Organochlorine Insecticide Residues in Ducklings and Their Dilution by Growth

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Dieldrin, an organochlorine insecticide, was used extensively in the prairie region of Alberta for control of grasshoppers from 1960 to 1964. Sloughs and marshes, often catchment basins for the farmlands, are breeding sites for many species of ducks. As use of these insecticides increased, contamination of the aquatic environment and, in time, of the entire ecosystem seemed inevitable.

Most organochlorine insecticides are persistent and accumulate in tissues of ducks (HEATH 1969) because of their high lipoid solubility.

BERNARD (1963) suggested that DDT may be passed on directly from the female robin to the eggs and young. SHELDON et al. (1962) found that 61% of the waterfowl and all clutches of eggs collected near Yellowknife, North West Territories, contained DDT and its metabolites ranging in amounts from 0.0 to 1.0 ppm in ducks and from 1.3 to 4.0 ppm (average 2.2 ppm) in eggs. SHELDON et al. (1963) again identified insecticides in waterfowl eggs from North America in 1963. STICKEL et al. (1963) found DDT or its metabolites in black duck and osprey eggs from the Atlantic coast. SHELDON et al. (1962) noted that the eggs contained higher concentrations of DDT and metabolites than did the mature ducks.

Residues of DDE have been shown to result in egg-shell thinning (LANGCORE et al. 1971; HAEGELE and TUCKER 1974; HASELTINE et al. 1974) in various species of ducks.

Some insecticide residues are excreted by contaminated birds (EVANS 1974), possibly through the preen gland (CHARNETSKI and STEVENS 1974). Hence, some birds may be able to reduce their levels of residues by means other than metabolism.

The present study, conducted in 1964, was designed to establish the levels of dieldrin and DDT, DDE, and DDD in ducklings and to determine if the dieldrin used between 1960 and 1964 contributed to their residue load.

Description of Study Area

Ducklings were collected from ponds within a 15-km radius of Strathmore, Alberta. Much of the area is scrub pasture land, the arable area is devoted to mixed farming, including some irrigation. Drainage could facilitate the movement of insecticides to ponds, sloughs, and irrigation canals. During spring runoff, some ponds

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interconnect; during the summer, however, most water entered the test area through irrigation canals.

MATERIALS AND METHODS

Sampling and Duckling Classification

The muscle and fat were analysed for residues in ducklings of 7 species, the baldpate or American Widgeon (*Mareca americana*), the gadwall (*Anas strepera*), the pintail (*A. acuta*), the blue-winged teal (*A. discors*), the mallard (*A. platyrhynchos*), the lesser scaup (*Aythya affinis*), and the shoveller (*Spatula clypeata*). The birds were shot and weighed, and their sexes and ages were determined. The ducklings were frozen within 24 hr of collection and kept frozen until 24 hr before analysis. From 3 species, 34 birds (8 baldpates, 15 gadwalls, and 11 pintails) were chosen at random for the growth dilution portion of the study. In addition, supplemental analyses were conducted on 11 birds, chosen at random, of 4 species (3 blue-winged teal, 6 scaup, 1 mallard, and 1 shoveller). These birds are referred to here as "other species".

The muscle samples were taken from the breast, but when sufficient breast muscle was unavailable, leg muscle was taken. Samples of subcutaneous fat were taken from the thigh.

Method of Sample Cleanup and Analysis

The methods of LANGLOIS et al. (1964) and STEMP et al. (1964) were modified for use in determining the insecticide content. Twenty-five grams of deactivated Florisil (5% water was mixed with the activated Florisil and the mixture held in an airtight container for 48 hr) was added to a Pyrex chromatographic column (20 mm inside diameter x 600 mm long) with a glass-wool plug at the base. The Florisil was washed with a 50:50 mixture of methylene chloride and petroleum ether. The sample, ground with 30 g deactivated Florisil to a free-flowing powder, was added to the pre-washed column and eluted with 700 ml of 20% methylene chloride in petroleum ether. The eluate was collected and evaporated to near dryness at 55°C. The final extract was made up to 10 ml (with spectroanalyzed n-hexane) and an aliquot of the resulting solution was injected into the gas chromatograph. An analytical column packing of a mixture of 6% QF-1 and 4% SE-30 mixed silicone on 60/80 mesh acid-washed Chromosorb W (McCULLY and McKINLEY 1964) was used.

A control extraction based on DDT, DDD, DDE, and dieldrin standards was made with each set of 8 sample extractions.

A Model 680-A Varian-aerograph gas chromatograph with oven temperature at 180°C and injector and detector at 185°C was used for the analyses. The injection port was equipped with a Pyrex liner to prevent decomposition of insecticides. The nitrogen carrier flow was maintained at 40 ml/min.

The amount of insecticide was calculated by comparing the area of each unknown peak to that of a reference standard.

RESULTS AND DISCUSSION

Quantitative determinations were made for dieldrin, DDE, DDD, and DDT. For this study, however, the residue levels for DDE, DDD, and DDT were totalled and are reported here as DDTT.

Total Duckling Residue Load

The levels of DDTT in the 45 ducklings ranged from 0 to 36.48 ppm in the fat of 96% of the birds and from 0 to 0.97 ppm in the muscle of 67% of the birds. The levels of dieldrin were lower, ranging from 0 to 2.62 ppm in the fat and from 0 to 0.11 ppm in the muscle of 43 and 19% of the birds, respectively. Because organochlorine insecticides are lipophilic, the higher levels in fat tissue are not unexpected.

The percentages of ducklings falling into 4 ranges of residue levels are shown in Table 1. Pintails had the largest percentage (72) over 0.5 ppm DDTT in the fat, while gadwalls (53) and "other species" (44) were next and baldpates had the smallest percentage (13). DDTT levels in muscle were lower, only 9% of the pintails and 7% of the gadwalls registering over 0.5 ppm.

Dieldrin levels were lower than DDTT with only pintails and "other species" registering levels over 0.5 ppm in the fat. The gadwalls had the greatest proportion of birds with no dieldrin in the fat. The ranking of zero dieldrin residues in muscle was "other species" (91%), gadwall (87%), baldpate (63%), and pintails (55%).

The most probable source of contamination of the ducklings was the parent duck, the insecticide being transferred through the egg.

No dieldrin or DDT residues were found in ducklings' food sources analysed. In addition, there is no record of DDT use in the area. The use of dieldrin in this habitat cannot be considered a contributing factor because the insecticide concentrations decreased with duckling weight.

TABLE 1

Percentages of ducklings with various levels of residues of DDTT[a] and dieldrin

Species	Residue and tissue	Residue level (ppm, wet weight)			
		0	Trace-0.50	0.51-1.00	1.01
Pintail (11)[b]					
	DDTT				
	Fat	0	27	36	36
	Muscle	18	73	9	0
	Dieldrin				
	Fat	55	27	0	18
	Muscle	54	46	0	0
Gadwall (15)[b]					
	DDTT				
	Fat	7	40	7	46
	Muscle	13	80	7	0
	Dieldrin				
	Fat	67	33	0	0
	Muscle	87	13	0	0
Baldpate (8)[b]					
	DDTT				
	Fat	0	87	0	13
	Muscle	62	38	0	0
	Dieldrin				
	Fat	50	50	0	0
	Muscle	63	37	0	0
Other species (11)[b]					
	DDTT				
	Fat	0	55	18	27
	Muscle	27	73	0	0
	Dieldrin				
	Fat	55	27	18	0
	Muscle	91	9	0	0
Total (45)[b]					
	DDTT				
	Fat	2	49	16	33
	Muscle	27	69	4	0
	Dieldrin				
	Fat	58	33	4	4
	Muscle	76	24	0	0

a - Total DDT, DDE and DDD.

b - Number of birds analysed.

Growth Dilution of Residues

The average levels of DDTT and dieldrin residues in the fat and muscle of baldpate, gadwall, and pintail ducklings were compared by weight groups (Table 2). The relationship of residues to weight is very pronounced; concentrations of both DDTT and dieldrin in fat and muscle samples decreased as weight increased in all these species of ducklings. This trend of decreasing residues is more obvious when comparing DDTT levels than dieldrin levels (especially in pintails and gadwalls) because of higher DDTT levels. Nevertheless, the results indicate the importance of growth dilution as a factor in reducing concentrations of insecticide residues when birds are exposed to an uncontaminated habitat.

TABLE 2

The average concentrations of DDTT[a] and dieldrin in duckling fat and muscle compared to duckling weights by species

			Average concentration (ppm, wet weight)			
			DDTT[a]		Dieldrin	
Species	Weight[b] group	No. birds	Fat	Muscle	Fat	Muscle
Pintail	I	4	12.18	0.48	0.36	0.04
	II	2	2.02	0.04	0.01	0.00
	III	5	0.34	0.02	0.03	0.00
Gadwall	I	11	7.19	0.14	0.08	Trace
	II	2	0.25	0.02	0.00	0.00
	III	2	0.01	0.01	0.01	0.01
Baldpate	I	4	0.47	0.02	0.01	Trace
	II	2	0.30	0.00	0.00	0.00
	III	2	0.09	0.04	0.00	0.00

a - Total DDT, DDE, DDD.

b - Weight group I = 0 to 200 g.
- Weight group II = 201 to 400 g.
- Weight group III = 401 g. and over.

The possibility of excretion along with volatilization or degradation of insecticides, however, cannot still be overlooked.

The differences in initial concentrations between species could be due to geographical differences between wintering areas, since the ducks from the Strathmore area use the Central and Pacific Flyways. In addition, the random manner of collection was not selective for ducklings whose parents were exposed to insecticides in their wintering areas.

It is concluded that residues of DDTT (DDT, DDE, and DDD) and dieldrin were transferred to the ducklings from the hen via the egg. The adult birds had evidently accumulated this insecticide in an area other than the breeding area, because DDT was not used in the study area and because no DDT or dieldrin were found in the duckling food sources. Therefore, the use of dieldrin, for grasshopper control, did not result in any detectable increase in the residue load of the birds studied.

The apparent decrease in residues of DDTT and dieldrin can be partially accounted for by the effects of growth dilution.

SUMMARY

Residues of DDT, DDD, DDE, and dieldrin in 7 species of ducklings from Alberta, Canada, were measured. Levels of DDT and metabolites ranged from 0 to 36.48 ppm in fat of 96% of the birds and from 0 to 0.97 ppm in muscle from 67% of the birds. Residue levels of dieldrin ranged from 0 to 2.62 ppm in fat and from 0 to 0.11 ppm in muscle of 43 and 19% of the birds, respectively.

Growth dilution was considered to be the most significant factor in reducing the insecticide residue levels in the ducklings. DDTT (total DDT, DDE, and DDD) residue levels were decreased with increased weight of pintail (*A. acuta*), baldpate (*Mareca americana*), and gadwall (*A. strepera*) ducklings.

Dieldrin used in grasshopper control did not contribute to residue levels in the ducklings. Contamination by DDT was considered to have originated from outside the habitat. No dieldrin or DDT residues were found in ducklings' food sources analysed.

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