EFFECTS OF DIAZINON, FENSULFOTHION AND ISAZOPHOS ON PREDATORY INVERTEBRATES IN PASTURE

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SUMMARY

The relative toxicity of fensulfothion, isazophos and diazinon to predatory invertebrates from pasture was determined by topical application, soil bioassays and field trials. Predatory wireworms, staphylinids and carabids were susceptible to varying degrees to all three chemicals. Isazophos showed consistently high toxicity to all predatory groups in the laboratory and the field. Carabids (*Rhytisternus miser*) were relatively tolerant of fensulfothion. Diazinon was generally less toxic to most predators in two field experiments. LD₅₀ values varied with different populations of pasture wireworm (*Conoderus exsul*), and with different soil types in bioassays. Pasture wireworm was as susceptible as grass grub (*Costelytra zealandica*) to these three insecticides which are used to control grass grub. Spider numbers were lowered by field applications of insecticides, but ant numbers were not significantly affected.

INTRODUCTION

Pesticides are seldom specific in their action, and beneficial organisms as well as target pests can be affected. Recent work has shown that predatory insects are important in the control of at least one pasture pest, the Australian soldier fly (*Inopus rubriceps*) (Doane *et al* 1985; Robertson *et al* 1981; Robertson 1986). The application of insecticides to pasture for the control of pests such as grass grub (*Costelytra zealandica*) can lead to increased densities of other pests, such as soldier fly, which are tolerant to the chemical. Increased densities of soldier fly have been recorded after application of DDT, lindane and fensulfothion, broad spectrum insecticides which kill predatory insects as well as pasture pests (Robertson *et al* 1981; Robertson 1986). Suttman and Barrett (1979) showed that one application of a broad spectrum, but transient insecticide to pasture resulted in long-term depression of certain predator numbers.

The present paper describes work aimed at determining the toxicity to predatory invertebrates of three organophosphate insecticides currently registered for use against grass grub larvae in pasture. Except for soldier fly, there has been little effort to determine the effects of predatory invertebrates on pasture pests but if the general usefulness of such predators can be demonstrated, conservation of natural enemies should be one criterion in the selection of insecticides against pasture pests.

METHODS AND RESULTS

Topical Application of Insecticides

Insects known to be predators of pasture pests (Doane *et al* 1985; Robertson *et al* 1981) were collected from the field between June and September 1985. Each species was treated within seven days of collection with one or more of three chemicals; fensulfothion (76.5% technical material), diazinon (Dyzol 80 EC) and isazophos (Miral 50 EC) dissolved in acetone. The number of predators collected dictated the number of treatments applied, but eight to ten insects were used at each of four or five rates for each chemical. One 0.4 microlitre droplet was applied to each insect, including controls using acetone only, with an Arnold Burkhardt microapplicator. The methods employed were similar to those described by Miln *et al* (1985) and Wrenn *et al* (1985).

After treatment, each insect was left for 48 h on damp vermiculite. Insects unable to re-bury in the substrate in a subsequent 4 h period were then considered dead. Laboratory temperature was 17 ± 3 °C.

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TABLE 1: Predator species topically tested for susceptibility to insecticides used on pasture, with calculated LD₅₀ values (μ g ai/insect and 95% confidence intervals).

Predator (collection site)	Mean weight (mg)	Insecticide		
		fensulfothion	isazophos	diazinon
Elateridae (larvae)				
<i>Conoderus exsul</i> (Rukuhia)	22	0.03 (0.01-0.13)	0.03 (0.0-0.11)	0.49 (0.19-1.74)
<i>Conoderus exsul</i> (Rukuhia)	NA	0.06 (0.03-0.12)		
<i>Conoderus exsul</i> (Glenbrook)	26	0.69 (0.33-1.41)		
Staphylinidae (adults)				
<i>Thyreoscephalus orthodoxus</i> (Rukuhia)	33	2.0 (0.1-10.0)		
Carabidae (adults)				
<i>Rhytisternus miser</i> (Ngaruawahia)	32	0.64 (0.14-2.45)	0.32 (0.11-0.90)	0.11 (not calc.)
<i>Prosopogmus oodiformis</i> (Tokanui)	20	0.02 (0.0-0.15)		
Grass grub larvae				
Authority:				
Wrenn <i>et al</i> 1985 and unpublished	100	0.09	0.2-0.5	0.1-1.0
Miln <i>et al</i> 1985		0.05-0.12		

Note: NA = not available. Carabid and staphylinid control mortality was zero; wireworm mortality averaged 7.8%. No correction factors have been incorporated in analyses.

The species used in each test are presented in Table 1, with the LD₅₀ values calculated by logit analyses on log_e transformed data.

Soil Bioassays

Fensulfothion (Dasanit 5G), isazophos (Miral 10G) and diazinon (Dyzol 20G) were applied at 5 rates (0.25, 0.5, 1.0, 2.0 and 4.0 kg ai/ha) to 2 m x 2 m pasture plots at two sites by hand shaker. Ten 10 cm diameter soil cores, 2 cm deep, were removed at various intervals after each treatment (Table 2), the foliage discarded and the soil diced and crumbled before placing in 350 ml plastic pots. One test insect was placed in each pot, which was then covered with a clear plastic lid, on the same day the soil was removed from the field. After two weeks, the insect was recovered and placed on the soil surface. Those which could not re-bury themselves in 4 h were recorded as dead. Experiments were conducted between July and September 1985. At least eight insects were used at each treatment rate.

The species of predator tested are given in Table 2 with the EC₅₀ values (median effective concentration) calculated by logit analyses on log_e transformed results. The fitted dose response curves for pasture wireworm and *R. miser* are shown in Figure 1.

Similar methods have been used to bioassay insecticides by Henzell *et al* (1981) and Wrenn *et al* (1985).

Field applications

Two experiments were conducted to determine the mortality of invertebrate predators when insecticides were applied to pasture. Both trials were at Rukuhia, the first on a Bruntwood-Te Kowhai silt loam (5 December 1985) and the second on a

TABLE 2: The calculated EC_{50} values (kg ai/ha and 95% confidence intervals) for predator species bioassayed in soil treated with granular insecticides, with soil type and intervals between treatment and initiation of tests.

Predator (soil type)	Test interval (days)	Insecticide		
		fensulfothion	isazophos	diazinon
Elateridae (larvae)				
<i>Conoderus exsul</i>	7	1.2 (0.8-1.7)	0.3 (0.1-0.4)	1.1 (0.7-1.7)
(Peria silt loam)	13	1.5 (1.0-2.3)	0.2 (not calc.)	1.6(0.9-2.6)
<i>Conoderus exsul</i>	14	5.1* (2.4-200)	1.0 (0.7-1.4)	
(Patamahoe clay loam)				
Carabidae				
<i>Rhytisternus miser</i>	1	5.9* (2.7-?)	0.4 (0.2-0.6)	1.3(1.0-1.8)
(Peria silt loam)	17	4.0* (not calc.)	1.5 (1.1-2.1)	1.1(0.8-1.6)

*beyond test range (0.25-4.0 kg ai/ha)

Fig. 1: Fitted dose response curves for A, pasture wireworm, and B, *R. miser*, approximately two weeks after treatment of soil with insecticide (see Table 2).

Horotiu sandy loam (24 March 1986). The area surrounding the plots was hard-grazed, and the interplot buffer strips were mowed to encourage predatory insects to seek the shelter in the ungrazed plots. Immediately after grazing and before insecticide treatment, each plot was encircled with black polythene barriers, the bottom edge of which was buried to a depth of 10 cm, with the top edge standing 40 cm above soil level. Fensulfothion (5G) isazophos (10G) and diazinon (20G) were each applied at 2.0 kg ai/ha to 7 m x 7 m plots in complete randomised block experiment with four replicates of each treatment including untreated controls. Buffer strips 2 m wide separated each plot.

Three pitfall traps filled with Gault's solution were operated in each plot for 12 days following treatment. The polythene barriers were removed after five days, and one, 7 m by 0.45 m, strip was mowed across each plot. Six people searched the soil surface along this strip for 5 min. on each plot, and recorded the numbers of live and dead insects. Mowing may have removed some insects, but all plots received the same treatment. Thirty soil cores (10 cm diameter) were removed from each plot in Trial 1, 18 days after treatment, and Trial 2, 30 days after treatment and hand-sorted for predatory invertebrates.

TABLE 3: Numbers of live predatory invertebrates recovered from two insecticide field trials (sampling methods and replicates pooled within treatments; see text for details), and density of *C. exsul* and *T. orthodoxus* from soil sampling.

Predator	Trial No.	Treatment			
		untreated control	fensulfothion	isazophos	diazinon
<i>C. exsul</i>	1	8	2	3	7
	2	111	78	57	93
<i>T. orthodoxus</i>	1	19	1	0	8
	2	21	1	1	1
Other Staphylinidae	1	12	5	2	7
	2	3	1	2	0
Carabidae	1	1	1	0	3
	2	1	0	0	0
<i>Lamycetes</i> sp. (Centipede)	1	1	0	0	0
	2	11	0	2	2
Spiders	1	226	124	52	103
	2	43	23	17	23
Ants	1	49	16	12	34
	2	110	73	128	96
Density from soil sampling: mean no./m ² (± s.e.)					
<i>C. exsul</i>	1	8 (3)	3 (2)	3 (3)	6 (3)
	2	115 (18)	81 (10)	59 (7)	96 (23)
<i>T. orthodoxus</i>	1	10 (1)	1 (1)	0	4 (3)
	2	5 (3)	0	0	1 (1)

The numbers of predatory invertebrates recovered from each treatment in the two field trials are presented in Table 3. Analysis of variance on log (x + 1) numbers in soil samples indicated fewer predatory Coleoptera in insecticide-treated plots (Trial 1, $P < 0.025$; Trial 2, $P < 0.05$). Insecticide also depressed spider numbers in pitfall traps (Trial 1, $P < 0.001$; Trial 2, $P < 0.01$) but ants were not significantly affected (Table 3).

DISCUSSION

Topical testing, soil bioassays and field applications all indicated that the three insecticides tested are toxic to predatory invertebrates in pasture. Isazophos was apparently the most toxic to the widest range of predators, as it consistently showed high mortality rates. Diazinon generally was less toxic than fensulfothion or isazophos in the field trials (Table 3). In the soil bioassay fensulfothion was not as toxic to the carabid *R. miser* as the other two chemicals (Table 2). Too few carabids were present in the field trials to determine the effects on this predatory group in the field.

All three chemicals gave LD₅₀ values for predatory wireworms in the same order as those reported for the usual target pest, grass grub (Table 1). This predator species is known to be a beneficial insect because of its role in suppressing soldier fly populations (Doane *et al* 1985; Robertson *et al* 1981). The reasons for the higher LD₅₀ values for wireworms collected from Glenbrook compared to Rukuhia (Table 1) are unknown. Similarly, the lower level of control (higher EC₅₀) on Patamahoe soil compared to Peria soil cannot be explained by the data available (Table 2 and Fig. 1). However, an insecticide trial at Glenbrook on Patamahoe soil had no effect on wireworm numbers (Wrenn and Robertson unpublished).

Widescale and frequent use of these chemicals would be disruptive to predatory invertebrates, and would increase the risk of outbreaks of secondary pests such as soldier fly. Diazinon may be preferable to the other two insecticides if grass grub outbreaks require suppression in areas with soldier fly, as this chemical was less harmful

to predators. Diazinon is cheaper than fensulfothion and isazophos, but it generally gives lower levels of grass grub control (East *et al* 1981).

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REFERENCES

- Doane, J.F., Scotti, P.D. Sutherland, O.R.W. and Pottinger, R.P., 1985. Serological identification of wireworm and staphylinid predators of the Australian soldier fly (*Inopus rubriceps*) and wireworm feeding on plant and animal food. *Ent. exp. appl.* 38: 65-72.
- East, R., Henzell, R.F. and Lauren, D.R., 1981. Grass grub: biology and control. *Proc. Ruakura Farmers' Conf.* 33: 65-70.
- Henzell, R.F., Lauren, D.R., du Toit, G.D.G. and Wrenn, N.R., 1981. Do soil applied insecticides control grass grub beetles? *Proc. 34th N.Z. Weed and Pest Control Conf.*: 234-8.
- Miln, A.J., Byett, A. and Thomson, N.A., 1985. Differences in susceptibility of grass grub in Taranaki to organophosphate insecticides. *Proc. 38th N.Z. Weed and Pest Control Conf.*: 27-30.
- Robertson, L.N., 1986. Experimental studies of predation on grassland populations of Australian soldier fly, *Inopus rubriceps* (Macquart) (Diptera: Stratiomyidae). *N.Z. J. Zool.* 13: (in press).
- Robertson, L.N., Firth, A.C. and Davison, R.H., 1981. Predation on Australian soldier fly, *Inopus rubriceps* (Diptera: Stratiomyidae), in pasture. *N.Z. Zool.* 8: 431-9.
- Suttman, C.E. and Barrett, G.W., 1979. Effects of Sevin on arthropods in an agricultural and an old-field plant community. *Ecology* 60: 628-41.
- Wrenn, N.R., McGhie, R.A. and Pottinger, R.P., 1985. Evaluation of terbufos for grass grub control. *Proc. 35th N.Z. Weed and Pest Control Conf.*: 23-6.