Residue Accumulation in White-throated Sparrows Fed DDT for 5 and 11 Weeks

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Although DDT has a number of undesirable side-effects on birds (see STICKEL 1968 or PIMENTAL 1971 for recent reviews), there is little published information on the chronic accumulation of DDT-derived residues (DDTR) in non-domestic species under controlled conditions. This is especially true for passerines. Most passerine residue studies have concentrated on determination of lethal dosages and associated residues (BERNARD 1963, HILL et al. 1971, STICKEL and STICKEL 1969, STICKEL et al. 1966a). Most information on sublethal DDT residue accumulation in birds comes from studies on chickens (CECIL et al. 1972, CUMMINGS et al. 1967, DRAPER et al. 1952) although some data are available on Bald Eagles, Haliaetus leucocephalus, (STICKEL et al. 1966b) and Starlings, Sturnus vulgaris (HARVEY 1967).

This report examines the accumulation of DDT-derived residues in White-throated Sparrows, Zonotrichia albicollis, after 5 and 11 weeks treatment with technical DDT at 5 or 25 ppm. The data were collected during a study of pesticide effects on migratory condition which will be published elsewhere.

METHODS

Birds were captured in the vicinity of Athens, Georgia, and held in individual Hendryx SB special cages for at least two months prior to initiation of dosage. Feed (Purina "Eggena") and water were available ad libitum. The aviary was a converted rooftop greenhouse subject to natural light and temperature conditions.

Diets of 5 and 25 ppm, dry weight basis, were prepared by mixing dry technical grade DDT (78.9% p,p-DDT and 21.1% o,p-DDT on the basis of 4 replicate analysis) into feed in a Hobart A-200 mixer.

The 60 birds were assigned at random to control, 5 ppm, and 25 ppm groups of initially equal size and sacrifice groups were randomly designated. At the initiation of dosage on March 13, 10 controls were sacrificed to determine baseline

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TABLE 1. DDTR residues in White-throated Sparrows fed technical DDT diets from March 13 to April 17 or May 29. Values are presented as $\bar{x} \pm$ se (n).

treatment and tissue	DDTR (ppm) April 17	DDTR (ppm) May 29	DDTR (log ppm + 1) April 17	DDTR (log ppm + 1) May 29	t value for log data	DDTR (total micrograms) April 17	DDTR (total micrograms) May 29	t value for total micrograms
5 ppm body	18.11 ±3.41 (7)	30.72 ±4.81 (10)	1.239 ±0.078 (7)	1.460 ± 0.063 (10)	* 2.210	115.4 ±22.0 (7)	284.7 ±46.6 (10)	* 2.861
5 ppm brain	6.22 ±0.60 (8)	6.90 ±1.13 (9)	0.845 ±0.042 (8)	0.867 ±0.057 (9)	0.256	1.355 ±0.195 (8)	1.278 ±0.246 (9)	0.251
25 ppm body	159.4 ±10.8 (10)	217.4 ±26.1 (8)	2.195 ±0.033 (10)	2.318 ±0.051 (8)	2.086	808.4 ±45.4 (10)	2001. ±232.6 (8)	*** 5.610
25 ppm brain	51.44 ±4.64 (9)	38.42 ±9.44 (8)	1.702 ±0.046 (9)	1.539 ±0.085 (8)	1.733	10.57 ±0.98 (9)	7.00 ±1.30 (8)	* 2.219

residues. Half of each remaining group was sacrificed on April 17 and May 29, 5 and 11 weeks after the initiation of dosage.

Pesticide residues, expressed as ppm on a dry weight basis, were determined for brains and prepared bodies. The bodies were prepared by skinning and removing feet, beaks, and digestive tracts to eliminate external or unabsorbed pesticide. Any fat adhering to the skin was scraped off and included with the body for analysis.

Samples were extracted for 16 hours in pre-extracted Whatman cellulose thimbles on a Soxhlet extractor and prepared using Acetonitrile-Florisil cleanup.

RESULTS AND DISCUSSION

All raw data sets were tested for normality using the central moment test given by SOKAL and ROHLF (1969). As found by ROBINSON et al. (1967) and HILL et al. (1971) pesticide residues expressed as ppm require a log transformation and all statistical testing was done on properly transformed data. However, total body burdens appeared to be normally distributed and no transformations were made for these data.

During the spring, this species, like other migratory birds, deposits a large amount of migratory fat (HELMS 1968, ODUM and PERKINSON 1951). This weight increase makes interpretation of residue results more difficult but reflects a natural and important phenomena affecting the storage of lipophilic DDT residues in wild migrants.

The absolute body burdens increased significantly between the 5th and 11th week of exposure at both treatment levels (Table 1). This increase is partially masked by increased body weight when ppm residue values are considered but the increase for the 5 ppm group is still significant while that for the 25 ppm group approaches significance. This indicates that the expected equilibrium level (ROBINSON 1970, STICKLE 1968) had not been reached after 5 weeks of exposure during the migratory period, probably due to the increased amount of migratory fat in which the pesticide is stored. The deposition of fresh lipid does not balance or dilute the added storage of pesticide, since concentration values increase, although only approaching significance in the 25 ppm group. STICKLE et al. (1966b) found equilibrium level had not been reached after 8 weeks in DDT-dosed Bald Eagles. In the rat, DDT equilibrium is obtained in from 7 to 23 weeks (HAYES 1965). The cited times are assumed to be for animals of constant weight for which the concept of an equilibrium level is more strictly applicable.

Absolute levels in brains of high treatment birds showed a significant decrease between the 5th and 11th week on dosage. (Table 1). The same trend was evident, but not statistically significant, for concentration values. There was no significant

TABLE 2. Metabolites of technical DDT in bodies and brains given as per cent of total DDT derived residues (DDTR). See Table 1 for DDTR levels.

date and tissue	treatment level	% of DDTR p,p-DDE	p,p-DDD	p,p-DDT
17 April body	5 ppm	22.8	32.6	44.5
	25 ppm	21.6	31.2	47.2
17 April brain	5 ppm	27.2	56.7	16.1
	25 ppm	32.5	56.0	11.4
29 May body	5 ppm	19.7	35.8	44.5
	25 ppm	22.9	25.7	51.4
29 May brain	5 ppm	36.8	40.6	22.6
	25 ppm	21.6	46.4	32.0

difference in brain weights. In the low treatment group, there was no significant change in either measure of brain residues. Constant or decreasing brain residues during a period of increasing body fat and body residues may indicate the temporary protective role of increased body fat in keeping lethal DDT levels from accumulating in the brain (STICKLE 1968). Of course, in nature these temporary fat stores would be rapidly depleted after migration (HELMS 1968), releasing stored pesticide into the blood and endangering the bird. Lethality resulting from fat loss through starvation in DDT burdened birds has been well documented (recently by ECOBICHON and SASCHENBRECKER 1969, PERSSON 1971, SODERGREN and ULFSTRAND 1972, and VAN VELZEN et al. 1972).

The much greater residue decrease in brains of high treatment birds can be explained by their greater body fat gain between the two sacrifice dates. For the 5 ppm birds the fat index (g dry fat x 100/g fat-free dry carcass weight) increased from 50.5 $\pm$ 11.4 to 103.7 $\pm$ 9.2 ($\bar{x}$ $\pm$ se) while in the 25 ppm group the gain was from 23.6 $\pm$ 6.2 to 119.5 $\pm$ 5.2. It should be emphasized here that the apparently greater migratory fattening in the more heavily treated birds does not indicate an improved storage of migratory fat. On the contrary, the greater lipid increase during the time period discussed here results from a suppression and delay of migratory fattening at the normal time (MAHONEY, in preparation) so that relatively more fattening occurred later, during the time period of this paper, in the more heavily treated birds.

Since residue results have been expressed only in DDTR, it would be of interest to briefly examine the major components of the total pesticide burden (Table 2). Although relative

amounts of the three chemicals probably changed during sample drying (JEFFERIES and WALKER 1966), a few generalities are worth noting. Considering all samples, the percentage of DDE is most consistent, varying only from 19.7 to 36.8%. These values agree well with several studies reviewed by CECIL et. al. (1972), which found DDE as either 22, 25, 33 or 66% of DDTR in birds fed technical grade DDT.

Brains contained considerably less unaltered DDT than bodies, about 1/4 in three of the four groups. The percentage of unaltered DDT varies by less than 10% when high and low treatment samples are compared for the same date or when comparing the values for the same type of treatment and sample on different dates. The only exception is 25 ppm brains which contained 11.4% DDT on 17 April and 32.0% on 29 May.

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