot be fully explained by the selective mortality of resistant pupae over winter. Dilution of local resistant populations by immigration of individuals from more susceptible populations in spring appears to be the most likely cause of the fall in resistance between autumn and spring.

ADULTS

Adults are directly exposed to insecticide sprays at the time of application and also by contact with residues on leaf surfaces. We undertook some experiments in the Namoi Valley during January 1988 to determine if resistant adults could survive direct exposure to pyrethroids moreso than susceptible ones.

The fore- and hindwing on one side of each adult were removed to prevent the adults from flying. Adults were placed onto a platform, at crop height, the evening before a commercial application of a pyrethroid. A control group of adults was placed outside the spray area. The following morning all adults were returned to the laboratory and the proportion surviving for two days was recorded. Two groups of adults were used. The first consisted of four laboratory strains (one susceptible and three resistant strains) and the second group was of adults collected in the Namoi Valley from pheromone traps (males only) and light traps (both sexes). The proportion of resistant and susceptible moths which survived exposure is given in Table 2. The results have been adjusted for control mortality.

Table 2. Adults exposed to pyrethroid sprays in commercial cotton farms.

Strain	% Survival	Number Tested
Susceptible	23	57
Resistant-1	75	16
-2	65	90
-3	57	84
Pheromone traps	42	55
Light Traps	44	21

It is clear that laboratory resistant strains and field caught adults have a higher survival compared with the laboratory susceptible strain. These data suggest that selection for resistance can also occur in the field in adults.

Forrester and Cahill (1987) have observed an increase in the frequency of resistance in stage 2, when pyrethroids are used. Because they collected eggs from fields which had not been recently sprayed, this increase could not have been the result of larval selection. Our results show that the increase can be explained, in part, by adults ovipositing in unsprayed fields after selection by pyrethroids in nearby fields.

CONCLUSIONS

We have demonstrated that selection against overwintering resistant pupae is not able to account for the large decline in pyrethroid resistance that usually occurs in larval populations of H. armigera between autumn and spring each year. Immigration of moths more susceptible to pyrethroids is likely to be the main cause of this decline. However, destruction of local overwintering pupae by cultivation could be important in some years in which immigration is low as a result of unfavourable weather. In this case, the spring population would be recruited predominantly from local moths, a high proportion of which are resistant.

The rise in resistance during the period in which pyrethroids are being used is also a result of selection for resistance in adults. In this way selection occurs in two successive generations of H. armigera.

REFERENCES

Fitt, G.P. and J.C. Daly. 1988. The Overwintering Foe. Australian Cotton Growers Research Assocation Meeting, Surfers Paradise, August 1988.

Forrester, N.W. and M. Cahill. 1987. Management of insecticide resistance in Heliothis armigera (Hübner) in Australia. pp 127-137. In M. Ford, B.P.S. Khambah, D.W. Holloway and R.M. Sawicki [eds]. Combating resistance in xenobiotics: biological and chemical approaches. Ellis Horwood, Chichester.