SOME OBSERVATIONS ON THE EFFECTS OF FIELD APPLICATIONS OF FENSULFOTHION AND PARATHION ON BIRD AND MAMMAL POPULATIONS

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SUMMARY: The application of fensulfothion and parathion for the control of invertebrate pasture pests in Canterbury during March, April and May 1970 killed many birds and mammals. Two hundred and thirty-six dead birds were found after a single application of fensulfothion to 123.4 ha, and 158 birds were recovered from 78.5 ha of pasture treated with parathion. The main species killed were white-backed magpie *(Gymnorhina tibicen)*, black-backed gull (*Larus dominicanus*) and harrier hawk (*Circus approximans*). Field trials of fensulfothion on 72.8 ha of pasture at Rotorua reduced the bird population using the treated areas by 86 percent within two days of treatment. Most deaths probably occurred through secondary poisoning, although the possibility of primary poisoning through contact or the ingestion of the insecticide granules cannot be discounted.

INTRODUCTION

In 1970, the large scale use of chlorinated hydrocarbons for the control of invertebrate pasture pests was banned in New Zealand, and the use of organophosphates for this purpose has since increased. In the two decades in which DDT has been used it has been rare for large scale mortality of birds and mammals to occur immediately after application. The exceptions have been documented by Benton (1951), Hickey and Hunt (1960) and Hunt (1960). In contrast the current extensive use of the organophosphates fensulfothion* and parathion** on pasture lands has in many areas resulted in severe losses of birds and mammals soon after the application (Bucknell 1970, 1971, and unpublished reports on Wildlife Service files). One investigation showed that over 1,100 birds died after 121.4 ha were treated (Bucknell 1971).

To evaluate the effects of fensulfothion and parathion on wildlife, simple questionnaires were sent to Canterbury farmers who had used the chemicals on their pastures between March and May 1970. In January 1971 more detailed information was obtained from a large-scale fensulfothion field trial initiated by the Agricultural Chemicals Board in the Waikite Valley, Rotorua.

* fensulfothion: diethyl 4-(methylsulphinyl) phenyl phosphorothionate.

* parathion: diethyl 4-nitrophenyl phosphorothionate.

Fensulfothion and parathion are applied on granule carriers, 0.3 to 0.75 mm in diameter, which are dyed green to reduce their attractiveness to birds (Caithness and Williams 1971). The active ingredient of fensulfothion constitutes five percent of the weight of the granule while parathion makes up 10 percent by weight. For control of grass grub *(Costelytra zealandica)* and porina *(Wiseana* sp.) the recommended application of parathion to pasture is 2.8-3.4 kg of active ingredient/ha (2.5-3.0 lb/acre). Fensulfothion is applied at the rate of 1.1 kg active ingredient/ha (1 lb/acre) for porina control and 2.2 kg/ha (2 lb/acre) for grass grub.

Both insecticides are highly toxic but have a comparatively short residual life. Technical data supplied by the Bayer Company listed the oral toxicity (LD_{50}—lethal dose to 50 percent of the population) of fensulfothion for white rates and domestic hens as 1.9-10.5 mg/kg and 2.5-5.0 mg/kg of body weight respectively, and the dermal toxicity of white rats as 3.5-30.0 mg/kg in 14 days with the active ingredient not removed. Data from the Monsanto Company gave the LD_{50} values of one percent aqueous suspension of parathion and ground granule administered orally to rats as 38-49 mg/kg. Hayes (1963) lists the oral LD_{50} toxity to male white rats of parathion emulsions as 13 mg/kg, and for mallard ducks (*Anas platyrhynchos*) the values were found by Keith and Mulla (1966) to be about 1-2 mg/kg of body weight. Both insecticides are extremely soluble; fensulfothion requires 25 mm of rain for good penetration into the soil but five millimetres will wash the insecticide off the carrier (Mr C. K. Proude pers. comm.).

In toxicological studies of parathion on laboratory animals symptoms of poisoning appeared within six hours and were most marked within 12 hours with death or recovery occurring within 24 hours of the symptoms appearing (Golz and Shaffer 1960). Keith and Mulla (1966) found that mallards killed by parathion usually died within three hours of ingestion. Death is apparently caused by respiratory failure (McFarland and Lacy 1968).

METHODS

1. *Canterbury Farm Survey*

The addresses of 21 farms where fensulfothion and parathion had been used was obtained from chemical applicator contractors and the Ministry of Agriculture and Fisheries. In general, the contractors were reluctant to give the addresses of farms where the chemcials were used. One contractor refused to give any details because of the large mortality of wildlife after applying fensulfothion. Of the 20 contractors contacted by letter only 12 replied despite repeated requests; six stated that they used one or both of the chemicals. Questionnaires were sent to the farmers within four weeks of the insecticides being applied. Returns were received from 15 (71%) of the farmers; seven had fensulfothion applied to their pastures, seven used parathion and one farmer replied that he had used both chemicals.

The farmers were asked the area and the date of treatment, the application rate and the number and species of birds and mammals found dead on or adjacent to the treated area. The farms surveyed were distributed throughout the province (Fig. 1). On all farms the insecticides were spread from vehicles by mechanical spreaders.

2. *Rotorua Fensulfothion Field Trial*

On 28 January 1971, 202.3 ha of farmland in Rotorua were treated with a single aerial application of fensulfothion at the rate of 2.2 kg of active

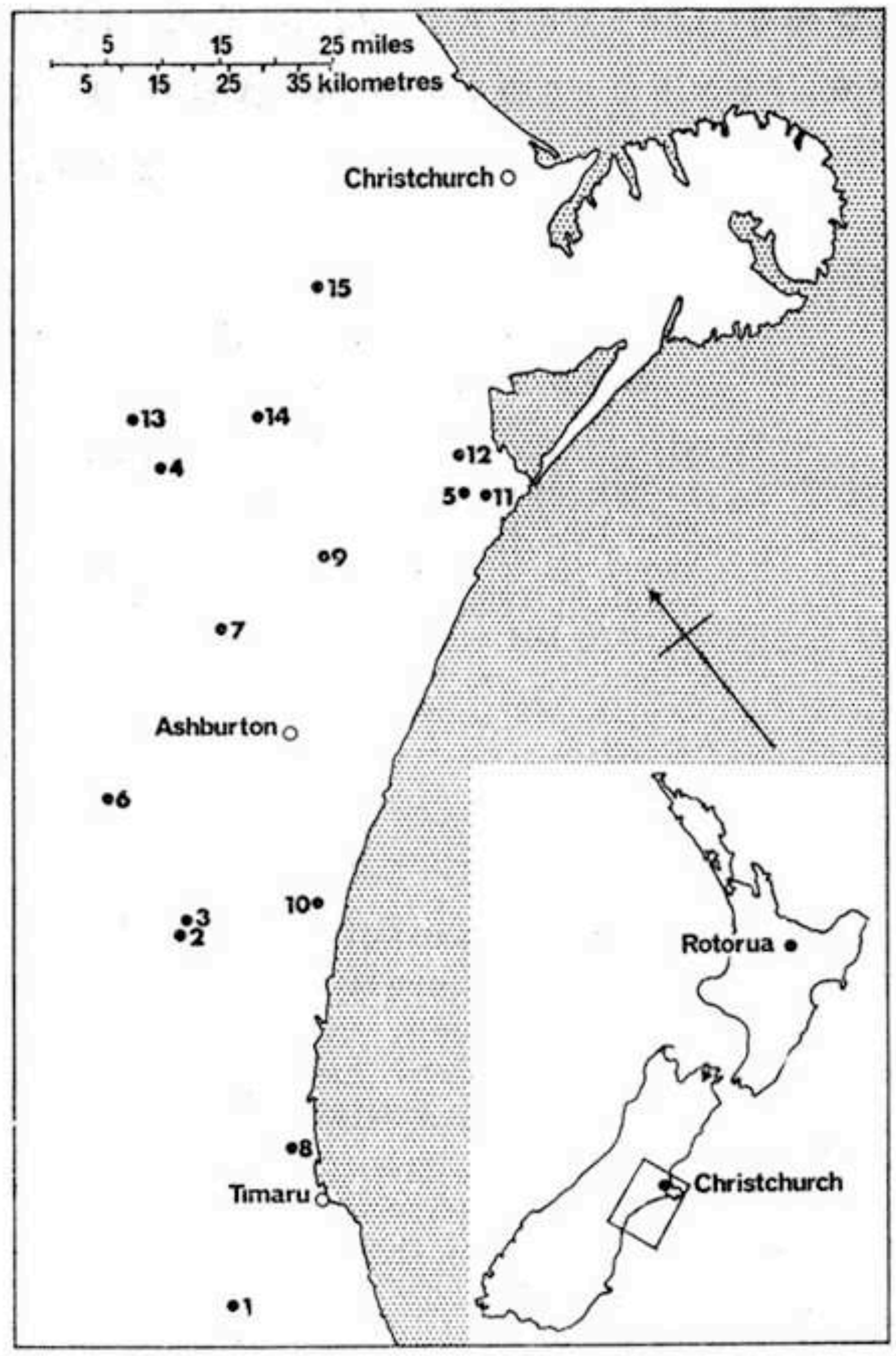

FIGURE 1. *Locations of Canterbury farms that were surveyed by questionnaires in March, April and May 1970. Farms 1 to 9 had bird or mammal deaths following the use of organophosphates. The farmers of properties 10 to 15 reported no deaths to wildlife.*

ingredient/ha. Efforts were made to achieve a uniform application but the undulating topography made this difficult. Kain and Crabtree (1972) found that the flat contours had a higher application rate compared with the steep contours and there was a difference between the steep contours on each property but no difference on the flat relief. The method of application and details of the efficiency of the treatment for the control of grass grub are discussed by Kain and Crabtree (1972). Fifty millimetres of rain fell during the three days following the application.

Five farms involving 72.8 ha were selected for study prior to treatment. No attempt was made to measure the total bird numbers in the study areas as this would have required more census work than time or manpower permitted. The aim was to ascertain the relative effect of the chemical on the bird and mammal populations from pre- and post-treatment counts. The pre-treatment censuses of the bird and mammal populations were conducted between 22 and 26 December 1970 by means of line transects. Post-treatment censuses were conducted by the same method and personnel between one and nine days after the application of the insecticide. Complete searches for dead animals were not possible because of the long grass, but searching was carried out by walking slowly, taking meandering routes, and special searches were made under trees and hedges.

The study areas varied considerably in topography and land use. The properties B, C, D and E were fairly steep sheep runs containing scattered areas of scrub and isolated trees, and bird populations were generally low. Property A had the highest density of birds and was made up of flat, intensively managed dairy land with numerous hedgerows.

No tests were carried out to ascertain whether the mammals and birds found in the treated areas had died of organophosphate poisoning. It is unlikely, however, that the large number of birds and mammals found dead shortly after the treatment died from other causes.

RESULTS

1. *Canterbury Farm Survey*

Six of the eight farmers who had used fensul-'othion and four of the eight farmers with para-hion-treated pastures reported deaths of wildlife. [he number of birds recovered dead per treated ıectare was similar for both insectides. Two hun-lred and twenty-eight dead birds were recovered rom 123.4 ha (1.85/ha) treated with fensulfothion nd 153 birds from 78.5 ha (1.95/ha) treated with ›arathion. On individual farms the number of ird deaths varied from 0.5 to 5.2/ha on para-ıion-treated pastures and 0.2 to 11.0/ha on pas-ıres treated with fensulfothion (Table 1). The number of bird deaths per treated hectare reported by the farmers is considerably less than was reported by Bucknell (1971). Between 1969 and 1972, Bucknell inspected less than 121.4 ha of pasture in Canterbury that had been treated with organophosphates and recovered 1,100 dead birds. On an 11.3 ha paddock treated with parathion he found 135 red-billed gulls *(Larus novaehollandiae scopulinus)* and 12 white-backed magpies (*Gymnorhina hypoleuca tibicen* and from 6.5 ha treated with fensulfothian 94 dead white-backed magpies and 74 dead black-backed gulls *(Larus dominicanus)* were picked up.

It is likely that more birds die than are found dead on the treated areas since some birds probably disperse before the insecticide begins to affect them.

Most dead birds were of omnivorous, carrion eating and insectivorous species. On the properties where the dead bird species were identified by the farmer the main types listed were white-backed magpies, black-backed gulls and harrier hawks (*Circus approximans*). White-backed magpies constituted 60 percent of the bird deaths on parathion treated pastures and 37 percent on pastures where fensulfothion was used. Black-backed gulls made up 18 percent of the birds dying on fensulfothion pastures and 22 percent on parathion pastures. Only one harrier hawk death was reported from parathion-treated pastures but this species made up 18 percent of the bird deaths on fensulfothion pastures. Finches, which are predominantly seed eating birds, constituted only a small proportion of the total bird deaths. Mice *(Mus musculus)* and hedgehogs *(Erinaceus europaeus)*, which are omnivorous, were the only mammals killed (Table 1).

On three farms, two treated with fensulfothion and one with parathion, bird deaths occurred only after the first period of rain, which was seven and 14 days respectively after the application of the chemicals. On the other farms, however, deaths occurred during dry conditions.

2. *Rotorua Fensulfothion Field Trial*

The effects on bird populations of the application of fensulfothion to the pasture were dramatic.

TABLE 1. *The Number of Birds and Mammals Found Dead Following the Application of Fensulfothion and Parathion to Pastures of Farms in the Canterbury Province.*

	Parathion				Fensulfothion					
Property	1	2	3	4	5	6	7	8	9	3
Area treated (ha)	13.8	29.9	13.4	34.0	5.3	16.2	13.4	7.3	4.0	10.1
Application rate (kg/ha)	2.2	3.1	3.3	3.1	2.2	2.2	2.2	2.2	2.2	1.1
Black-backed gull		c18		3			40		2	
Black-billed gull				1		4				
Red-billed gull			70							
White-backed magpie	3	11		37	6	2	50		c28	1
Blackbird					2				4	1
Starling							12		2	
Harrier hawk	1				11		30		1	
Skylark							15			
House sparrow	3	11								
Greenfinch										
Goldfinch								ca.25		
Redpoll										
Chaffinch										
Yellowhammer										
Hedgehog				1	4		2		*	
Mouse					*					
Total birds found dead	7	40	70	41	19	6	147	25	37	2
Deaths/treated ha	0.5	1.3	5.2	1.2	3.6	0.7	11.0	3.4	9.3	0.2

Note: * farmers indicated that numerous died.

Within two days the number of birds in the study areas dropped by 86 percent on average, and remained low for seven days after treatment (Table 2). Many of the birds seen alive the day after the insecticide was applied showed the poor co-ordination typical of sufferers from organophosphate poisoning (see Keith and Mulla 1966). The species most severely reduced in numbers were blackbirds (*Turdus merula*), song thrushes (*Turdus philomelos*), skylarks (*Alauda arvensis*) and pipits (*Anthus novaeseelandiae*) (Table 2). It is probably significant that these species are largely insectivorous ground-feeders. Chaffinches (*Fringilla coelebs*), which spend 95 percent of the time feeding on the ground (Newton 1967), were also found dead in comparatively large numbers. In contrast, redpolls (*Carduelis flammea*), greenfinches (*Chloris chloris*), goldfinches (*Carduelis carduelis*), silvereyes (*Zosterops lateralis*) and fantails (*Rhipidura fuliginosa*), which spend little time on the ground, were not found dead.

Most of the dead birds examined had insects in their stomachs but none contained fensulfothion granules.

DISCUSSION

The questionnaire survey and the field trial have shown that fensulfothion and parathion applied to pastures in granulated form severely reduce the bird populations in a treated area. Different bird species show differential vulnerability to organophosphate poisoning; this is probably because of their various feeding habits rather than differing tolerance to the poison. Insectivorous and carrion feeders are vulnerable because they feed respectively on the insects and the carcasses of birds and mammals contaminated with insecticide. On the treated areas dead and moribund insects were frequently found on the surface of the pasture. The day after the treatment at Rotorua, dead flies (*Musca* sp.) and numerous species of small insects appeared on the surface after heavy dew had acti-

TABLE 2. *Census of the Bird and Mammal Populations in the Treated Areas Prior to and After the Application of Fensulfothion at Rotorua and the Number of Birds and Mammals Found Dead After Treatment.*

	Property A† (8.1 ha)				Properties B & C† (40.5 ha)				Property D† (16.2 ha)					Property E† (8.1 ha)
	Pre-treatment census	No. seen alive after treatment		No. found dead 9 days after treatment	Pre-treatment census	No. seen alive after treatment		No. found dead 7 days after treatment	Pre-treatment census	No. seen alive after treatment			No. found dead 9 days after treatment	No. found dead 9 days after treatment
		Day 2	Day 9			Day 1	Day 7			Day 1	Day 2	Day 9		
Blackbird	13	5	0	15	4	2	0		4	0	0	0	3	28
Thrush	12	2	0	3	6	1	0	6	0	0	0	0		19
Myna	0	0	0		2	0	0	1	4	0	0	0	3	4
Starling	0	0	0		0	0	0	9	0	0	0	0		
Harrier hawk	0	0	0		1	1	0		0	0	0	0		
California quail	3	0	0		4	1	0		2	0	0	0		
Grey warbler	1	0	0		0	0	0		0	0	0	0		1
Skylark	14	1	0		} 11	1	0	2	14	0	0	3	8	
Pipit	0	0	0			0	0	4	0	0	0	0		
Hedge sparrow	0	0	0		0	0	*		0	0	0	0		1
House sparrow	16	4	0	11	0	0	*	3	0	0	0	0	1	13
Chaffinch	1	0	0	3	1	0	*	8	7	0	0	0		14
Yellowhammer	4	0	0		0	0	*	1	1	0	0	0		11
Greenfinch	0	0	0		0	0	*		1	0	0	0		
Rabbit	3	0	0		2	2	0	1	0	0	0	0		
Hare	1	0	0		0	0	0		0	0	0	0		

* Not counted but present.

† Some of the properties listed here were also examined by Kain and Crabtree (1972). The notation, however, is slightly different. Kain and Crabtree's Property "A" is Property "C" in this paper. Properties "B" and "D" are the same in both and Properties "A" and "E" in this paper were not studied by Kain and Crabtree.

vated some of the insecticide. An inspection immediately following rain eight days later revealed areas with concentrations of dead earthworms (*Lumbricus* sp.). On both visits birds were observed feeding on the dead insects. On Canterbury farms dead earthworms and porina were frequently observed on the surface of the ground (Mr E. S. Bucknell pers. comm.).

Secondary poisoning of wildlife can be expected most times fensulfothion and parathion are used, because some species of insects tend to rise to the surface when poisoned. The surfacing of poisoned porina caterpillars is due to an irritant effect during intoxication, but the number at the surface is unrelated to the number killed (Mr P. G. Fenemore pers. comm.).

There is a possibility that some birds die from primary poisoning, either from contact with the insecticide or through the ingestion of insecticide granules. Some bird species, especially seed and leaf eaters, ingest grit to assist with the breakdown of food. These birds could pick up insecticide granules mistakenly for grit. The granules are of similar size to the grit particles normally ingested by finches (Dr I. Newton pers. comm.), white-backed magpies (McIlroy 1968), black-backed gulls (Fordham 1963) and starlings (*Sturnus vulgaris*) (Dr J. D. Coleman pers. comm.). The number of birds dying from this cause, however, is thought to be small since the granules were dyed green to prevent such an occurrence (see Caithness and Williams 1971). This method appears to be very effective, because none of the large number of dead birds examined at Rotorua had granules in their stomachs. Dermal toxicity tests of fensulfothion and parathion (Monsanto Company and the Bayer Company technical data) indicate that a long period of exposure is required at high concentrations before mammals and large birds die. Small birds may, however, be more susceptible to small concentrations of insecticide, as has been found to be the case for the weaverbird, *Quelea quelea* (Pope and Ward 1972). Pope and Ward found that small concentrations of the organophosphate fenthion* applied to the feathers disrupted the feeding behaviour of the bird and death resulted from starvation one to two days later, rather than from direct toxic effects. Many small birds, e.g. bullfinches *Pyrrhula pyrrhula* (Newton 1969), weaverbirds *Quelea quelea* (Pope and Ward 1972) and yellow-vented bulbuls *Pycnonotus goiavier* (Ward 1969) roost with energy reserves sufficient to sustain a high metabolic rate during the night. If feeding is prevented the next day the birds could die during the following night. More research is needed to establish whether contact poisoning is an important factor.

The number of birds killed is likely to be much higher than is indicated by the deaths on the treated areas. Flock-feeding species such as finches and gulls which are attracted to the area may disperse and die one or two days later.

Fortunately, organophosphates are very expensive and so the blanket coverage that occurred with DDT is not likely to occur. Nevertheless, the continued use of fensulfothion and parathion must be viewed with concern because of the high mortality they cause to the resident bird population and the attraction of flock-feeding species from further afield caused by dead or moribund insects lying on the surface of the ground. Furthermore, the importance of many of the bird species in the ecology of the pasture and as biological control agents has not been evaluated. If organophosphates are to be used on farms an integrated programme involving management and limited use of the insecticides should be implemented along the lines suggested by Kain and Atkinson (1970).

* fenthion: dimethyl 3-methyl-4-methylthiophenyl phosphorothionate.

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