EFFECTS ON BIRDS OF SPRAYING DDT AND DDD IN ORCHARDS

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SUMMARY: The quantities of organochlorine insecticide residues in mynas *(Acridotheres tristis* L.) and especially in their eggs and nestlings reflected the concentrations of these pesticides in the soil of the birds' territories. Nearly all residues were derived from contamimated invertebrates, not fruit. Samples of soil, eggs and nestlings from areas adjacent to sprayed orchards contained little pesticide-no more than was found in samples collected several kilometres from orchards.

Although some adult starlings *(Sturnus vulgaris),* blackbirds *(Turdus merula)* and song thrushes *(Turdus philomelos)* died in tremors typical of organochlorine poisoning, no mynas were seen with these symptoms; earthworms, which readily accumulate DDT, DDD and DDE from the soil, are eaten less by mynas than by these other species.

Fewer myna eggs hatched, and fewer nestlings survived in areas with much residue in the soil than elsewhere. The degree to which this mortality resulted from a shortage of insect food in heavily sprayed areas, rather than direct pesticide poisoning, was not determined. However, some eggs and nestlings probably died because of inadequate incubation or lack of food, while others were probably poisoned by pesticides.

INTRODUCTION

In Hawke's Bay, New Zealand, the growing of pip and stone fruit is a major industry. Orchards receive several applications of acaricides, fungicides and insecticides from September to March each year.

The effects of persistent organochlorine insecticides (DDT and DDD) on common mynas *(Acridotheres tristis* L.) breeding in orchards was investigated as part of a study into the general ecology of mynas in Hawke's Bay during 1966-70 (Wilson, 1973). Factors limiting a population of individually marked mynas in the DSIR research orchard at Havelock North were compared with those operating in another population living in private commercial orchards 1 km away. These two populations were compared with those from two small pockets of mynas (Washpool and Valley Road) separated from orchards by 9 km and 11 km of pasture respectively. All samples were obtained between 1966 and 1969.

This paper tests the hypothesis that DDT and DDD spraying and their residues caused appreciable mortality among myna populations in Hawke's Bay orchards.

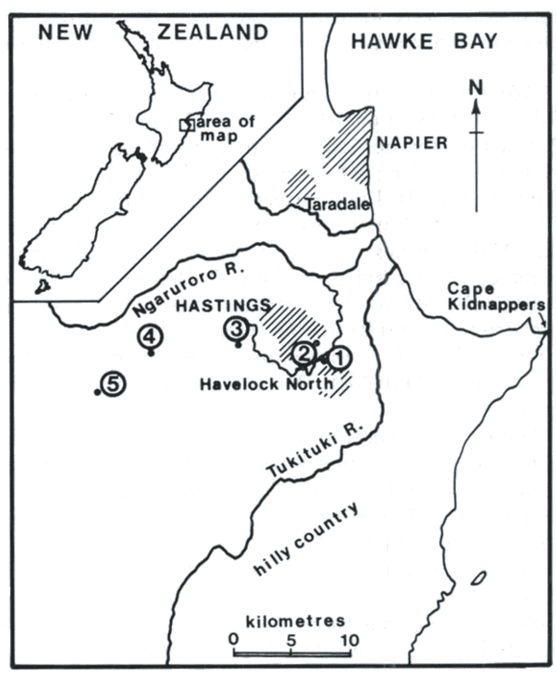

FIGURE 1. *Map of Hawke's Bay, showing the five areas referred to in text:* (1) *DSIR research orchard;* (2) *Louie Street orchards;* (3) *Piggery at Longlands;* (4) *Wash pool (homestead of sheep and cattle farm);* (5) *Valley Road piggeries.*

STUDY AREAS

The study covered four areas: a research orchard, a commercial orchard, and two localities remote from orchards (Fig. 1).

The 14 ha DSIR research orchard is planted with mixed pip and stone fruit trees, is partly grassed, and has some crops nearby. Approximately half of the orchard consists of commercial fruit trees; the other half contains a collection of numerous varieties of pip and stone fruits.

Although both parts of the research orchard are sprayed, only the commercial varieties receive the heavy spraying characteristic of commercial orchards. I have called this area the "high-spray" area, and the collection of genetic stock (which also has more unsprayed cropping land than the "high-spray" area) the "low-spray" area (Fig. 2).

The second study area comprised three adjacent commercial orchards (the Louie Street orchards), totalling about 15 ha of pip and stone fruits.

Information was also collected from two small groups of mynas not in orchards: one living around farm buildings at Washpool and the other at two piggeries 2 km apart in Valley Road (Fig. I).

Material And Methods

Ten soil cores, 150 mm deep x 25 mm diameter, were collected at random at each of 33 sites selected to cover all parts of the DSIR orchard. Residues in these cores were measured using gas chromatography and are expressed as parts per million (ppm) of dry weight.

Adult mynas, eggs and nestlings were collected as follows. DSIR orchard: 6 adults (2 shot, 2 drowned, 2 killed on the nest by a carnivore), 49 eggs from 30 clutches and 3 eggs laid by aviary birds; 26 nestlings from 15 broods. Louie Street orchards: 15 eggs from 11 clutches; 9 nestlings from 8 broods. Washpool and Valley Road piggeries: 16 fresh eggs from 10 clutches (9 starling eggs from 2 clutches were also collected). Strawberry garden near the research orchard: 10 adults (shot). Piggery near Longlands (site 3, Fig. 1): 10 adults (drugged with alpha-chloralose). Havelock North: clutch of 3 myna eggs.

With the exception of one fresh egg from a clutch of four at Louie Street orchards, all specimens analysed for DDT, DDD and DDE from the two orchard populations were adults or nestlings found dead or eggs that had failed to hatch. All of the birds were nesting in nest boxes. Eggs were opened to see if there was any embryonic development and embryos were measured. Most eggs, muscle tissue of all nestlings, and the breast muscles of adults collected for analysis were stored in sealed containers at -20∞C. Gas chromatography was used to measure the presence of the isomers p,p'-DDT, p,p'-DDD and p,p'-DDE, and p,p'-DDT in extracts of the samples. However, p,p'-DDT was either not detected or found in insignificant quantities. Samples were prepared and analysed as described by Collett and Harrison (1968).

Residues in eggs and tissue are expressed as parts per million (ppm) of wet tissue. Dehydration was a problem in analysing residues in eggs. Some

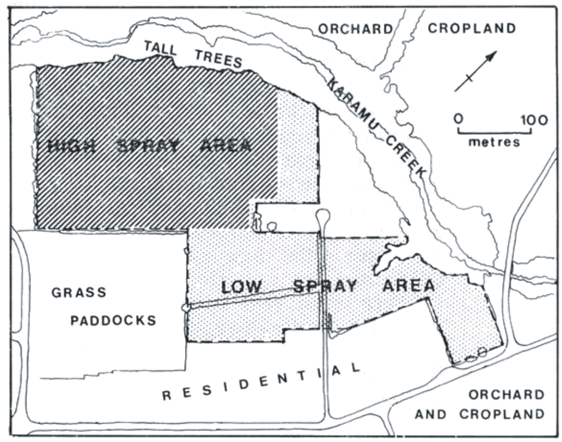

FIGURE 2. *The DSIR research orchard at Havelock North showing "high-spray" and "low-spray" areas.*

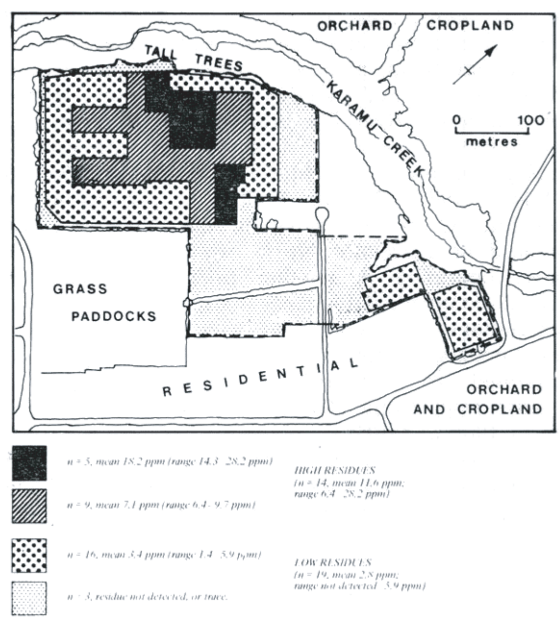

FIGURE 3. *Levels of DDT equivalent (the sum of DDT, DDD and DDE) in the soil of the DSIR orchard at Havelock North. (Dashed outline is boundary of orchard.)*

TABLE 1. *Levels (ppm) and per cent composition of organochlorine residues in the DSIR orchard soil. (N D = not detected).*

Residue level in soil		DDE (ppm)	DDE (%)	DDD (ppm)	DDD (%)	DDT (ppm)	DDT (%)	Mean DDT equivalent
HIGH (n = 14)	Mean:	2.2 ± 0.35*	19.0	2.7 ± 0.45	23.3	6.7 ± 0.90	57.8	11.6 ± 1.64
	Min.:	0.9		1.0		3.3		6.4
	Max.:	6.4		7.6		14.2		28.2
LOW (n = 19)	Mean:	0.5 ± 0.08	17.9	1.1 ± 0.14	39.3	1.2 ± 0.23	42.9	2.8 ± 0.40
	Min.:	trace		ND		ND		trace
	Max.:	1.2		1.9		3.1		5.9

* Standard error of mean

eggs collected early in the study and frozen in inadequately sealed containers, lost much moisture. Others, collected after incubation, were also unduly light. Because of this, the results could be misleading if uncorrected. Since the contents of each egg were weighed before analysis and the average weight of the contents of fresh myna eggs was 6.5 g, all results for eggs were therefore adjusted using this figure.

RESULTS

Residues in soil

The average pesticide (DDT, DDD and DDE) content of the soil samples ranged from a trace (< 0.01 ppm) in areas planted for only one season to 28.2 ppm in a block sprayed for 18 years (Table 1). Residues in the soil in the Louie Street orchards (sampled by the Ministry of Agriculture and Fisheries two years before this study) were, on average, similar to those in the DSIR "high-spray" area (N. Hunnego, pers. comm.). Eggs and nestlings sampled in Louie Street did not, however, contain as much pesticide as those in the DSIR "high-spray" area, suggesting that in some places the soil in the DSIR "high-spray" area contained more residue than in any area at Louie Street.

The data on residues in soil were split into two groups (Table 1): (a) high residues; (b) low residues. The soil cores with high residues came from the central part of the "high-spray" area, while low residues came from around the edge of the "high-spray" area and throughout the "low-spray" area (Fig. 3).

Residues in adult mynas

Six adult mynas from the DSIR orchard "low-spray" area (Fig. 2) averaged 4.1 ppm (S.E. 1.02; range 2.4-7.4 ppm) total DDT equivalent (i.e. the sum of the DDT, DDD and DDE components in the sample). Ten adults from a strawberry garden surrounded by orchards contained more residue, averaging 10.8 ppm (S.E. 1.74; range 4.5-22.9 ppm), and 10 birds from a piggery 1.5 km from the nearest orchard, averaged only 0.8 ppm (S.E. 0.16; range 0.3-1.9 ppm).

Residues in eggs and nestlings

Residues (DDT equivalent) in eggs and nestlings were similar in the DSIR and Louie Street orchards (Table 2). In the DSIR orchard however, residue levels in eggs and nestlings from the area containing high residues in the soil were significantly greater than those from the area with low residues in the soil ($t = 4.42$; 28 d.f. : $p < 0.001$ for eggs and $t = 3.86$; 12 d.f. : $p < 0.01$ for nestlings).

In the areas with high residues in the soil, residues in nestlings were on average double those in eggs, while the residues in nestlings from areas with low residues in the soil were not significantly greater (Table 2).

Eggs from the outlying study areas (Valley Road and Washpool, Fig. 1) contained very little pesticide (0.23 and 1.38 ppm respectively, Table 2). Two clutches of starling *(Sturnus vulgaris)* eggs from Washpool contained 1.27 ppm on average. Three myna eggs from a nest in Havelock North, only 0.5 km from sprayed orchards, also contained very little pesticide-only 1.2 ppm DDT equivalent on average.

Two pairs of mynas in an aviary in the area with high residues in the soil fed on a diet of unwashed

TABLE 2. *Mean* (± *S.E.) and per cent composition of organochlorine residues* in *myna eggs and nestlings from all study areas*. (ND = not detected)

Locality	No. of samples	DDE (ppm)	DDE (%)	DDD (ppm)	DDD (%)	DDT (ppm)	DDT (%)	Total (ppm)
EGGS								
DSIR								
High residues in soil	8	12.1 ± 2.0	64.7	5.1 ± 1.4	27.3	1.5 ± 0.7	8.0	18.7 ± 2.9
Low residues in soil	22	5.4 ± 0.7	67.5	2.0 ± 0.5	25.0	0.6 ± 0.2	7.5	8.0 ± 1.0
Average:	30	7.2 ± 0.9	66.7	2.8 ± 0.6	25.9	0.8 ± 0.2	7.4	10.8 ± 1.4
Louie Street	13	9.1 ± 1.3	79.8	1.5 ± 0.3	13.2	0.8 ± 0.3	7.0	11.4 ± 1.7
Valley Road	6	0.23 ± 0.06	100.0	ND		ND		0.23 ± 0.06
Washpool	4	1.38 ± 0.27	100.0	ND		ND		1.38 ± 0.27
NESTLINGS								
DSIR								
High residues in soil	10	16.0 ± 2.5	42.8	20.5 ± 4.0	54.8	0.9 ± 0.2	2.4	37.4 ± 6.6
Low residues in soil	12	5.4 ± 1.3	56.8	3.5 ± 1.5	36.8	0.6 ± 0.4	6.3	9.5 ± 2.8
Average:	22	10.2 ± 1.7	46.0	11.2 ± 2.7	50.4	0.8 ± 0.2	3.6	22.2 ± 4.5
Louie Street	9	13.2 ± 4.3	64.4	7.0 ± 2.8	34.2	0.3 ± 0.1	1.4	20.5 ± 6.7

TABLE 3. *Comparative breeding statistics from nests in the "high-spray" (H) and "low-spray" (L) areas in the DSIR orchard. (Number of pairs breeding in each area, in each year, in parentheses).*

Season		No. eggs laid		No. eggs hatched	% eggs hatched	No. nestlings fledged*	% nestlings fledged	% eggs successful **
1965/66	H	37	(8)	20	54.1	5	25.0	13.5
	L	27	(6)	20	74.1	15	75.0	55.6
1966/67	H	53	(10)	32	60.4	17	53.1	32.1
	L	38	(8)	25	65.8	18	72.0	47.4
1967/68	H	70	(10)	39	55.7	21	53.8	30.0
	L	73	(9)	54	74.0	31	57.4	42.5
1968/69	H	59	(12)	18	30.5	14	77.8	23.7
	L	99	(16)	38	38.4	24	63.2	24.2
1969/70	H	68	(10)	39	57.4	18	46.2	26.5
	L	87	(11)	64	73.6	37	57.8	42.5
1970/71	H	52	(10)	22	42.3	10	45.5	19.2
	L	86	(13)	66	76.7	38	57.6	44.2
Total:	H	339		170	50.1	85	50.0	25.1
	L	410		267	65.1	163	61.0	39.8

* Flew fully developed from the nest
** Resulting in fledglings

orchard apples and minced meat, laid three eggs with only a little pesticide (0.9-1.5 ppm).

Appendices containing data on the levels of DDT, DDD and DDE in each sample of soil, eggs, nestlings and adult birds are available from Ecology Division, DSIR, Nelson.

Hatching and fledging success

Hatching success was lower in the "high-spray" area in every year (Table 3). Hedging success was also lower in the "high-spray" area in every year, except 1968/69.

Overall, from six years breeding, hatching success in the "high-spray" area was significantly lower than in the "low-spray" area (X^2 = 16.8; 5 d.f. : $p < 0.01$). Eleven per cent fewer nestlings fledged in the "high-spray" area, (50% and 61 % in the "high-spray" and "low-spray" areas respectively). Although

TABLE 4. *Stage of embryo development and pesticide content of eggs which failed in nests in the "low-spray" area of the DSIR orchard during 1966-67 and 1967-68.*

Nest identity	Number of eggs: Laid	Hatched	Lost	Failed	Resulting fledglings	Failed eggs: Total residue (ppm)*	Stage of development of embryos
K	2	0	0	2	0	3.3	2, 1/2 developed
K	2	0	0	2	0	11.0	1, 1/4 developed; 1, undeveloped
J	4	3	0	1	2	3.3	1, < 1/4 developed
M	4	3	0	1	1	1.0	1, 1/4 developed
O	4	3	0	1	3	8.8	1, undeveloped
F	5	2	1	2	2	8.2	2, undeveloped
F	4	3	0	1	2	8.5	1, undeveloped
G	4	3	0	1	0	7.2	1, undeveloped
G	3	2	0	1	2	6.6	1, undeveloped
N	3	2	0	1	0	2.3	1, < 1/4 developed
K	3	2	0	1	1	2.0	1, undeveloped
T	4	3	0	1	0	27.0	1, undeveloped
P	3	2	0	1	1	11.7	1, undeveloped
I	4	3	0	1	3	4.3	1, undeveloped

* DDT, DDD and DDE

this difference was not statistically significant, overall breeding success in the "high-spray" area was highly significantly less than that in the "low-spray" area ($\chi^2 = 28.4$; 5 d.f. : $p < 0.001$).

Embryonic development of eggs *that failed to hatch*

Of 17 eggs that failed to hatch in the "low-spray" area of the DSIR orchard, 11 (65 %) were undeveloped (Table 4). However, of 30 eggs that failed to hatch in the "high-spray" area, only 5 (17%) were undeveloped (Table 5). This difference was highly significant ($\chi^2 = 11.09$; 1 d.f. : $p < 0.001$).

Discussion

Tile diet of mynas includes fruit and invertebrates. Collett and Harrison (1968) found only 0.18 ppm DDT and less than 0.5 ppm DDD in a composite sample of apples harvested from their study orchard at the end of the season with the usual spraying programme. However, they found that earthworms from the same orchard contained 13.4 ppm DDT equivalent before the spraying season and 28.8 ppm after spraying. This indicates that most of the residues in mynas (breast muscle, eggs and nestlings) were derived from invertebrates captured within the mynas' breeding territories, not from fruit eaten there. It is partly confirmed by the low residues found in the eggs of aviary mynas fed on orchard apples and minced meat and deprived of invertebrates.

Adult mynas holding territories on ground with high levels of organochlorine pesticide residues ingest more contaminated invertebrates, lay eggs containing higher residues, and build up higher residues in their nestlings through the contaminated food than do birds from territories with lower residues. However, although high levels of pesticides were found in some unhatched eggs and dead nestlings, the extent to which pesticides were responsible for killing those eggs or nestlings is unknown.

The susceptibility of birds to a given pesticide varies from species to species. Pepperell (1972) had to feed domestic hens with 500ppm p,p'-DDT every second day for two months to produce significant decreases in the viability of eggs, and even greater tolerance to DDT was shown by hens studied by Cecil *et al.* (1972) and Lillie *et al.* (1972). On the other hand, Heath, Spann and Kreitzer (1969) showed that DDE in concentrations of only 10 ppm in the food of penned mallards *(Anas platyrhynchos),* caused significant eggshell thinning and higher embryo mortality. Cecil *et al.* (1972) demonstrated that the egg was an important route for eliminating ingested DDT and DDE: 34% and 42 % respectively of the daily intake was excreted in the egg contents.

In both the DSIR and Louie Street orchards, myna eggs contained much more DDE than DDD

TABLE 5. *Stage of embryo development and pesticide content of eggs which failed in nests in the "high-spray" area of the DSIR orchard during 1966-67 and 1967-68.*

Nest identity	Number of eggs				Resulting fledglings	Failed eggs	
	Laid	Hatched	Lost	Failed		Total residue (ppm)*	Stage of development of embryos
V	3	0	1	2	0	15.5	2, fully developed
D	4	0	0	4	0	20.5	1, undeveloped; 1, 1/4 developed; 1, 1/2 developed; 1, fully developed
D	3	0	0	3	0	29.2	1, undeveloped; 2, 3/4 developed
L	4	0	3	1	0	16.8	1, 3/4 developed
E	4	0	2	2	0	7.0	1, undeveloped; 1, fully developed
E	2	0	0	2	0	6.6	1, < 1/4 developed; 1, fully developed
E	3	0	0	3	0	7.9	2, < 1/4 developed; 1, fully developed
A	4	3	0	1	1	15.1	1, 3/4 developed
A	2	1	0	1	1	15.5	1, 3/4 developed
A**	4	0	0	4	0	12.4	4, 3/4 developed
H	4	3	0	1	2	16.5	1, < 1/4 developed
H	3	1	0	2	I	15.7	1, undeveloped; 1, fully developed
B	1	0	0	1	0	22.3	1, undeveloped
C	4	2	0	2	2	5.5	2. < 1/4 developed
C	3	2	0	1	0	29.1	1, < 1/4 develpped

* DDT, DDD and DDE

** Different ♀

or DDT (Table 2), whereas the soil in the DSIR orchard contained more DOT than ODD or DOE (Table 1). ODD, though still the second most abundant organochlorine in nestlings, was approximately twice as prevalent as in eggs (Table 2). Toe differences reflect the metabolic pathways that the fat-soluble organochlorines have taken before entering the lipids of eggs or nestlings. No experimental work has been done to determine how much organochlorine pesticide is needed in the diet of mynas to achieve these levels of residues in the eggs or nestlings. However, Collett and Harrison (1968) analysed soil, blackbirds *(Turdus rnerula),* song thrushes *(Turdus philornelos),* earthworms and apples in a commercial orchard near Christchurch, New Zealand, and found that 12 soil cores (150 mm deep x 25 mm diameter) taken at random in March averaged 22.2 ppm DDT equivalent. This is similar to the average amount found in the area with highest residues in the soil in the DSIR orchard (Fig. 3). Blackbirds and thrushes collected, or found dead or dying, on or near the Christchurch orchard had, on average, 35 ppm DDT equivalent (range 1.9-77.7 ppm) in the breast muscles.

Collett and Harrison (1968) concluded that about half the birds sampled probably died from organochlorine insecticide poisoning primarily derived from ingestion of earthworms, and agreed with Wurster, Wurster and Strickland (1965) that birds showing typical symptoms before death and found to contain residues of DDT and metabolites in the breast muscle in excess of about 20 ppm can "reasonably be presumed to have died of insecticide poisoning".

No mynas were observed dying of pesticide residues in the Hawke's Bay study orchards, although 5 starlings, 5 blackbirds and 3 song thrushes were found dying in tremors. Earthworms comprise a much smaller proportion of the myna's diet than that of starlings, blackbirds or song thrushes; hence the lower breast-muscle levels of total DDT recorded: 4.1 ppm (n = 6) in the "low-spray" area, 10.8 ppm (n = 10) in the strawberry garden / orchard (both this study), and 11.2 (n = 10) in an orchard (Harrison, 1971).

Adult mynas had a greater proportion of DOE in their breast muscles than any of the other three species. Residues in eggs of mynas in the DSIR and Louie Street orchards consisted respectively of 67% and 80% DDE, the metabolite now widely blamed for eggshell thinning and hatching failure in birds (Wurster, 1969; Heath *et al.*, 1969).

Not only did significantly more eggs fail to hatch in the DSIR "high-spray" area than in the "low-spray" area (Table 3), but the majority of these failed eggs were fertile and their embryos had died during development (Tables 4 and 5). Furthermore, embryonic development in eggs from the "high-spray" area was, on average, twice as advanced as in eggs from the "low-spray" area. Clearly, the embryos that failed in the "high-spray" area did so much nearer their hatching date, when the majority of the yolk and pesticide content in the lipids of the yolk may have been mobilised. The embryos with higher residues (see Tables 4 and 5) that died in the shell when nearly fully developed may have mobilised lethal quantities of pesticide.

An alternative explanation is that food shortage in the adults' territory may be responsible for poor hatching and fledging success. Dyck, Arevad and Weihe (1972) studied productivity of great tits *(Parus major),* blue tits *(P. caeruleus),* pied fly-catchers *(Muscicapa hypoleuca)* and tree sparrows *(Passer montanus)* in Danish orchards. They concluded that a shortage of invertebrates, caused by spraying, was responsible for low breeding success-not direct poisoning of the birds by the organochlorine residues. Potts (1977) suggested that survival of grey partridge chicks *(Perdix perdix)* declined because herbicide and insecticide spraying reduced the numbers of insects available to them.

Wilson (1973) argued that hatching failure of myna eggs in the DSIR orchard, especially of whole clutches, was caused primarily by inadequate incubation. Moreover, the majority of nests in which whole clutches failed were in the "high-spray" area. Mynas held larger territories in both the DSIR "high-spray" area and in the Louie Street orchards, than in the DSIR "low-spray" area; this may indicate that there was less food in the two more heavily sprayed areas.

During the 1968/69 breeding season, unusually windy wet weather and low mean maximum temperatures in December and February (3°C less than that experienced in any of the preceding 18 years) significantly reduced the breeding success of mynas in both the DSIR and Louie Street study orchards (Wilson, 1973). Significantly more whole clutches failed to hatch in the DSIR orchard, and most failed clutches were in the "high-spray" area. Hatching success was somewhat depressed in the Louie Street orchards, and only half the usual number of nestlings fledged. In the DSIR orchard, food shortage due to pesticide spraying apparently contributed to inattentive incubation as parents spent more time searching for food and less time incubating. In addition, the lower temperatures caused unincubated eggs to cool faster. A probable contributing factor was the increase in territorial fighting; more pairs attempted to establish territories and breed in 1968/69 than before or since. Fighting increased the disruption to incubation, and its effect was also apparent in the "low-spray" area. Louie Street parents may have had more difficulty finding food fo!" their nestlings, or may have needed more than in other years (Wilson, 1973). Pesticide residues may also have contributed to nestling mortality in some nests, especially if the nestlings which had built up substantial residues were forced by the cold weather to use their fat reserves.

During the period 1966/67-1968/69 inclusive, post fledging survival of young mynas from the "high-spray" and "low-spray" areas was similar: 73 % and 79% respectively (Wilson, 1973). Apparently, once the young mynas could follow their parents to food there was little difference between survival rates of young produced in either "high-spray" or "low-spray" areas. Post fledging survival from Louie Street was not determined.

Harvey (1967) found that starlings fed 4.75 mg radioactive DOT per day for five days absorbed less than 25% of the insecticide. Concentrations remained high in the body and liver for one week after the feeding period, but decreased more quickly in the brain. After less than 10 days, not more than 10% of the ingested DDT remained in the birds. Harvey found that all of the birds that died in tremors during the experiment had small livers and no body fat. These birds had five times as much residue in the brain as had birds with body fat and livers of normal size. A maximum tolerance of 30 ppm in the brain has been suggested for several bird species (Stickel, Stickel and Christensen, 1966). Harvey concluded that DDT accumulates in the body fat until it can be converted to an excretable metabolite, and suggested that birds with little stored fat, and which cannot excrete DDT fast enough to prevent 30 ppm building up in the brain, will probably die.

In commercial orchards sprayed with organo-chlorine insecticides, certain insectivorous and omnivorous birds and their nestlings may be dis-advantaged in two ways: (a) food may be relatively short and the birds' body weights low (with little stored fat) as a result of spraying, and (b) invertebrates ingested by these birds contain high levels of DDT equivalent. If the birds are light, lethal residues in the brain could accumulate much faster than in birds in good condition.

As incubation proceeds, embryos become increasingly susceptible to any drop in incubation temperature below the optimum; sudden chilling kills much faster than slow cooling (Romanoff, 1960). Embryos reared in sprayed orchards may also then be doubly disadvantaged-by the accumulation of pesticides from the yolk, and by erratic incubation.

CONCLUSION

Although adult mynas living in orchards treated with organochlorine sprays do not build up lethal levels of residue, they rear significantly fewer young. A reduction of insect food appears to be the primary cause, but some deaths of embryos or nestlings may be directly attributable to organochlorine poisoning.

Although organochlorine pesticides are now rarely used, current pesticides (e.g. Gusathion) also reduce invertebrate numbers in orchards, and the effect on the productivity of mynas (and some other species) breeding in orchards may still be the same.

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