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Organochlorine Residues in Bird Species Collected Dead in Ontario 1972–1988

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Organochlorine residues have been reported in many species of birds found dead or shot around the Great Lakes Basin. Raptors and fish-eating birds have had very high residues in the past while terrestrial seed- and insect-eaters have had relatively low residues (Frank et al. 1975, 1983; Sileo et al. 1977). Most of the organochlorine insecticides like DDT, aldrin, dieldrin, chlordane, endrin and heptachlor have been removed from field use, and controls have been placed on the dispersal of organochlorine industrial chemicals like mirex and PCB. These substances are very persistent. The major sources of contamination now are environmental residues picked up by birds in their normal feeding. These compounds bioaccumulate in bird species, and the highest residues accumulate at the top of the food chain. This paper is a compilation of data obtained from dead birds collected in the Great Lakes Basin over the last 16 years and analyzed for organochlorine contaminants.

METHODS AND MATERIALS

Between 1972 and 1988, dead birds were collected by staff of the Ontario Ministry of Natural Resources and submitted to the Department of Avian Pathology at the University of Guelph for clinical examination and diagnosis. As part of that procedure birds not obviously diseased were submitted to the Agricultural Laboratory Services Branch, Ontario Ministry of Agriculture and Food for analyses to assist in diagnosis. Some of these birds were obviously poisoned while others appeared normal or emaciated but an exact diagnosis of death was not possible. The birds have been categorized for review to determine if a trend could be determined over the last two decades. Small birds were submitted for analysis as whole carcasses while for larger birds clinicians dissected out and submitted specific tissues or organs for analyses.

Organochlorine insecticides and PCB, in tissues, organs, eggs and carcasses were extracted and cleaned up according to the procedure described by Frank et al. (1975, 1983). PCBs were

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separated from other organochlorine compounds including hexachlorobenzene (HCB), DDT, heptachlor expoxide, dieldrin, chlordane and mirex, on a charcoal column as described by Holdrinet (1974). The analysis for mirex and chlordane was initiated in 1976 according to the procedure of Holdrinet (1979).

Extracts were analyzed by gas-liquid chromatography (GLC) with an electron-capture detector. Residue identity was confirmed on random samples by thin-layer chromatography (TLC); appropriate areas of the chromatogram were removed, extracted, and re-examined by GLC. The presence of mirex was further confirmed by the nitration procedure as described by Holdrinet (1979).

Recoveries of pesticides, and PCBs were checked periodically by fortification of tissue homogenates before Soxhlet extraction. Average recoveries were as follows: p,p' DDT 89%, p,p' DDE 96%, p,p' TDE (DDD) 94%, o,p DDT 91%, dieldrin 89%, heptachlor epoxide 91%, HCB 74%, cis and trans-chlordane 87%, mirex 76%, and PCBs 85 to 90%. The data do not include corrections for recovery. Quantitation limits, below which values were designated as either trace or not detected, were set at 0.005 ug/g in fat for all organochlorine insecticides and 0.05 ug/g in fat for PCBs.

PCB estimations were based on comparison with standard mixture of Aroclors 1254 and 1260 and were quantitated by comparison of the sum of peak heights of VII, VIII, and X according to the Reynolds (1971) numbering system. The ratio of Aroclor 1254 to Aroclor 1260 in the standard mixture varied from 5:1 to 4:1. Reported values of chlordane residues represent the total of the cis and trans-chlordane isomers plus trans-nonachlor.

RESULTS AND DISCUSSION

The accumulated residue data on birds analysed between 1972 and 1988 were compiled and appear in Tables 1 to 4. Birds were categorized into the following four groups: (i) terrestrial seed-eaters, (ii) birds associated with the aquatic environment, (iii) raptors and (iv) gulls and terns.

The lowest brain residues were found in the seed eating birds (Table 1). Organochlorine residues among the group rarely exceeded 1.0 mg/kg and many were below 0.1 mg/kg throughout the two decades of sampling. A puree of two grackles and a liver from a robin were exceptions which exceeded these levels. No trend in organochlorine residues could be discerned between 1972 and 1985.

Organochlorine residues in birds associated the aquatic environment contained higher residues than the seed eaters (Table 2). Residues of t-DDT and PCB were above 0.1 mg/kg and frequently above 1.0 mg/kg with some above 10 mg/kg. Five great blue herons were analysed between 1973 and 1985 and brain and

Table 1. Organochlorine residues in the tissues of terrestrial seed-eating birds collected 1972 to 1988.

Year	Bird species	Location (County)	Tissue	Mean content in wet tissues (mg/kg) Number	t-DDT	Dieldrin	Chlordane	Heptachlor epoxide	PCB
1973	House sparrow	Wellington	puree	1	0.02	0.01	0.01	0.02	0.1
	Boat-tailed grackle	Niagara	puree	2	2.63	1.12	0.05	0.45	0.5
1974	Black-capped chickadee[1]	Wellington	puree	1	0.02	0.02	0.01	0.01	0.1
	Blue jay	Wellington	brain	1	0.21	0.002	0.001	0.001	0.2
			liver	1	0.16	0.001	0.001	0.001	0.2
			gizzard	1	0.01	0.001	0.001	0.001	0.04
	American woodcock	Bruce	muscle	12	0.89	0.04	0.01	0.01	0.4
	Rock dove	Peel	brain	2	0.03	0.001	0.001	0.003	1.2
			liver	2	0.005	0.002	0.002	0.01	0.3
			kidney	2	0.007	0.003	0.001	0.01	0.02
1975	House sparrow	Wellington	puree	2	0.08	0.01	0.01	0.01	0.6
1976	Mourning dove	Brant	muscle	5	0.24	0.01	0.003	0.007	0.05
1978	American woodcock	Bruce	muscle	4	0.02	0.003	0.001	0.001	0.3
1980	American robin	Wellington	brain	1	0.93	0.01	0.01	0.01	0.2
			liver	1	8.0	0.10	0.01	0.07	0.4
1981	Cuckoo	Waterloo	brain	1	0.04	0.01	<0.001	<0.001	0.1
			liver	1	0.07	0.007	<0.001	<0.001	0.1
1988	American robin	Wellington	brain	1	0.02	0.02	<0.001	0.006	0.23

[1]Endosulfan 0.007 mg/kg

Table 2. Organochlorine residues in the tissues of birds feeding in an aquatic environment collected 1972 to 1988.

Year	Bird species	Location	Tissue	Number	Fat(%)	Mean content in wet tissues (mg/kg) t-DDT	Dieldrin	Chlordane	Heptachlor	PCB
1972	Oldsquaw	L. Huron	muscle[1]	12	6.5	1.47	0.30	<0.01	NA	9.1
1973	Oldsquaw	L. Erie	fat[1]	1	69.3	15.3	5.83	0.21	NA	62
	Oldsquaw	L. Huron	muscle[1]	12	4.1	1.29	0.42	0.20	NA	4.1
	Mallard	L. Erie	liver	1	2.0	1.13	0.02	0.02	NA	8.2
	White-winged scoter	L.	muscle	6	4.2	0.55	0.04	0.01	NA	3.3
	Great blue heron	L. Ontario	liver	1	2.6	1.17	0.02	0.01	NA	5.4
			kidney	1	2.0	1.04	0.01	0.01	NA	4.0
1974	Mallard duck	L. Ontario	gizzard	2	-	0.01	0.01	<0.01	0.01	0.05
	Great blue heron	S.W. Ont.	brain	1	5.8	10.3	1.01	0.02	0.20	37
			liver	1	2.6	39.2	0.65	0.04	0.01	180
	Blue goose (J)	L. Simcoe	liver	2	2.2	0.03	0.52	0.01	0.01	0.2
1979	Wood duck	L. Simcoe	egg	2	9.6	0.20	0.008	<0.01	0.01	0.1
	Mallard	L. Simcoe	egg	1	46.0	0.24	0.06	0.18	0.01	0.2
1981	Great blue heron	S.W. Ont.	brain	1	NA[3]	0.28	0.02	0.02	0.01	0.1
			liver	1	NA	0.67	0.05	0.08	0.04	0.6
			kidney	1	NA	0.39	0.02	0.02	0.01	0.6
1982	Common loon	N.E. Ont.	brain	1	7.5	0.42	0.03	0.04	0.004	40
			fat	1	53.0	2.64	0.11	0.05	0.20	280
1984	Common loon	N.E. Ont.	brain	1	NA	8.36	0.03	0.23	0.02	50
1985	American bittern	Central Ont	brain	2	NA	0.02	<0.01	<0.01	0.01	0.04
1985	Great blue heron	S. Ont.	brain	2	NA	0.53	0.01	0.01	0.01	1.6[2]
1985	Mute swan	N. Toronto	egg	1	NA	4.51	0.25	0.02	0.09	0.2
1986	Mallard	L. Ontario	brain	4	NA	1.64	0.008	0.01	0.005	3.6[2]
	Red throated loon	N.E. Ont.	brain	1	NA	9.69	1.20	0.20	0.21	16
1987	Common loon	N.E. Ont.	liver	4	NA	1.07	0.05	0.02	0.02	5.2
	Common loon	Muskoka	brain	1	NA	7.25	0.47	0.03	0.10	7.7[2]
1988	Mute swan	N. Toronto	eggs	2	NA	5.29	0.22	0.01	0.08	0.4
	Common loon	N.E. Toronto	brain	1	6.8	0.16	0.03	0.01	0.009	0.7

[1]HCB in muscle, 1972 0.12 m/gkg, fat 0.07 mg/kg and muscle 1973 0.03 mg/kg Great Blue heron 1985 0.01 mg/kg; [2]Mirex in mallard 1986, 0.09 mg/kg and loon 1987, 0.03 mg/kg, Great blue heron 1985, 0.015 mg/kg, swans 1985, 0.08, 1986 0.03; [3]NA - not analysed

Table 3. Organochlorine residues in the tissues of raptors collected 1974 to 1988.

Year	Raptor	Location	Tissue	Number	Fat	Content in wet tissues (mg/kg) t-DDT	Dieldrin	Chlordane	Heptachlor epoxide	PCB	Mirex
					%						
1974	Bald eagle	S.W. Ont.	brain	1	5.51	7.96	7.94	NA[2]	2.75	20	
			liver	1	1.88	7.88	6.29	NA	8.25	30	
1975	Osprey	S.W. Ont.	brain	1	5.13	0.34	0.06	NA	<0.1	0.6	
			liver	1	1.11	0.14	0.03	NA	<0.1	0.7	
			body fat	1	93.1	14.7	2.65	NA	<0.1	24.0	
	Redtail hawk	S.W. Ont.	brain	1	5.65	0.006	0.03	NA	<0.1	0.9	
			liver	1	3.78	0.21	0.05	NA	<0.1	0.8	
	Goshawk	S.W. Ont.	muscle	1	1.76	0.30	0.01	NA	<0.1	0.3	
1979	Bald eagle	S.W. Ont.	brain	1	NA[3]	0.05	0.03	<0.01	0.005	0.9	
	Bald eagle	S.W. Ont.	brain	1	NA	19	0.59	0.28	0.44	6.3	
1980	Owl	S.W. Ont.	liver	1	NA	42	0.24	0.31	0.17	6.9	
	Owl	S.E. Ont.	brain	1	NA	110	1.60	0.10	0.66	160	
1981	Owl	S.W. Ont.	brain	1	NA	1.0	0.03	0.10	0.03	1.0	
	Bald eagle	S.W. Ont.	liver	1	NA	31.0	0.56	2.34	0.17	29.0	
1985	Bald eagle	S.W. Ont.	brain	1	NA	2.74	0.07	0.14	0.11	4.5	0.05
	Osprey (J)[1]	S.W. Ont.	brain	1	NA	0.28	0.01	0.01	0.006	1.3	
	American kestrel	S.W. Ont.	muscle	2	1.01	0.51	0.01	<0.01	0.01	0.2	<0.01
1986	Red tail hawk	S.E. Ont.	brain	1	NA	12.1	1.9	0.01	0.42	7.9	0.13
1987	Bald eagle (J)[2]	S.W. Ont.	liver	1	NA	0.02	0.02	0.08	0.01	0.6	
			muscle	1	NA	0.15	0.04	0.01	0.01	1.1	
	Osprey	S.W. Ont.	brain	1	NA	2.55	0.2	0.01	0.01	0.1[1]	0.01
	Bald eagle	S.W. Ont.	brain	1	NA	0.27	0.13	0.03	0.01	7.9	
	American kestrel	Niagara	brain	6	NA	6.27	0.91	<0.01	0.55	0.8	0.03
1987	Screech owl	Niagara	brain	1	NA	3.98	3.2	10.01	1.50	1.1[1]	0.01
1988	Owl		brain	1	NA	1.10	0.19	0.01	0.11	3.4	
	Golden eagle (I)	Muskoka	brain	1		0.07	0.01	<0.01	<0.01	0.14	

[1] 1985 fledgling osprey

[2] 1987 Juvenile Bald eagle chicks gamma HCH - muscle 0.07 mg/kg, fat 0.11 mg/kg, osprey flegling.

[3] NA - not analysed

Table 4. Organochlorine residues in the tissues of gulls and terns collected 1973 to 1988.

Year	Species	Location	Tissue	Number	Fat %	Mean content in wet tissues (mg/kg) t-DDT	Dieldrin	Chlordane	Heptachlor epoxide	PCB	Mirex
1973	Ring-billed gull	L. Erie	brain	2	6.2	27.6	1.07	0.01	NA	323	NA
			liver	3	2.6	81.7	2.03	0.02	NA	423	NA
			kidney	1	2.2	54.4	2.17	0.02	NA	280	NA
			muscle	1	0.7	29.0	0.84	0.01	NA	300	NA
	Bonaparte gull	N.E. Ont.	brain	2	7.1	2.90	0.23	0.01	NA	23	NA
			liver	2	3.1	6.30	0.16	0.01	NA	59	NA
1975	Herring gull	Parry Sound	eggs	3	10.5	46.3	0.35	0.01	0.15	60	NA
		S.W. Ont.	brain	4	9.5	0.23	0.05	0.01	0.10	3.4	NA
			muscle	4	2.4	0.43	0.09	0.02	0.05	4.9	NA
1979	Gull	L. Ont.	brain	1	6.0	0.19	0.03	<0.005	0.10	0.5	0.04
1980	Herring gull	S.E. Ont.	brain	1	5.8	3.30	0.27	0.36	0.26	27	<0.01
	Common tern	N. Ont.	eggs	12	NA	0.56	0.03	0.021	0.02	2.6	<0.01
			shells	8	NA	0.08	0.007	<0.005	0.003	0.3	<0.01
1981	Herring gull	L. Ont.	brain	7	6.5	6.92	0.45	0.10	0.01	13.7	0.96
	Ring-billed gull	L. Erie	brain	1	6.4	38.1	2.20	0.93	0.80	42.1	<0.01
1982	Ring-billed gull	L. Erie	brain	2	7.1	14.2	0.05	0.04	0.01	9.9	<0.01
	Ring-gilled gull	L. Ont.	brain	5	6.7	2.21	0.03	0.19	0.01	18.6	0.62
1983	Herring gull	L. Ont.	brain	1	7.4	5.39	0.10	0.30	0.09	69.0	0.90
	Ring-billed gull	L. Ont.	brain	7	6.3	1.35	0.08	0.04	0.006	5.1	0.06
	Caspian tern	L. Simcoe	brain	1	NA	0.23	0.05	0.008	0.007	1.1	<0.01

[1]NA - not analysed

liver levels appeared lower in 1980 than 1970. The brain of loons analysed between 1984 and 1987 had t-DDT residue levels of 1.07 to 9.7 mg/kg and PCB levels between 7.7 and 50 mg/kg. These levels were between the residue levels reported by Frank et al. (1983) for healthy loons (1.03 mg/kg t-DDT, 2.4 mg/kg PCB) and emaciated loons (20 mg/kg t-DDT and 55 mg/kg PCB) collected between 1971 and 1974. Both sets of data on herons and loons fail to confirm if residues have declined over the past two decades.

Organochlorine residues in rapters were both higher and lower than those of herons and loons (Table 3). Between 1974 and 1987 levels of both t-DDT and PCB in six bald eagles showed very little change. Over this period t-DDT ranged from 0.05 to 31 mg/kg in brain with the highest occurring in 1981 and the lowest in 1979. In the same period three Osprey brains were analysed and the highest t-DDT level was in 1987 and the highest PCB level was in 1985. Hence it was difficult with the limited data to conclude if residues were declining.

The highest organochlorine residues were present in gull brains (Table 4). t-DDT residues in brain in the early 1970s were frequently above 10 mg/kg and as high as 81 mg/kg while PCB residues were most frequently over 100 mg/kg. During the 1981 to 1983 period brain levels of t-DDT were rarely above 0.2 to 11 mg/kg and PCB were between 1 and 16 mg/kg. This group of birds appeared to be the only one where a definite decline in residues can be observed.

Many of the levels in gull brains were lower than the levels reported by Sileo et al. (1977) when ring bill gulls were analyzed during a die-off in 1969 and again in 1973. At that time residues ranged up to 582 mg/kg DDE and 940 mg/kg PCB in 1969 and 48 mg/kg DDE and 550 mg/kg PCB in 1973.

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