Organochlorine Residues in New Jersey Osprey Eggs

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New Jersey osprey (Pandion haliaetus) populations declined during the 1950's and 1960's and their reproductive success was also depressed for a number of years. SCHMID (1966) reported on osprey population declines for Cape May County, New Jersey, between 1939 and 1963. PETERSON (1969) reported on similar declines for southern New Jersey, including the Avalon area. HENNY et al. (in prep.) reported a low rate of reproductive success for the area between Sea Isle City and Hereford Inlet in Cape May County for the years 1968 through 1974; the number of occupied nests declined from 44 in 1968 to 28 in 1974. A number of hypotheses have been presented as possible explanations for these declines, including habitat destruction, human disturbance, a diminished food supply, and the adverse effects of environmental pollutants.

We now present data on levels of organochlorine pesticides and polychlorinated biphenyls (PCB's) in the eggs of New Jersey ospreys, the changes in eggshell thickness, and relate this information to similar data for declining and stable osprey populations in other areas.

Methods

Osprey eggs were collected from the Barnegat Bay area of New Jersey in 1971 and 1974. Four eggs, each from a different nest, were collected from Island Beach State Park on June 28, 1971, after they failed to hatch. Only two were suitable for residue analysis and measurements of shell thickness. Three eggs from each of five nests were collected during incubation from the same general area on May 2, 1974. These eggs were artificially incubated for an extended period, but they failed to hatch. Only seven eggs from four of the nests were suitable for residue analysis (Table 1). Seven eggs from four clutches were also measured for shell thickness; loss and/or disruption of shell membranes prevented accurate shell thickness measurements for the remaining eight eggs. Only three of the eggs collected in 1974 were suitable for both residue analysis and shell thickness measurements.

Bulletin of Environmental Contamination & Toxicology,
0007-4861/78/0019-0056 $1.60

Five eggs, each from a separate nest, were collected from the Avalon-Stone Harbor area of New Jersey in both 1970 and 1972. All eggs were collected after they failed to hatch. The eggs obtained in 1970 were collected in late May; those obtained in 1972 were collected in late May and early June. Three eggs from 1970 and all five from 1972 were analyzed (Table 1); shell thickness was measured on all five collected in 1970 and three in 1972.

Eggs were brought to Patuxent Wildlife Research Center for processing and analysis. The length and breadth of each egg were determined. The volume of each egg was calculated from these measurements as described by STICKEL et al. (1973). Eggs were opened and embryo age was estimated on the basis of a 37- to 38-day incubation period. Many eggs were badly addled and dehydrated, therefore small embryos may have gone undetected. Egg contents were placed in glass jars rinsed with nitric acid, distilled - deionized water, acetone, and hexane, except for the eggs collected in 1971 whose contents were placed in glass jars rinsed only with acetone. Egg contents were frozen before analysis. Shells were gently rinsed with tap water and air dried. Thickness measurements, which included the shell and shell membranes, were taken at the equator of each eggshell with a dial-guage micrometer graduated in units of 0.01 mm. The measurements (2 to 4) for each shell were averaged.

A 10-g portion from the homogenized sample of each egg was blended with sodium sulfate and extracted for 7 hours with hexane in a Soxhlet apparatus. The extract was cleaned up on a Florisil column and the pesticides and PCB's were separated into three fractions on a silicic acid column. Samples were analyzed on a gas chromatograph equipped with Ni^{63} detector, automatic sampler, computing integrator, and a 4% SE-3/6% QF-1 column. This procedure has been described in detail by CROMARTIE et al. (1975). The lower limit of detection for pesticides was 0.10 ppm and 0.5 ppm for PCB's. The average recovery from chicken eggs fortified with pesticides and PCB ranged from 86-104%, except for hexachlorobenzene (HCB) which was 71%.

The specimens were analyzed for additional toxicants in later years because of frequent refinements in chemical methodology. The osprey eggs collected in 1971 were analyzed for p,p'-DDE, p,p'-DDD, p,p'-DDT, dieldrin, heptachlor epoxide, and mirex; PCB's were determined semiquantitatively by thin layer chromatography. The 1970, 1972, and 1974 samples were also analyzed for oxychlordane, cis-chlordane and/or trans-nonachlor, cis-nonachlor, and HCB. Only the 1974 samples were analyzed for toxaphene. Residues were confirmed in six samples by gas chromatography-mass spectrometry.

TABLE 1

Organochlorine residues in New Jersey osprey eggs

Eggs Analyzed in Clutch	Residue concentration ppm (fresh wet weight)[a] p,p'-DDE	p,p'-DDD	p,p'-DDT	Dieldrin	Heptachlor Epoxide	Mirex	cis-Chlordane[b]	PCB's
			Barnegat Bay Area - 1971					
1	13.	1.2	0.11	0.11	n.d.	n.d.	n.i.	3.6
1	40.	6.7	n.d.	0.31	0.06	n.d.	n.i.	36.
			Barnegat Bay Area - 1974[c]					
1	7.6	0.57	0.07	0.09	0.06	n.d.	0.20	7.3
2	25.	42.	0.53	0.07	n.d.	0.02	0.48	8.8
1	23.	0.73	0.04	0.07	0.05	0.05	0.08	15.
3	8.8	0.49	n.d.	0.04	0.02	0.03	0.04	4.9
Mean[d]	16.	11.	0.16	0.07	0.03	0.03	0.20	9.0
Range[e]	7.5-26.	0.42-47.	n.d.-0.62	0.04-0.09	n.d.-0.06	n.d.-0.05	0.03-0.55	4.3-15.
			Avalon-Stone Harbor - 1970 and 1972					
1	10.	1.2	n.d.	0.37	0.08	n.d.	n.d.	9.8
1	26.	5.1	0.31	0.31	0.41	n.d.	0.08	13.
1	7.6	2.6	n.d.	0.32	0.10	n.d.	0.07	7.3
1	21.	1.5	0.15	0.12	0.12	0.06	n.d.	12.
1	17.	2.5	n.d.	0.07	0.11	n.d.	n.d.	6.7
1	17.	6.8	n.d.	0.29	n.d.	n.d.	n.d.	13.
1	6.5	1.4	n.d.	n.d.	n.d.	n.d.	n.d.	2.5
1	9.1	2.4	0.19	0.12	n.d.	n.d.	0.05	5.7
Mean	14.	2.9	0.08	0.20	0.10	0.01	0.03	8.8

Table 1. (footnotes)

a/ n.d. = not detected; n.i. = not identified by chemical methodology.

b/ and/or trans-nonachlor.

c/ The following maximum residues were also detected in the given number of eggs; 0.39 ppm o,p'-DDD (2 eggs), 0.32 ppm p,p'-DDMU (2 eggs), 0.10 ppm DCK (1 egg), 0.15 ppm oxychlordane (7 eggs), 0.13 ppm cis-nonachlor (5 eggs), 0.03 ppm hexachlorobenzene (1 egg), and 0.03 ppm toxaphene (3 eggs).

d/ Means on a clutch basis.

e/ Ranges on an egg basis.

Residue concentrations were calculated as micrograms per milliliter on the basis of total egg volume. This value was converted to a ppm basis by assuming a specific gravity of 1.0 as described by STICKEL et al. (1966). Residue levels were not corrected for recovery values.

Results and Discussion

Embryos were detected in only 1 of the 4 eggs collected at Barnegat Bay in 1971, and in 3 of the 15 eggs collected in that area in 1974. Four of the 10 eggs collected in the Avalon-Stone Harbor area in 1970 and 1972 contained detectable embryos.

DDE was the predominant pollutant found, was present in all of the eggs analyzed, and occurred at levels from 6.5 to 40 ppm. DDE has been shown to cause significant eggshell thinning when fed at low dietary levels to American Kestrels (Falco sparverius) (WIEMEYER and PORTER 1970; LINCER 1975), and in other species of birds (see COOKE 1973 for review on avian eggshell thinning). The average levels of DDE found in these New Jersey osprey eggs were considerably higher than the average levels found in osprey eggs from both stable and declining populations in other areas of the United States (Table 2).

PCB's were also found in all of the eggs. A high level (36 ppm) of PCB's was present in one egg from the Barnegat Bay area collected in 1971. The average PCB levels found in these eggs were somewhat below the average levels found in eggs from the declining Connecticut population but above the average levels found in stable populations in Maryland and Idaho (Table 2). PCB's at low to moderate levels have been shown to cause adverse effects on the reproduction of pheasants (Phasianus colchicus) (DAHLGREN and LINDER 1971; DAHLGREN et al. 1972), chickens (BRITTON and HUSTON 1973; BRIGGS and HARRIS 1973; LILLIE et al. 1974, 1975), and ring doves (Streptopelia risoria) (PEAKALL and PEAKALL 1973), but not of mallards (Anas platyrhynchos) (HEATH et al. 1972).

TABLE 2

Relationships between primary residues in eggs, population trends, and reproductive success of different osprey populations

Population	Year	Average Residues in Eggs (ppm wet weight) p,p'-DDE	Dieldrin	PCB's	Population Trend and Reproductive Success
Potomac River, Maryland[a/]	1968-69	2.4	0.25	2.6	Stable population; reproduction slightly depressed.
Lake Coeur d'Alene, Idaho[b/]	1972-73	8.5	n.d.	1.2	Stable or increasing population; reproduction normal.
Connecticut[a/]	1968-69	8.9	0.61	15.	Declining population; reproduction greatly depressed.
Barnegat Bay Area, New Jersey	1974	16.	0.07	9.0	Declining population; reproduction greatly depressed.
Avalon-Stone Harbor, New Jersey	1970 + 72	14.	0.20	8.8	Declining population; reproduction greatly depressed.

a/ From WIEMEYER et al. (1975).
b/ From JOHNSON et al. (1975); n.d. = not detected.

Residues of p,p'-DDD were also found in all of the eggs analyzed. Two eggs from one clutch at Barnegat Bay in 1974 contained extremely high levels (36 and 47 ppm) which exceeded the level of DDE in each egg. DDE levels in osprey eggs usually exceed those of p,p'-DDD by two to ten times. Dieldrin was detected in all but one egg, but was present in relatively low levels (0.04-0.37 ppm). Average dieldrin levels in New Jersey osprey eggs were similar to or lower than average levels in eggs from stable populations in Maryland and Idaho and considerably lower than the average level in eggs from the declining population in Connecticut (Table 2). Residues of other pollutants generally occurred less frequently and at lower levels.

The shells of eggs from the Barnegat Bay area in 1974 and the Avalon-Stone Harbor area (Table 3) were considerably thinner than shells of eggs collected before 1947 when the use of DDT was not widespread (ANDERSON and HICKEY 1972). HICKEY and ANDERSON (1968) previously reported a 25-percent decline in eggshell weight for six osprey eggs collected in New Jersey in 1957.

The average thickness of the eggshells from Barnegat Bay in 1971 and the Avalon-Stone Harbor area may be biased upward because the eggs were collected after the normal incubation period when they failed to hatch. Thinner shelled eggs would tend to be broken before the end of the normal incubation period, whereas thicker shelled eggs would be more apt to remain throughout the incubation period. However, the eggs from the Barnegat Bay area in 1974 should not be subject to the same bias, because all were collected early in incubation from clutches containing three or more eggs.

The high residue levels of DDE and possibly the moderate levels of PCB's in the New Jersey osprey eggs appear to have been an important factor in the reduced rate of reproductive success for this population. HENNY et al. (in prep.) reported that only 0.22 to 0.37 young were produced per occupied nest between Sea Isle City and Hereford Inlet (which includes the Avalon-Stone Harbor area) in 1970 through 1972. HENNY and WIGHT (1969) estimated that 1.22 to 1.30 young ospreys must be produced per active nest to maintain a stable population. For comparison, the stable population on the Potomac River, Maryland, produced 0.70 young per accessible active nest in 1970 (WIEMEYER 1971), and the stable or increasing population on Lake Coeur d'Alene, Idaho, produced 1.57 young per nesting attempt in 1973 (JOHNSON et al. 1975).

TABLE 3

Changes in shell thickness of New Jersey osprey eggs.

Area	Year	Sample Size[a]	Average Shell Thickness ± 95% CL[b]	% Change from pre-1947
Eastern U. S.[c]	pre-1947	365 (-)	0.505 ± 0.004	--
Barnegat Bay Area	1971	2 (2)	0.485 ± 0.064 (0.48 - 0.49)	-4
Barnegat Bay Area[d]	1974	7 (4)	0.408 ± 0.073 (0.34 - 0.44)	-19
Avalon-Stone Harbor Area[d]	1970 + 72	8 (8)	0.443 ± 0.024 (0.40 - 0.49)	-12

a/ Number of eggs measured; number of clutches represented in parentheses.
b/ Means for current samples are on a clutch basis, while that for pre-1947 is on an egg basis. Complete clutches are usually represented in museum collections (pre-1947), whereas most recent samples are single eggs from clutches. Extremes of clutch means in parentheses. CL = confidence limits.
c/ From ANDERSON and HICKEY (1972).
d/ The eggs represented here are different in part from those that were analyzed for pollutants, as reported in Table 1; see text.

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Acknowledgments

We thank R. M. Wilson for submitting the osprey eggs from the Barnegat Bay area in 1971.