PYRETHROID RESISTANCE IN *HELIOTHIS ARMIGER*

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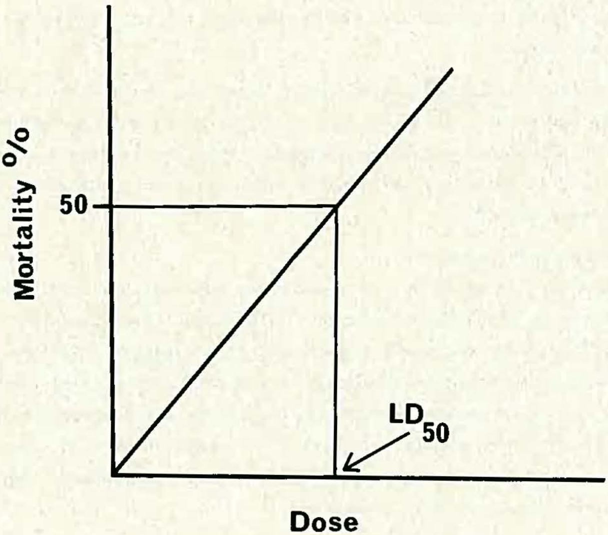
The cotton bollworm, *Heliothis armiger* is a very important cotton pest in Australia. It has a long history of insecticide resistance in Australia, to DDT in the early 1970's and to the pyrethroids in 1983.

In 1976, entomologists from the New South Wales Department of Agriculture at Tamworth began a nation wide resistance monitoring program for *H.armiger*. Each year *Heliothis*, collected mainly from New South Wales and Queensland cotton sites, are sent to the Tamworth Agricultural Research Centre for testing. The progeny from the moths in each sample are reared in the laboratory on an artificial diet and are tested with insecticides when they reach 30-40 mg weight. Varying concentrations of insecticides, dissolved in solvents, are tested against *Heliothis* by putting a 1 ul drop on each caterpillar back and count the number dead after 48 or 72 hours. Mortality is plotted against concentration and we calculate the LD_{50} (the concentration required to kill 50% of the test group) and the slope of the line (a measure of the variation of response to the insecticide). We test all insecticides which are used against *H.armiger* and those with potential for use.



Since 1976 the Tamworth laboratory has accumulated much baseline toxicity information for a range of insecticides. We have been monitoring the effectinvess of the pyrethroids since their first registrations in 1977 and our results are shown in Table 1 along with 1983 resistant Emerald values. The differences between them are quite startling! Thus the benefits of having a regular resistance monitoring program were that when resistance did appear we were able to recognise it immediately.

Testing of the pyrethroid resistant H.armiger showed that they were resistant to all pyrethroids and that the most resistant caterpillars took 50-100 times more pyrethroid to be killed than did susceptibles. We did not find that there was any marked increase in kill by mixing pyrethroids with other insecticides or synergists. Resistance monitoring of over 200 Heliothis strains from eastern Australia in the last 18 months has shown resistance is spread from Mareeba in Northern Queensland to the summer cropping zones of New South Wales. Despite the 1983/84 pyrethroid management strategy there does not appear to have been a serious decrease in the frequency of pyrethroid resistance either in Queensland or New South wales. At Emerald, the pyrethroid resistance gene is alive and well, despite a season of non-pyrethroid use.

At Tamworth, we have investigated the inheritance of pyrethroid resistance in H.armiger and we have found that one major incompletely dominant gene seems to be responsible. This means that the progeny of resistant susceptible crosses are also resistant, but not as much as the pure resistant parent.

Pyrethroids are nerve poisons and by examining the effects of them on Heliothis nerves we have identified the major resistance mechanism. The nerves of pyrethroid resistant H.armiger larvae are insensitive to the chemical, this mechanism is known in other pyrethroid resistant insects as the "knockdown factor".

Status of Other Insecticides

At Tamworth, in the last two seasons, we have particularly monitored the performance of endosulfan, methomyl, thiodicarb, chlordimeform, sulprofos and profenofos against resistant and susceptible H.armiger. We have two aims; firstly to accumulate baseline toxicity data, about these chmicals and secondly to check whether pyrethroid resistance has conferred cross resistance to any other chemials. (Pyrethroid resistance could cause resistance to other insecticides that had never been used against Heliothis if there was an identical mode of action).

The organophosphates (sulprofos and profenfos) and some carbamates (e.g. Larvin) work well against resistant H.armiger. Methomyl is slightly less effective against resistants compared to susceptibles but the practical significance is not clear. DDT and endosulfan are much less toxic to resistant Heliothis than susceptibles, it seems that pyrethroid resistance has caused cross resistance to them.

From a practical point of view, there is a distinct danger that the pyrethroids and endosulfan will become unusable against Heliothis armiger if these insecticides are abused. For other insecticides a similar danger exists because high levels of use will inevitably mean that these chemicals will produce their own resistance problems.

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TABLE 1

Log-dose probit mortality data obtained by topical application of insecticides to Australian strains of *Heliothis armiger* larvae.

Insecticide	Location	Date	No. tested	Slope ± S.E.	LD_{50} ug/larva	Fiducial Limits 95%
permethrin	Moore Creek, NSW	1977	150	3.4 ± 0.2	0.05	(0.04 - 0.06)
	Narrabri, NSW	1978	150	3.2 ± 0.2	0.04	(0.03 - 0.05)
	Wee Waa, NSW	1978	150	3.0 ± 0.2	0.04	(0.03 - 0.05)
	Wee Waa, NSW	1979	150	4.0 ± 0.4	0.04	(0.03 - 0.05)
	Emerald, Qld	1979	150	2.6 ± 0.2	0.03	(0.03 - 0.04)
	Emerald, Qld	1983	150	4.3 ± 0.2	0.29	(0.24 - 0.35)
fenvalerate	Moore Creek, NSW	1977	150	2.5 ± 0.2	0.07	(0.06 - 0.08)
	Tamworth, NSW	1979	150	3.0 ± 0.3	0.03	(0.02 - 0.04)
	Wee Waa, NSW	1979	150	5.4 ± 0.6	0.04	(0.03 - 0.05)
	St. George, Qld.	1979	150	2.6 ± 0.2	0.05	(0.04 - 0.06)
	Cecil Plains, Qld.	1979	150	3.9 ± 0.2	0.03	(0.02 - 0.04)
	Emerald, Qld.	1979	150	2.1 ± 0.2	0.06	(0.05 - 0.08)
	Wee Waa, NSW	1980	150	2.5 ± 0.2	0.04	(0.03 - 0.05)
	Ord River, W.A.	1981	150	2.4 ± 0.3	0.02	(0.01 - 0.03)
	St. George, Qld.	1981	150	2.7 ± 0.4	0.03	(0.02 - 0.04)
	Cecil Plains, Qld.	1981	150	3.1 ± 0.4	0.02	(0.01 - 0.03)
	Ord River, W.A.	1982	150	3.3 ± 0.3	0.04	(0.03 - 0.05)
	Narrabri, NSW	1982	150	2.8 ± 0.3	0.04	(0.03 - 0.05)
	Cecil Plains, Qld.	1982	150	3.0 ± 0.5	0.03	(0.02 - 0.04)
	Emerald, Qld.	1982	150	2.8 ± 0.4	0.04	(0.03 - 0.05)
	Narrabri, NSW	1983	150	3.7 ± 0.2	0.02	(0.01 - 0.03)
	Ord River, W.A	1983	150	2.8 ± 0.3	0.02	(0.01 - 0.03)
	Cecil Plains, Qld.	1983	150	2.7 ± 0.2	0.03	(0.02 - 0.04)
	Biloela, Qld.	1983	150	2.5 ± 0.2	0.03	(0.02 - 0.04)
	Bowen, Qld.	1983	150	3.6 ± 0.2	0.04	(0.03 - 0.05)
	Emerald, Qld.	1983	150		0.23	
	Emerald, Qld. DD Selected	1983	150	1.5 ± 0.2	0.56	(0.44 - 0.72)
	2 x DD Selected	1983	150	1.6 ± 0.1	1.5	(1.2 - 2.0)

TABLE 1 cont.

Insecticide	Location	Date	No. tested	Slope ± S.E.	LD_{50} ug/larva	Fiducial Limits 95%
cypermethrin	Ord River, WA.	1982	150	3.8 ± 0.03	0.03	(0.02 - 0.04)
	Cecil Plains, Qld.	1982	150	2.3 ± 0.4	0.08	(0.06 - 0.12)
	Narrabri, NSW	1983	150	3.8 ± 0.3	0.03	(0.02 - 0.04)
	Bellingen, NSW	1983	150	4.3 ± 0.3	0.03	(0.02 - 0.04)
	Cecil Plains, Qld.	1983	150	2.5 ± 0.2	0.04	(0.03 - 0.05)
	Biloela, Qld.	1983	150	2.4 ± 0.2	0.03	(0.02 - 0.04)
	Emerald, Qld.	1983	150		0.16	
	Emerald, Qld. DD Selected	1983	150	2.7 ± 0.2	0.47	(0.37 - 0.58)
deltamethrin	Ord River W.A	1981	150	3.2 ± 0.2	0.006	(0.005 - 0.008)
	Cecil Plains, Qld.	1981	150	3.9 ± 0.3	0.011	(0.010 - 0.012)
	Ord River, W.A	1982	150	2.6 ± 0.4	0.012	(0.009 - 0.016)
	Grafton, NSW	1982	150	2.4 ± 0.3	0.012	(0.009 - 0.016)
	Bellingen, NSW	1982	150	2.6 ± 0.2	0.005	(0.004 - 0.006)
	Narrabri, NSW	1983	150	2.0 ± 0.2	0.006	(0.004 - 0.008)
	Bellingen, NSW	1983	150	2.6 ± 0.2	0.010	(0.008 - 0.013)
	Cecil Plains, Qld.	1983	150	2.6 ± 0.3	0.019	(0.014 - 0.025)
	Biloela, Qld.	1983	150	1.8 ± 0.2	0.008	(0.005 - 0.011)
	Emerald, Qld.	1983	150		0.057	
	Emerald, Qld. DD Selcted	1983	150	3.1 ± 0.3	0.18	(0.14 - 0.20)