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Effects of Urban Pesticide Applications on Nesting Success of Songbirds

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Many companies, in recent years, have become involved in the lawn and tree care industry. Pesticides are an important component of this care. Property owners, neighbors, biologists, and others are concerned about the safety of the materials being used, and their impact on ecosystems. Nontarget organisms may be affected. The impact of commonly used organophosphate (OP) and carbamate pesticides on the reproductive success of songbirds is not well known. During 1986 and 1987, a Wisconsin company cooperated in a study to determine whether nesting success of songbirds was reduced by the application of insecticides to trees.

Acephate (O,S-dimethyl acetylphosphoramidothioate), carbaryl (1-naphthyl methylcarbamate), and diazinon (O,O-diethyl O-[2-isopropyl-6-methyl-4-primidinyl] phosphorothioate) were used during this study. The effects of these and other insecticides on wildlife have been studied primarily in controlled situations or where insecticides were applied aerially to large areas. This study was designed to assess the effects of select insecticides on robins (*Turdus migratorius*) and mourning doves (*Zenaida macroura*) when applied to small areas and, in some cases, to single trees. The objectives were to determine whether commercial applications of acephate, carbaryl, or diazinon affected nesting success, or cholinesterase (ChE) levels of the nestlings, and if pesticide drifted from spray sites.

MATERIALS AND METHODS

The study was conducted on private properties in Winnebago, Outagamie, and Calumet counties which surround the city of Appleton in east-central Wisconsin. Nesting robins and mourning doves were chosen for study because of the potential sensitivity of their young to insecticides, and because they are found commonly in urban, suburban, and rural areas. No attempt was made to isolate the effects of dermal and respiratory exposure, which certainly occurred, or that from the ingestion of contaminated foods which probably occurred at times with robins. We searched

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carefully for sick or dead birds, and analyzed blood and brain tissue for ChE inhibition.

Between May and August 1986 and 1987, 63 robin and 62 mourning dove nests were located. Homeowners were contacted and permission gained to study birds on their properties. Birds were observed on properties where trees were sprayed, and as a control measure, on properties where no spraying was done. Only those nests in the incubation stage or with nestlings were studied. Thirty-five robin and 37 mourning dove nests in sprayed trees (n=45) or within 10.7 m (35 ft) of a spray application and with probable drift to the nest (n=27) were selected as treatment nests. Twenty-eight robin and 25 mourning dove nests which were a minimum of 15.2 m (50 ft) away from any spraying, and with no probable drift toward the nest, were studied as control nests.

The majority of the spraying was done in May and June during the peak of bird reproduction. Sprays were applied in the standard manner with a hand-held (Greengarde JD-9C) spray gun with adjustable nozzle. Pressure (250-400 psi) was provided by a truck-mounted, power-take-off driven (Hydra-cell D-25) pump. The applicator stood on the ground 1 to 4 m from the tree and moved around the tree as necessary. Sprays were applied until just before the spray began to drip from the leaves. Acephate (Orthene) was applied at a rate of 601 ppm, carbaryl (Sevin) at 1196 ppm, and diazinon at 598 ppm. The fungicides benomyl (597 ppm) and mancozeb (1433 ppm) were applied with the insecticides carbaryl and diazinon.

Nests were studied after spraying. Those higher than eye-level were viewed with a pole and mirror device. Nests which had nestlings at spray time were checked 24 and 48 hr after spraying to monitor nestling survival. Control nests were also visited, 24 and 48 hr after initially being located. All nests were visited every other day until the young birds reached 10 d old or the nest was destroyed or abandoned.

Nests were considered successful if at least one young bird was alive 10 d after hatching (Westmorland and Best 1985). The percentage of successful nests, young fledging, and eggs hatching for treatment and control nests were compared using 2-tailed z tests. Values for these variables were also compared using analysis of variance (ANOVA) by further classifying the treatment nests as acephate-, carbaryl- or diazinon-exposed nests.

Nestlings were collected between June and August 1986 for ChE level determination. Sixteen nestling mourning doves and 14 nestling robins from the control nests were analyzed. Their nests had been monitored since before hatching, hence their ages were known. Nestlings at 1, 4, 7, and 10 d of age were collected to determine the effects of age on nestling ChE levels (Grue et al. 1981; Grue and Hunter 1984).

Five robins and five mourning doves were collected from nests exposed to acephate, and five each from nests exposed to carbaryl. All but three of these nests were in sprayed trees; the remaining three were adjacent to and within 1 m of sprayed trees. The ages of birds were determined by comparing size, weight, and feather development with that of known-age nestlings (Hanson and Kossack 1963; Holcomb and Jaeger 1978). All nestling samples were between 1 and 10 d old and were collected 24 hr after spraying to compare their ChE levels with those of control birds. Samples were not collected from diazionon-exposed nests since only two of those nests were in the nestling stage during exposure.

Each nestling was weighed and two blood samples were taken from the brachial artery with 50 μl capillary tubes. Nestlings and blood samples were put on ice immediately after the birds were killed. Blood samples were centrifuged and plasma portions were frozen with the nestlings until analyzed. Control and treatment birds were handled the same.

Brain and plasma ChE levels were determined colorimetrically using the method of Ellman et al. (1961) as described by Hill and Fleming (1982). A Perkin Elmer spectrophotometer and strip chart recorder were used to measure the rate of enzyme reaction. Brains were removed while frozen, and all brain and plasma samples were analyzed in duplicate on the same day. The average ChE activity for each specimen was used in all calculations. ChE activity was expressed as micromoles of acetylthiocholine iodide hydrolyzed per minute per gram of brain tissue (wet weight), or per mL of plasma. ChE levels of 1-, 4-, 7-, and 10-d old control birds were plotted using linear regression to compare with ChE levels of acephate and carbaryl exposed birds.

Water sensitive cards (manufactured by CIBA-GEIGY) were used to determine if pesticides were being deposited downwind from application sites. Cards were clipped to wire supports and suspended horizontally approximately 50 cm above the ground. They were placed at distances of 7.6, 15.2, 22.9, 30.5 and 45.7 m (25, 50, 75, 100 and 150 ft) downwind of spray applications. This was done at seven sites where wind speeds were 2-5 kph (1-3 mph) and at eight sites where wind speeds were 6-11 kph (4-7 mph). Most tree-spraying was done early in the morning when there was not wind, and heavy dew prevented the use of water sensitive cards. Drift measurements were then made later in the day when dew was absent and wind speeds tended to be higher. Wind speed was measured with a hand-held anemometer. Cards were left on the wire supports for 15 min after treatment, collected, and stored in plastic bags along with data from the site.

Instructions for measuring droplet density and size were provided by the card manufacturer. The number and size of spots on the cards indicated the quantity of spray being deposited. No attempt was made to determine the amount of pesticide that remained airborne, or differences between pesticides. The number of spots/cm^2 were counted with the aid of a magnifying glass. The mean diameter of spots was measured with a microscope equipped with an ocular micrometer. A spread-factor of 2 was used to calculate actual droplet size. The quantity of pesticide deposited was then calculated for various distances from the treatment site.

RESULTS AND DISCUSSION

There were no significant differences ($p>0.10$; 2-tailed z test) between treatment and control nests when comparing percentage of nest success, eggs hatched, and nestlings fledged (Table 1). There were no significant differences ($p>0.10$; ANOVA) between acephate-exposed, carbaryl-exposed, diazinon-exposed and control nests. The sample of diazinon-exposed nests was small and provides limited insight into possible harmful effects of this compound. Two of two robin and two of six mourning dove nests exposed to diazinon were successful. In five mourning dove nests, exposed to diazinon during incubation, only 22% of the eggs hatched. One of three nests exposed to both acephate and carbaryl was successful.

Table 1. Success of control and pesticide treatment nests

	% Nest success (n)		% Eggs hatching (n)		% Nestlings fledging (n)	
Exposure	Robins	Doves	Robins	Doves	Robins	Doves
Control	75.0 (28)	64.0 (25)	73.1 (52)	63.4 (41)	91.3 (23)	78.9 (19)
Treatment-exposed (total)	80.0 (35)	70.3 (37)	66.7 (63)	60.9 (46)	92.6 (27)	92.0 (25)
acephate	76.5 (17)	66.7 (15)	63.0 (27)	73.7 (19)	80.0 (10)	100.0 (8)
carbaryl	86.7 (15)	92.9 (14)	69.0 (29)	75.0 (16)	100.0 (14)	84.6 (13)
acephate and carbaryl	0.0 (1)	50.0 (2)	33.3 (3)	0.0 (2)	-- (0)	100.0 (2)
diazinon	100.0 (2)	33.3 (6)	100.0 (4)	22.2 (9)	100.0 (3)	100.0 (2)

Nest success for treatment and control birds was high. Egg-to-fledging nest success was 62.5% (n=16) for control robins, and 78.9% (n=19) for treatment robins. Robin researchers report nest success ranging from 37% to 90% (Young 1955; Graber et al. 1971; Kemper and Taylor 1981). Egg-to-fledging nest success for mourning doves in this study was 53.3% (n=15) and 56.5% (n=23) for control and treatment nests, respectively. McClure (1945) reported a 46% nest success for mourning doves, and Westmoreland and Best (1985) reported 37% and 50% success for disturbed and undisturbed nests, respectively.

Although the sample sizes are small, there was no increase in mortality of young birds when exposed to these insecticides in this manner. Thirty of the treatment nests had nestlings at the time of spraying, and only four of these nests were unsuccessful. Nestlings were exposed to diazinon in one robin nest and one mourning doze nest; both nests were successful. None of the nestlings showed visible signs of poisoning at 24 or 48 hr after insecticide treatments. Dead nestlings were found only once after exposure to insecticide. Two young robins were found beneath a nest 1 d after exposure to acephate, both had abrasions suggesting avian predation.

Plasma ChE levels were sometimes depressed significantly in nestling robins when exposed to either acephate or carbaryl, and in mourning doves exposed to carbaryl (Fig. 1). Plasma ChE levels of treatment exposed robins were all below the regression line for control birds. Neither robins nor mourning doves had depressed brain ChE activity. Plasma and brain ChE activities are presented in Table 2. The depression of plasma ChE did not reduce fledging success of treatment birds in this study. Behavioral abnormalities are generally associated with brain ChE depression of 40-60% or greater (Grue et al. 1983). Stromborg et al. (1988) reported that the effects of dicrotophos (an OP insecticide) on nestling starlings (*Sturnus vulgaris*) were rapid, reversible in survivors, and did not extend into the postfledging period despite a 46% average depression in brain ChE activity.

Drift of insecticide from spray sites occurred in this study. A mean deposition level was calculated using the highest quantity of spray deposited on cards at each distance downwind from each spray site (Table 3). Drift amounts ranged from 0 to 12.79 L/ha at 7.6 m (25 ft) downwind from a spray site. The amount of active ingredient (AI) deposited in 12.79 L/ha was approximately 0.015 kg/ha of carbaryl, or 0.008 kg/ha of either acephate or diazinon. Carbaryl is commonly applied to fruit trees at a rate of 1870-2800 L/ha (200-300 gal/A), at concentrations used during this study. Various concentrations are used to apply carbaryl to fruit and nut trees, and acephate to ornamental and forest trees at 0.57-2.24 kg AI/ha.

This study suggests that skilled application of acephate and carbaryl to individual trees does not negatively affect hatching success or fledging rates of robins or mourning doves. Mourning dove nests exposed to diazinon were only 33% successful, but the small sample size did not provide significant results. The majority (62.5%) of all treatment nests were located in trees that

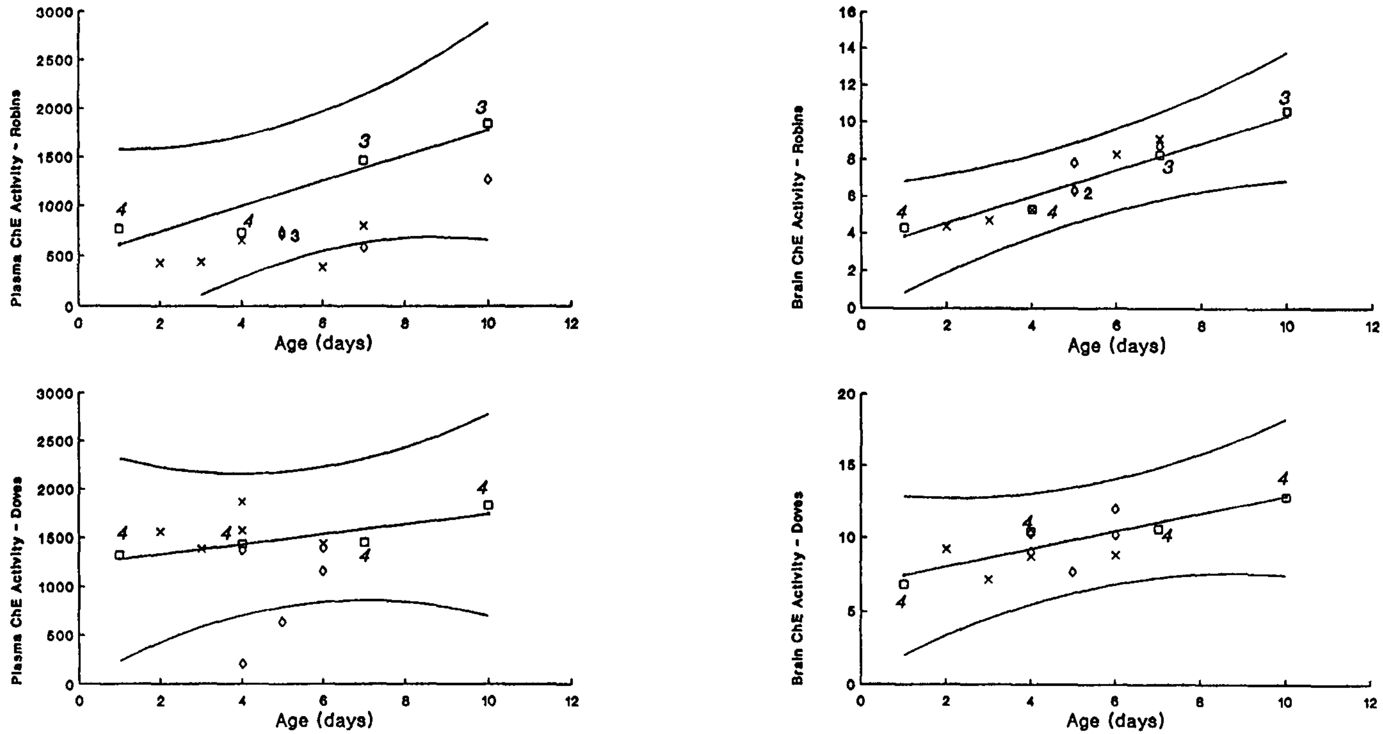

Figure 1. Plasma and brain cholinesterase (ChE) activity in control nestlings (□), and in nestlings exposed to acephate (×) or carbaryl (◇). ChE activity is expressed as μmoles acetylthiocholine iodide hydrolyzed per minute per ml of plasma or gram of brain tissue (wet weight). Numbers of birds are shown at points representing control means, and where points overlap. Ninety-five % confidence bands are represented by the bowed lines above and below the regression line.

were sprayed. Nests in sprayed trees and nests in which the adult left during spraying were as successful as those exposed only to drift, and those in which the adult remained on the nest. Plasma ChE levels were sometimes depressed in acephate and carbaryl-exposed nestlings, but brain ChE depression was not detected. Insecticides drifted from spray sites, but did not reduce nest success.

Table 2. Cholinesterase (ChE) activity of nestlings*

Treatment	Robin				Dove			
	Age (d)	n	Plasma ChE	Brain ChE	Age (d)	n	Plasma ChE	Brain ChE
Control	1	4	769	4.27	1	4	1318	6.81
	4	4	731	5.28	4	4	1430	10.41
	7	3	1464	8.23	7	4	1448	10.58
	10	3	1839	10.57	10	4	1827	12.80
Acephate	2	1	433	4.35	2	1	1556	9.23
	3	1	439	4.68	3	1	1381	7.15
	4	1	655	5.26	4	1	1866	8.71
	6	1	386	8.25	4	1	1568	8.77
	7	1	801	9.10	6	1	1433	8.84
Carbaryl	5	1	702	6.24	4	1	205	9.03
	5	1	720	6.37	4	1	1369	10.27
	5	1	743	7.80	5	1	632	7.67
	7	1	585	8.71	6	1	1392	10.20
	10	1	1269	11.05	6	1	1152	11.96

* μmoles acetylthiocholine iodide hydrolyzed per minute per mL of plasma or gram of brain tissue (wet weight).

Table 3. Quantity (L/ha) of pesticide deposited downwind of spray sites at various windspeeds

Distance		2-5 kph (1-3 mph)			6-11 kph (4-7 mph)		
m	ft	n	Mean	Range	n	Mean	Range
7.6	25	7	1.79	0.00-4.80	8	5.93	0.30-12.79
15.2	50	5	0.47	0.00-2.29	7	0.85	0.11- 1.46
22.9	75	2	0.17	0.00-0.34	6	0.19	0.00- 0.29
30.5	100	2	0.03	0.01-0.04	4	0.09	0.00- 0.18
47.7	150	0	--	--	2	0.05	0.02- 0.09

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