

Residues of Organochlorine Pesticides and Polychlorinated Biphenyls and Autopsy Data for Bald Eagles, 1971-72¹

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ABSTRACT

Thirty-seven bald eagles found sick or dead in 18 States during 1971-72 were analyzed for organochlorine pesticides and polychlorinated biphenyls (PCB's). DDE and PCB's were detected in all bald eagle carcasses; 30 carcasses contained DDD and 28 contained dieldrin. Four eagles contained possibly lethal levels of dieldrin and nine eagles had been poisoned by thallium. Autopsies revealed that illegal shooting was the most common cause of mortality. Since 1964 when data were first collected, 8 of the 17 eagles obtained from Maryland, Virginia, South Carolina, and Florida possibly died from dieldrin poisoning; all four specimens from Maryland and Virginia were from the Chesapeake Bay Tidewater area.

Introduction

The purpose of this paper is to report and evaluate residue and autopsy data on bald eagles (*Haliaeetus leucocephalus*) collected in 1971 and 1972. Data for specimens collected in 1964 through 1970 have been previously reported (1-3).

Sampling

Bald eagles found dead or moribund in the field are collected by Federal, State, and private cooperators, packed in dry ice, and shipped air express to the Patuxent Wildlife Research Center in Laurel, Md., where they are stored intact in plastic bags at -25° C. Thus sampling for the present study was not systematic

because of the relatively low population and protected status of these birds. Table 1 shows the collection areas of the 37 birds analyzed; 25 birds were collected in 1971 and 12 in 1972. Decomposed specimens were not analyzed.

TABLE 1. Distribution of eagles collected by State and year of death, 1971-72

STATE	NO. EAGLES COLLECTED	
	1971	1972
California	1	
Florida	1	
Illinois	4	
Indiana		1
Iowa	1	
Maine		1
Michigan		1
Minnesota		2
Missouri	4	1
New Mexico		1
New York		1
Ohio	1	
South Carolina	1	
Texas		1
Utah	2	
Virginia	1	2
Wisconsin	1	
Wyoming	8	1
TOTAL	25	12

Autopsy and Analytical Procedures

Procedures for autopsy followed those reported previously by Belisle et al. (3). After removal of the skin, feet, wings, liver, and gastrointestinal tract, the carcass was ground and homogenized in a Hobart food cutter. A 10-g aliquot of the carcass and the entire brain were

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mixed separately with anhydrous sodium sulfate in a blender and extracted for 7 hours with hexane in a Soxhlet apparatus. Extracts were evaporated, lipid weights were determined, and the extracts were redissolved in 20 ml hexane. A 10-ml aliquot of extract containing not more than 0.5 g lipid was cleaned on a florisil column.

The florisil had been washed and recalcined at 675° C according to Hall's method (4) and partly deactivated with 1.0-1.5 percent water to permit the elution of dieldrin with the other pesticides. Approximately 21 g of the treated florisil was placed in each 2-by-20-cm column with a 250-ml reservoir and topped with 1 cm anhydrous sodium sulfate. Columns were prewashed with 50 ml hexane and the extract was eluted with 200 ml 6 percent ethyl ether in hexane.

The florisil eluate was concentrated to 5 ml and a 4-ml aliquot was placed on a silicic acid column to separate pesticides from PCB's. Armour and Burke's separation method (5) was used with the following modifications: the silicic acid, Mallinckrodt Silicar CC-4, was heated at 130° C for 24 hours in a pan covered with aluminum foil containing a few pinholes; celite and air pressure were eliminated; and the petroleum ether eluate was collected in two separate fractions of 100 ml and 300 ml followed by 200 ml of the polar eluate. The adsorbent usually was deactivated with 3 percent water, and the flask was sealed with paraffin tape, shaken for 3 hours on a reciprocating shaker, and allowed to equilibrate for 24 hours before use. The amount of water was adjusted by running standards to assure that all the DDE was in the second fraction.

Using this procedure, hexachlorobenzene (HCB) and mirex were collected in the first 100 ml petroleum ether, PCB's and DDE were in the second fraction, and the remaining pesticides were in the polar eluate. Silicar CC-4 did not require celite or air pressure to maintain the specified flow rate. Covering the pan with aluminum foil during the heating process eliminated certain interfering background peaks.

Samples were analyzed with a Hewlett-Packard 5753 gas-liquid chromatograph equipped with a Ni⁶³ detector, automatic sampler, digital integrator, and a 4 percent SE-30/6 percent QF-1 column at 190° C. The flow rate of 5 percent methane in argon was 60 ml/min for columns and 40 ml/min for purge. DDE was quantitated by peak height to avoid possible errors from PCB interference; other pesticides were measured by digital integration of area, and PCB's were estimated by comparing total peak area with Aroclor 1254 or 1260.

Residues in 15 specimens (40 percent) were positively identified with an LKB gas-liquid chromatograph/mass spectrometer (GLC/MS). Operating procedures have been described (3) except that a 1 percent SE-30 column was temperature-programmed. Program rate was

2° C/min; initial temperature was 135° C, rising to a maximum of 220° C.

Average recoveries from spiked mallard carcass tissue were: DDE, 96 percent; DDD, 103 percent; DDT, 110 percent; dieldrin, 101 percent; heptachlor epoxide, 104 percent; mirex, 106 percent; oxychlordan, 98 percent; *cis*-chlordan, 100 percent; *cis*-nonachlor, 98 percent; HCB, 69 percent; and Aroclor 1254, 101 percent. Residue levels for eagle samples were not corrected for recovery. The lower limit of sensitivity was 0.05 ppm; residue levels less than 0.05 ppm were not reported "trace" as in the previous reports.

Samples were not analyzed for oxychlordan, *cis*-chlordan, *cis*-nonachlor, or HCB in 1971. GLC/MS analyses using temperature programming revealed both *cis*-chlordan and *trans*-nonachlor. In one sample, only *trans*-nonachlor was detected. Authors were unable to obtain a GLC column for the electron-capture detector that would separate both compounds without interference from another pesticide. The peak was quantitated as *cis*-chlordan because standards of these compounds have the same detector response.

Thallium levels in eagle kidneys were determined by flame atomic absorption using the method described by Curry et al. (6) except that a sampling boat was not used. The lower limit of sensitivity was 2.0 ppm.

Results and Discussion

RESIDUES

Table 2 summarizes residues of organochlorine pesticides and PCB's in 37 bald eagle carcasses and brains; all data are reported on a wet-weight basis. All carcasses contained PCB and DDE residues, 30 contained DDD, and 28 contained dieldrin.

Four specimens had concentrations of dieldrin in the brain within the range known to have caused death by dieldrin. Table 3 shows dieldrin levels in the brains of these specimens to range from 4.0 to 7.8 ppm. Stickel et al. (7) concluded from an experimental study on Japanese quail (*Coturnix coturnix*) and from residues in brains of several kinds of animals found dead in the field following heavy dieldrin treatments that a concentration of 4-5 ppm indicated that the animal was in the danger zone. Linder et al. (8) concluded from studies of capsule-dosed pheasants that a level of 3-4 ppm, or greater, of dieldrin in the brain indicates death by dieldrin.

During the 1964-72 period, 190 eagles were analyzed; 19 (10 percent) of these specimens were suspected cases of dieldrin poisoning. The incidence of dieldrin poisoning is high, particularly among specimens from Maryland, Virginia, South Carolina, and Florida. Of the 17 eagles collected (3 from Md., 4 from Va., 4 from S.C., and 6 from Fla.), 8 (47 percent) were possible victims

TABLE 2. Pesticide and PCB residues in 37 bald eagles, 1971-72

COMPOUND	YEAR	RESIDUES, PPM WET WEIGHT					
		CARCASS			BRAIN		
		NO. SPECIMENS ¹	MEDIAN ¹	RANGE	NO. SPECIMENS ¹	MEDIAN ¹	RANGE
p,p'-DDE	1971	25	5.7	0.77- 210.0	25	0.95	0.07- 89.0
	1972	12	11.0	0.83- 110.0	12	1.3	0.14- 55.0
p,p'-DDD	1971	18	0.40	0.10- 33.0	9	0.19	0.05- 9.9
	1972	12	0.54	0.14- 18.0	8	0.35	0.06- 2.9
p,p'-DDT	1971	4	0.33	0.26- 3.2	2	0.08	0.05- 0.11
	1972	5	0.42	0.12- 0.94	1	0.34	-
Dieldrin	1971	16	0.72	0.10- 33.0	12	0.30	0.05- 7.8
	1972	12	0.65	0.14- 12.0	8	0.61	0.23- 4.6
Heptachlor epoxide	1971	9	0.36	0.06- 5.5	6	0.18	0.05- 1.5
	1972	5	0.72	0.06- 2.7	3	0.35	0.11- 1.7
Mirex	1971	10	0.30	0.10- 1.3	4	0.10	0.10- 0.13
	1972	6	0.26	0.06- 0.60	2	0.13	0.11- 0.13
Oxychlorane	1972	6	0.34	0.18- 1.4	6	0.09	0.05- 0.34
cis-Chlordane ²	1972	10	0.30	0.11- 7.4	7	0.11	0.05- 1.7
cis-Nonachlor	1972	6	0.29	0.07- 0.95	2	0.59	0.19- 0.98
Hexachlorobenzene	1972	4	0.30	0.11- 0.50	4	0.14	0.05- 0.18
PCB's	1971	25	8.6	0.30- 290.0	24	1.1	0.10- 150.0
	1972	12	26.0	0.60- 1200.0	11	16.0	0.65- 140.0

¹ Number of specimens containing residues; the median is based on this number.² And/or trans-nonachlor.

TABLE 3. Data on four suspected cases of dieldrin poisoning of adult eagles, 1971-72

STATE	YEAR	SEX	DIELDRIN RESIDUE IN BRAIN, PPM	AUTOPSY FINDINGS ¹
Iowa	1971	F	7.8	Open, no fat deposits
South Carolina	1971	M	6.5	Emaciation
Virginia	1971	M	4.0	Open, no fat deposits
Virginia	1972	F	4.6	Open, no fat deposits

¹ Open = no diagnosis could be made on the basis of autopsy findings.

of dieldrin poisoning. Two eagles suspected of dieldrin poisoning were collected from each State. It is of special concern that all four eagles from Maryland and Virginia suspected of dieldrin poisoning were from the Chesapeake Bay tidewater area. No specimens were collected from North Carolina or Georgia.

A large group of bald and golden eagles found dead near Casper, Wyo., in May 1971 were suspected of having been killed by ingestion of poisoned bait. Specimens were analyzed for cyanide, strychnine, sodium fluoroacetate (1080), and thallium. Residues of thallium in the kidneys ranged from 14 to 59 ppm. Eight of the eleven bald eagles from this group which were suitable for residue analysis are included in this report. In an eagle from Utah, the kidney contained 63 ppm thallium. It was concluded from autopsies and chemical analyses that these eagles had died from thallium ingestion.

AUTOPSY

Results of the autopsies are summarized in Table 4. Illegal shooting, the most common cause of mortality, was responsible for the death of 35 percent of the eagles.

Three eagles suspected of dieldrin poisoning were in good flesh but lacked deposits of fat. The other bird

TABLE 4. Probable causes of bald eagle mortality, 1971-72

CAUSE OF DEATH	NO. EAGLES
Shooting	13
Thallium poisoning	9
Dieldrin poisoning	4
Nephrosis	1
Drowning	1
Drowning; coccidiosis	1
Coccidiosis	1
Strychnine poisoning	1 ¹
Impact	1
Electrocution	1
Open ²	4
TOTAL	37

¹ Specimen from New Mexico; analyzed for strychnine by Denver Wildlife Research Center, Denver, Colo.² No diagnosis could be made on the basis of autopsy findings or chemical analysis.

listed as emaciated showed marked atrophy of the pectoral and leg muscles, and had no fat deposits.

Coccidiosis caused by *Isospora* sp. was apparently responsible for the death of an eagle from Minnesota. It was a contributing factor in the death of an emaciated adult female found downstream from Flaming Gorge Dam, Utah; immediate cause of her death was reported as drowning.

Drowning was also the immediate cause of the death of an adult female eagle from Michigan that had high levels of DDE (55 ppm) and PCB's (190 ppm) in the brain. The eagle, which had been observed perched on a snag over the water, suddenly fell into the water and drowned. No injuries were found, and both aerobic and anaerobic cultures of liver, heart blood, and intestinal tract failed to reveal any pathogenic bacteria.

The thallium-poisoned eagles usually had normal amounts of adipose tissues, were in good flesh, and had no gross lesions except congestion of vessels overlying the cerebellum. Microscopically, there were no acid-fast intranuclear inclusion bodies which sometimes indicate lead poisoning, and examination of the kidney sections stained by the Pritschow technique proved to be equivocal.

An adult female eagle from Missouri had a shattered lower left leg, the result of an earlier gunshot wound. She had valvular endocarditis, probably the result of a secondary bacterial infection from the leg wound. *Escherichia coli* appeared in the heart blood but not in the lungs and liver; thus the cause of death is listed as shooting (Table 4).

Conclusion

Bald eagles are subject to a wide variety of environmental insults, including infectious agents, chemical pollutants, and human-related trauma. Levels of pesticides and PCB's in eagles continue to be high, reflecting widespread contamination by these compounds.

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