DDT in Connecticut Wildlife

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Contents

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The effects of insecticides on wildlife may be classified as either direct or indirect. The direct effect may be compared to acute toxicity, in which a single dose is applied to the animals, to the food consumed, or as in the case of aquatic animals, to the water in which they live. It occurs at or very near the site of application of the insecticide. Direct effects are usually evident within a few days of the time of treatment. The indirect effect is more analogous to chronic toxicity resulting from exposure to doses less than required to produce acute toxicity.

The report of Governor Dempsey's Committee (Wallace, 1963) stated: "Wildlife has been killed in Connecticut, not en masse, but accidentally in isolated instances. Without minimizing the desirability of preventing such accidents, these known deaths are not the major concern. Rather, the appearance and accumulation of DDT in fish and birds that have not been sprayed is the concern."

Connecticut was the first state to regulate airplane spraying by statute. The original statute of 1947 and each revision provides for a permit system. The records show that most of the airplane spraying with DDT has been done in the western half of the state for control of gypsy moths and mosquitoes. This suggested that a comparison of the amount of DDT in wildlife in "sprayed" western Connecticut and "unsprayed" eastern Connecticut might be revealing.

This preliminary study was initiated with the cooperation of Cole W. Wilde, Chief, Fisheries Division, and Arroll Lamson, Chief, Game Division, State Board of Fisheries and Game. Their interest in the study and contributions to it are acknowledged with thanks. The areas for collection of samples of fish, birds, and mice were selected on the basis of the records of spraying. Fish from both rivers and lakes were included.

The analyses were made by Lloyd G. Keirstead of the Station staff and are acknowledged with thanks both for selection of methods and for careful and meticulous work.

The data in Tables 1 and 3 were obtained by following the Official Method for food products, Sec. 24, 106C, as published by Horowitz (1960). The determination of DDT in this procedure was by the Schecter-Haller colorimetric test. Data in the other Tables were obtained by following Sec. 2.21A of the procedure of Barry and Hundley (1963). The determination of DDT and related compounds was by gas chromatography. In this method, *p,p'* DDT (the isomer most toxic to insects) is measured separately from *o,p'* DDT (a less toxic isomer present in varying amounts) and TDE (another chlorinated insecticide, in animals probably produced by metabolic processes from DDT). The amounts of the measurements may be combined to provide figures comparable with the results of the Schecter-Haller test.

In accordance with common practice in toxicology, the DDT content

has been expressed as parts per million (ppm) of fresh weight. This is identical with milligrams per kilogram (mg/kg) which is also found in publications on toxicology.

Fish

In the "sprayed" section of the state, samples of yellow perch were collected by staff workers of the Fisheries Division from one lake, one river, and three impoundments in rivers.

The lake was Bantam Lake, located in Litchfield and Morris, in which towns some 25,230 acres of woodland were sprayed by airplane in the period 1954-1962.

The river was the Pomperaug, tributary to Lake Zoar in Southbury, where some 14,700 acres have been sprayed for control of the gypsy moth.

Two of the impoundments were in the Farmington River watershed. The Compensating Reservoir is in the West Branch of the Farmington River in the towns of Barkhamsted and New Hartford. Gypsy moth spraying in these towns has been done on 19,640 acres. Rainbow Reservoir is in the Farmington River in the towns of Windsor and Bloomfield. Gypsy moth spraying in these two towns has amounted to about 3,000 acres. The other towns through which the Farmington River flows have sprayed about 60,000 acres. The third impoundment is Lake Zoar in the Housatonic River. The three towns, Newtown, Oxford, and Southbury, have sprayed about 22,000 acres, and some 80,000 acres have been sprayed in the watershed.

Table 1. **DDT in whole yellow perch (on the basis of fresh weight), 1963**

Location	Area Sprayed *Acres*	Age of fish *Years*	DDT *ppm*
	"Sprayed Area"		
Compensating Reservoir	19,640	4	1.8
Rainbow Reservoir	60,000*	4	1.3
Bantam Lake	25,230	2	0.5
Pomperaug River	14,770	2	0.5
Lake Zoar	22,000 (80,000)*	3	0.5
		2	0.5
		Average	0.8
	"Unsprayed Area"		
Aspinook Pond		3	0.9
		2	0.8
Wamguambaug Lake		3	0.3
			0.8
Gardner Lake		4	0.6
		3	0.3
			0.4
Mashapaug Lake		4	0.2
		3	0.1
		1	0.4
		Average	0.5

* Spraying in the watershed

In "unsprayed" eastern Connecticut, samples were taken from three lakes and one impoundment. The lakes were Wamgumbaug in Coventry; Gardner in Salem, Bozrah, and Montville; and Mashapaug in Union. The impoundment was Aspinook Pond in the Quinebaug River, bordered by Lisbon and Griswold.

The areas from which other samples were taken are mentioned with the results.

Analyses of the yellow perch is given in Table 1. The age of the fish is given because the older the fish the more opportunity for accumulation of DDT. These results show that there was a difference in the average amounts of DDT in fish from the two areas. The DDT content of two lots of fish from the sprayed area exceeded the largest amount found in a sample from the unsprayed area. However, the content in four lots from the unsprayed area was greater than four from the sprayed area. The significance of these and other results will be discussed later.

One female lake trout from Wononscopomuc Lake in Salisbury was submitted by Cole W. Wilde. This trout was taken alive in the fall of 1963 as a source of eggs. The records show that 2,080 acres in this town were sprayed in 1957 for control of gypsy moth, and that the edge of the sprayed area was more than one-half mile from the edge of the lake. The results of the analyses are summarized in Table 2. The size of this trout necessitated analyses of tissues. Direct comparison with the results from whole perch is difficult. However, the flesh of the trout contained a total of 1.8 ppm DDT and its degradation products, which was as much as the maximum found in whole perch.

The Shade Tobacco Growers Association submitted samples of fish caught in an old tobacco irrigation pond. This pond is more than an acre in size, surrounded on all sides by tobacco fields, and fed by springs and by drainage. Yellow perch contained 3.6 ppm DDT, an eel 2.0 ppm, and bullheads 0.6 ppm.

The Madison Fish and Game Club cooperated by furnishing trout from two locations on the Hammonassett River. Woodlands near the river had been sprayed with DDT before May 25 to control gypsy moth, and there were rumors that trout contained large amounts of DDT. The fish were caught on May 31. The stomach contents contained no DDT. Flesh of fish from the two locations contained 0.2 and 0.4 ppm DDT, and viscera 0.7 and 1.8 ppm. The absence of DDT in the stomach contents suggested that the 1963 gypsy moth spraying was not the source

Table 2. **DDT Content of lake trout tissues (on the basis of fresh weight)**

Tissue	p,p′ DDT *ppm*	TDE and o,p′ DDT *ppm*
Visceral fat	3.8	1.8
Flesh	1.1	0.7
Kidney	0.1	trace
Liver and gall bladder	1.1	1.2
Ovary	0.2	0.1
Stomach and intestine	0.8	0.3
Eggs	0.5	0.3

of DDT in these fish. These trout were reared in a hatchery, and released in the river just before the opening of the fishing season.

Van Valin *et al.* (1964) have reported that trout from five hatcheries, fed various diets, all contained DDT. The range was from 0.07 to 1.3 ppm, with variations between hatcheries, samples, and diets.

Shellfish

A sample of mussels was collected in Madison on June 14, 1964. These contained 0.013 ppm of DDT and 0.013 ppm of degradation products of DDT. The calculation was made on the basis of the fresh weight of the edible portion.

Oysters were collected from the Housatonic River by Ernest J. Bontya of the Shell Fish Commission in November, 1964. These contained 0.03 ppm DDT, 0.04 ppm DDE, and 0.008 ppm dieldrin. Butler (1964) has recently published results of studies of accumulation of DDT in oysters. He reported that oysters exposed to .0001 ppm would contain 7.0 ppm DDT at the end of 40 days. Further, he found that transfer of oysters to unpolluted water resulted in a decrease in DDT.

In this case the Connecticut oysters were either exposed to a much smaller amount of DDT than .0001 ppm, or exposure to DDT was followed by unpolluted water. The same is true of dieldrin, which Butler (1964) reported as accumulating at 3.5 ppm after 60 days of exposure to dieldrin at .001 ppm.

Birds

Eleven species of birds were collected by Arroll Lamson from Pine Mountain in Hartland, in an area that had been sprayed in 1961. No spraying was done there in 1963. Nine species were taken in Natchaug Forest, Eastford, where no airplane or ground spraying has been done.

Table 3. **DDT in viscera of birds (on the basis of fresh weight)**

Species	DDT content	
	Pine Mountain *ppm*	Natchaug Forest *ppm*
Towhee	0.3	0.1
Wood Thrush	0.7	0.1
Red-Eyed Vireo	0.4	0.1
Blue Jay	0.5°	0.2
Nuthatch	0.3°	0.6°
Flicker	0.6	
Ovenbird	0.7	
Scarlet Tanager	0.5	
Veery	0.5	
Rose-Breasted Grosbeak	0.4	
Wood Pewee	0.8	
Hairy Woodpecker		0.2°
Cowbird		Less than 0.1°
Chicadee		0.3
Blue-Winged Warblers		0.5
Average	0.52	0.23

° Immature

Table 4. **DDT and other insecticides in viscera of migrating birds (on the basis of fresh weight)**

Type of Bird	Number of birds	DDE *ppm*	DDT *ppm*	Dieldrin *ppm*	Heptachler epoxide *ppm*
Indigo buntings	3	0.37	0.06	0.04	present
Catbirds	8	0.34	0.10	°	"
Flycatcher	1	0.75	0.14	0.04	"
Redstart	2	0.80	0.16	0.04	"
Sparrows	5	0.18	0.008	0.006	not detected
Tanagers	9	0.18	0.08	0.01	0.01
Thrushes	12	0.75	0.32	0.08	present
Warblers A	6	1.47	0.32	0.06	0.02
Warblers B	20	0.41	0.13	0.02	0.02
Warblers (oven birds)	3	0.34	0.11	0.01	0.01

° The extracts contained an unidentified substance that interfered with the dieldrin determination.

Results of analyses are given in Table 3. As in the case of fish, birds from the sprayed area contained on the average more DDT than those from the unsprayed area. One of the five species, the nuthatch, common to both areas, contained more DDT in the unsprayed area. It is noteworthy that immature birds from both areas contained DDT, although no DDT was sprayed on either site in 1963.

Sixty-nine birds killed by flying into a ceilometer at an airport during a storm were submitted by Arroll Lamson in October, 1963. Results of analyses of the viscera are given in Table 4. These birds obviously were migrating and probably did not breed in Connecticut. The point of interest is that all contained DDT, and many in larger quantities than birds collected in Connecticut during the breeding season. All samples contained dieldrin in very small amounts, and all but one, heptachlor epoxide in even smaller quantities.

Mice

Two species of mice were trapped by Arroll Lamson in three locations: (1) An area in West Simsbury where a great deal of airplane spraying had been done for control of mosquitoes, (2) Pine Mountain in Hartland, and (3) Natchaug Forest in Eastford. The results are presented in Table 5, with the locations given in the order of amount of airplane spraying.

Kidneys were selected for analyses because of the statement of Ludwig and Chanutin (1964) attributed to a personal communication of Lang, that "By far, the greatest amount of DDT was found in the perirenal fat." Mr. Keirstead has pointed out in his report that the kidney of a mouse weighs only one-fourth of a gram, and that two of the samples were of only one mouse. This small number of specimens does not furnish a sufficient basis for any detailed conclusions. About all that can be said with confidence is that all mice contained DDT and that red-backed mice contained more than deer mice from the same location.

Table 5. **DDT residues in mouse kidneys**

Location	Species	DDT and metabolites	
		Whole kidneys *ppm*	Kidney fat *ppm*
West Simsbury	deer mice	0.10	2.24
	red-backed mice	0.25	3.45
Pine Mountain	deer mice	0.08	2.31
	red-backed mouse	0.32	6.25
Natchaug Forest	deer mice	0.03	1.01
	red-backed mouse	0.73	8.19

Lehman (1952) has determined the accumulation of DDT in rats after 15 weeks of feeding at four rates of DDT. By extrapolation, the mice may have been exposed to the equivalent of as little as 0.06 ppm or as much as 0.6 ppm of DDT in food for 15 weeks.

Discussion

These results establish that DDT is present in fish, shellfish, birds, and mice in areas where no airplane spraying has been done. The amounts in whole fresh fish varied from 0.1 to 0.9 ppm, in the viscera of birds from less than 0.1 to 0.8 ppm, in shellfish from 0.031 to 0.07 ppm, and in mice from 0.03 to 0.73 ppm fresh weight (1.01 to 8.19 ppm "fat basis").

Fish and birds from areas in which airplane spraying had been done in the recent past (but not the season samples were taken), contained more DDT on the average, than those from the unsprayed areas. In both fish and birds there were specimens from the sprayed areas which contained less DDT than some from the unsprayed areas.

The relatively small differences in DDT content of both fish and birds from sprayed and unsprayed areas were unexpected. Perhaps the most logical explanation might be that the sprayed areas were sprayed in the past, and that the proportion of the direct residue getting into the food chains was lower than the proportion of the contamination which occurred in unsprayed areas.

There was poor agreement between the known amount of airplane spraying and the accumulation of DDT in fish. The largest accumulation was in fish from an irrigation pond surrounded by tobacco fields. However, Rainbow Reservoir, in the same tobacco area, had fish with less DDT than from Compensating Reservoir, located in a non-agricultural area.

There was also lack of consistency between long rivers and short, and between rivers and lakes.

It has been difficult to compare quantities of DDT found in Connecticut with those in other areas because of differences in both tissues analyzed and basis of calculation. Thus Tompkins (1964) has reported results calculated on dry weight, and apparently analyzed the wall of the digestive tract rather than the entire fish. Fresh fish contain approximately 75 per cent water. The amount of DDT in visceral fat of

lake trout (Table 2) was three times as much as in flesh. Multiplying the amount of DDT in our Table 1 by a factor of 12 brings the results within the range reported by Tompkins (1964).

The results from the lake trout appear to be about the same as found in lakes in New York where little spraying had been done, as reported by Burdick *et al.* (1964).

The residues in birds from sprayed areas in Connecticut were somewhat lower than from birds taken in a New Mexico forest before spraying, as reported by Pillmore *et al.* (1964).

The exact significance of residues of this size on the health of the wildlife cannot be determined at this time. The toxicological studies reported in the literature have been carried out with dosages far larger than indicated by these analyses. Further evaluation of the significance of the findings must await additional toxicological studies.

Both the data obtained in this study and some other published information can be used to speculate on the means of transport of DDT from sprayed to unsprayed areas.

Three means of transport are obvious: (1) Migration of wildlife, (2) movement of water, and (3) movement of air.

Migrating fish and birds are known to carry residues. Fish do not migrate from one watershed to another, however, and it would be difficult to imagine transfer in quantity by birds to water. As a matter of fact, the amount of movement seems far beyond the capacity of migrants.

Movement of water can undoubtedly transport some DDT. However, it cannot account for contamination of entire unsprayed watersheds.

Thus, if only by a process of elimination, movement of DDT in air seems to be probable. Information now available seems to support this hypothesis. The deposit on plates from airplane spraying with DDT at the rate of one-half pound per acre was .06 to .21 pound per acre in the open (Turner, 1963). In other words, less than half the DDT released reached the ground below the plane. Some was undoubtedly deposited nearby as "drift." Carroll (1964) has measured the amount of drift to areas adjacent to airplane spraying. When his figures are reduced to dosage per acre, drift of deposits varied from 1.5 to 3.6 ounces per 100 acres. Thus a large portion of the DDT discharged from an airplane must travel for some distance in the air before being deposited. This amount is supplemented by DDT evaporating from sprayed leaves. Kirk (1952) has reported a 70 per cent "loss" of DDT from shaded potato leaves in three days.

Additional evidence is contained in the statement of Anderson (1964): "The Air Sampling Network recently studied a group of 15 samples of air from 9 different localities in the country and found varying levels of DDT." Sheldon *et al.* (1964) reported traces of DDT in two samples, 0.7 mg DDT in one sample and 45.0 mg DDT in another. In their method a glass tube filled with glass wool coated with mineral oil was attached to the outside of an aircraft. The tube with 45.0 mg was exposed one-half hour above an area immediately after treatment with DDT.

Thus DDT is known to "disappear" in the air, and has been recovered from samples of air. The exact means by which it is deposited on the ground or in water has not been determined.

It is apparent that the food chains of birds and fish in areas unsprayed by airplane contain 45 to 60 per cent as much DDT on the average as food chains in some sprayed areas.

One of the purposes of a preliminary study is to provide results to use in planning further work. State regulatory agencies have assumed that accumulation of any quantities of DDT in unsprayed areas is undesirable, and have taken the steps necessary to reduce the amount of DDT used. Analyses to measure the effect of reduction in use might be more informative than continued general surveys.

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Appendix. After this manuscript was in the process of publication, the Connecticut River Watershed Council published a report on "A pesticide study on the Westfield, Farmington, and Connecticut River watersheds." The sponsoring agencies were the Connecticut, Farmington, and Westfield River Watershed Associations and the New England Interstate Water Pollution Control Commission. Cooperating agencies were the Connecticut Board of Fisheries and Game, Massachusetts Division of Fisheries and Game, and Massachusetts Health Research Institute. The Project Director was W. A. Tompkins of the Massachusetts Division of Fisheries and Game.

Analyses were reported of fish, bottom fauna, and mud from five locations in Connecticut in 1963 and 1964, one location in 1963, and one in 1964. The discussion of results includes the following points: "A. Lack of any obvious relationship between pesticides applied to a watershed and residuals in aquatic life . . .; B. Apparently great decrease in DDT residuals in fish from summer 1963 to spring 1964 . . .; C. Apparent lack of increase of DDE in relation to DDT from 1963 to 1964 . . .; and D. Appearance of relatively high DDT residues at a few stations."

The detailed results supplement those reported in this bulletin. They also establish the large differences in DDT content of fish from the same source in the same season.