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Brown Pelican: Population Status, Reproductive Success, and Organochlorine Residues in Louisiana, 1971-1976

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In a previous report (BLUS et al. 1975), we briefly described the recent troubled history of the brown pelican (Pelecanus occidentalis) in Louisiana and discussed the relationship of organochlorine pollutants and certain metals to the welfare of the newly established breeding colony in Barataria Bay. The purpose of this report is to further interpret the impact of organochlorine residues on population status and reproductive success of Louisiana brown pelicans.

MATERIALS AND METHODS

The materials and methods closely followed those in our previous report (BLUS et al. 1975). Approximately 800 pelican nestlings were transplanted from Florida to Louisiana from 1968 through 1976. From 1971 through 1976, 171 eggs were collected including freshly laid eggs and both viable and addled eggs in all stages of incubation. The eggs were frozen soon after collection and were sent to the Patuxent Wildlife Research Center several months later for processing, measurement of eggshell thickness, and analysis for organochlorine pollutants.

The contents of 110 eggs were analyzed individually for residues of organochlorine pesticides, their metabolites, and polychlorinated biphenyls (PCB's). For eggs collected in 1971, the contents of the entire egg were homogenized, and a 20-g portion of the homogenate was mixed with anhydrous sodium sulfate in a blender and extracted for 7 hours with hexane in a Soxhlet apparatus. The extract was cleaned up by acetonitrile partitioning and eluted on partially deactivated Florisil. For pesticides, residues in the cleaned extract were separated and removed in four fractions from a silica gel thin-layer plate (MULHERN et al. 1970). Each thin-layer fraction was analyzed by electron-capture gas chromatography (GC) on a column of 3% OV-1 or 3.8% UCW-98 on Chromosorb WHP. DDT and its metabolites in fractions III or IV were confirmed on a column of 3% XE-60 or 3% QF-1 on Gas Chrom Q. Polychlorinated biphenyls were identified and measured semi-quantitatively by thin-layer chromatography (MULHERN et al. 1971). The average recoveries of organochlorine pesticides and their metabolites ranged from 75 to 112 percent.

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For eggs collected from 1972 to 1976, the methodology was modified as described by CROMARTIE et al. (1975). The extract of the 10-g portion was cleaned up on a Florisil column. Pesticides and PCB's were separated into three fractions on a Silicar column and analyzed by GC on a 4% SE-30/6% QF-1 column. Using this methodology, we were able to detect additional pesticides (toxaphene, cis-chlordane and/or trans-nonachlor, and cis-nonachlor). Before 1973, we did not have a cis-nonachlor standard for quantitation, and a procedure to estimate toxaphene levels was first developed in 1973. For the eggs collected in 1974 through 1976, the lipids were removed either by a Florisil column or by automated gel permeation chromatography. In 1974, we were able to separate and quantitate cis-chlordane and trans-nonachlor by changing to a 1.5% OV-17/1.95% QF-1 column. A combined gas chromatograph-mass spectrometer (GC-MS) was used to confirm residues in about 10 percent of the samples. The average recoveries from spiked chicken eggs ranged from 81 to 110 percent.

RESULTS

Population status -- From 1968 through 1976, 765 young pelicans were transplanted from Florida to Louisiana. The transplanted pelicans in Barataria Bay started breeding in 1971, and the breeding population increased each year (Table 1) until a disastrous die-off in May and June 1975 reduced the population 40% from 400 to 250 birds. Several months earlier, a die-off of approximately 100 white pelicans (Pelecanus erythrorhynchos) occurred near the same area.

TABLE 1

Reproductive success of brown pelicans in Louisiana

Year	No. of nests	Number of young fledged	
		Total	Per nest
1971	13	8	0.62
1972	28	14	0.50
1973	50	26	0.52
1974	83	104	1.25
1975	62	13	0.16
1976	38	56	1.47

On the basis of a recruitment standard of 1.2 to 1.5 young per breeding female necessary to maintain a stable population (HENNY 1972), the standard was attained in 1974 and 1976 (Table 1). The poor reproductive success in several years was partially attributable to pelicans nesting on a low shell bank where tidewaters washed away most nests. Flooding was a minor problem in

1976 because the pelicans nested on a higher island where approximately 20% of the nests were in black mangroves (Avicenna nitida).

There has been some problem with breeding phenology of the pelicans that were transplanted from Florida to Louisiana. The breeding season of pelicans on the Atlantic Coast of Florida is irregular and may occur year-round. The breeding season of pelicans on the Gulf Coast of Florida begins in March or April and continues into late summer (MASON 1945) -- the same breeding season as that of the original population of pelicans in Louisiana (OBERHOLSER 1938). Florida pelicans transplanted to Louisiana and their offspring have followed the breeding schedule of Atlantic Coast pelicans and reproductive activities occur throughout the winter. Consequently, they are sometimes exposed to harsh weather such as on 20 December 1976 when 48 active nests failed after temperatures in the 20's ($^{\circ}$F) were recorded. Future plans call for utilization of Florida Gulf Coast pelicans in the transplanting program.

Eggshell thickness -- Eggshell thickness means of pelican eggs from 1971 through 1976 averaged 6.7 to 13.5% less than the mean thickness for eggs collected before 1947 (Table 2). Multiple range tests (KRAMER 1956) and tests for sample size (SOKAL and ROHLF 1969) indicated a significant difference between the pre-1947 mean and each of the other means except 1971 ($P < 0.05$, power = 0.9, and coefficient of variation = 6%).

TABLE 2

Eggshell thickness of brown pelican eggs from Louisiana

Year	No. of eggs	Thickness (mm) Mean + Standard Error	Range
Pre-1947*	24	0.554 ± 0.007 a**	
1971	7	0.517 ± 0.007 ab	0.49-0.53
1972	39	0.486 ± 0.006 b	0.41-0.57
1973	21	0.488 ± 0.009 b	0.40-0.54
1974	25	0.479 ± 0.005 b	0.44-0.54
1975	30	0.480 ± 0.006 b	0.40-0.56
1976	25	0.494 ± 0.009 b	0.42-0.63

*Pre-1947 eggshell thickness data from ANDERSON and HICKEY (1970); range not listed.
**Means sharing a common letter are not statistically different ($P > 0.05$) from one another as calculated by multiple range tests (KRAMER 1956) and tests for adequate sample size (SOKAL and ROHLF 1969).

Residues -- All of the eggs analyzed contained residues of

p,p'-DDE and polychlorinated biphenyls (Table 3). Most eggs contained residues of p,p'-DDD, dieldrin, and endrin. Residues of p,p'-DDT, heptachlor epoxide, hexachlorobenzene, toxaphene, and chlordanes were also identified; however, mirex residues were not identified in any of the samples.

We previously reported an absence of endrin in brown pelican eggs collected in Louisiana from 1971 through 1973 (BLUS et al. 1975). Since then, we reanalyzed those eggs and found endrin in all of them. Endrin was also present in most of the eggs collected from 1974 to 1976 (Table 3).

Sufficient residue data were available to statistically analyze trends for DDE, DDD, dieldrin, PCB's, and endrin. Although there were significant differences ($P < 0.05$) between DDE means for several years, there was no pronounced trend (Table 3). PCB residues remained essentially the same through the 6 years. There were some significant differences ($P < 0.05$) between years for DDD residues, but like DDE, no trend was evident. There was a significant increase ($P < 0.05$) in dieldrin residues during the study; endrin residues increased significantly ($P < 0.05$) through 1975 then dropped sharply in 1976.

DISCUSSION

There has been much speculation as to the cause of the extirpation of the large breeding population of brown pelicans in Louisiana (JAMES 1963, JOANEN and DUPUIE 1969, BLUS et al. 1975, and KING et al. 1977). Estimates of the Louisiana population during 1918 to 1933 ranged from 12,000 to 85,000 pelicans (KING et al. 1977). Birds from the original Louisiana population were last seen nesting in 1961 (VAN TETS 1965).

Data from Christmas bird counts indicated that the Louisiana brown pelican population crashed in the late 1950's and was extirpated by 1963 (JAMES 1963). Obviously, the agent or agents responsible for the disappearance of a population containing thousands of pelicans within a few years was extremely lethal to these normally long-lived sea birds (HENNY 1972). Furthermore, the brown pelican was extremely sensitive to the causative mechanism since it was the only species known to be extirpated in the Louisiana estuaries at that particular time.

There was no direct evident regarding the agent or agents responsible for the disappearance of the original population; however, prolonged freezing temperatures, hurricanes, disease, and endrin were mentioned as possible causes (BLUS et al. 1975, KING et al. 1977). Die-offs involving several species of fish and other vertebrates occurred every year from 1960 through at least 1963 (U.S. CONGRESS 1964). Endrin was implicated in the 1963-1964 die-off of fish when diagnostic lethal levels of endrin were found in the blood of dead or dying fish (MOUNT and PUTNICKI 1966); there were no residue analyses of pelican

tissues or eggs at that time.

Residues of endrin and several other organochlorines were found in tissues of brown and white pelicans involved in the die-offs in Louisiana in 1975 (WINN 1975). Endrin was the major factor in the die-offs because residues in brains of several of the pelicans were similar to those found in brains of experimental birds dying on endrin dosage (LUDKE 1976, W. H. STICKEL 1977). The die-off in 1975 coincided with the peak in endrin residues in pelican eggs; this tends to substantiate the contention by WINN (1975) that endrin residues were unusually high in Barataria Bay in the spring of 1975. The die-off in 1975 indicated that the brown pelican is sensitive to endrin--the white pelican was the only other organism involved in the die-off. This is in contrast to the die-offs in 1958 to 1963 when fish, snakes, turtles, and several species of birds were involved (U.S. CONGRESS 1964).

On the basis of our studies with brown pelicans in South Carolina (BLUS et al. 1974), residues of DDE were high enough in Louisiana brown pelican eggs to induce eggshell thinning but were not high enough to interfere with reproductive success. The significant ($P < 0.05$) increase in dieldrin concerned us initially, but pelicans in Louisiana had an excellent reproductive season in 1976 when their eggs contained an average of 0.94 µg/g of dieldrin. Dieldrin may have exerted an adverse effect on reproduction in several females that laid eggs containing 2 or 3 µg/g. The effect of endrin on reproductive success is unknown, but the egg with the highest residues (1.47 µg/g) contained an embryo that died while pipping.

Although the combined effect of several agents may have caused the demise of the original brown pelican population, the apparent sensitivity of the brown pelican to endrin in the 1975 die-off and high levels of endrin in biota in Louisiana estuaries at the time of extirpation strongly suggest that endrin was the major factor in the extirpation, acting primarily through direct toxicity to the pelican and perhaps secondarily through food shortage as a result of short-term reductions in prey fish populations.

The brown pelican population in Louisiana has received several severe setbacks and is not yet self-sustaining. The future of this population remains uncertain and, among other factors, is dependent upon decreased exposure to endrin. Declining agricultural usage of endrin in Louisiana and neighboring states (EPA 1975) and a decline in endrin residues in pelican eggs from 1975 to 1976 are optimistic signs.

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TABLE 3

Residues of organochlorine pollutants in eggs of the brown pelican from Louisiana

Year	µg/g (fresh wet weight)								
	p,p'-DDE	p,p'-DDD	p,p'-DDT	Dieldrin	Heptachlor epoxide	Chlordanes**	Toxaphene	PCB's	Endrin
1971 (3)*									
G.M.***	0.97 ab****	0.28 abcd	0.10	0.33 a	--	--	--	3.91 a	0.10 a
Range	0.58-1.30	0.18-0.40	ND-0.14	0.24-0.54	ND	NI	NI	3.0-5.0	0.08-0.12
1972 (12)									
G.M.	1.36 a	0.26 cd	0.15	0.45 a	--	0.39	--	3.51 a	0.18 ab
C.L.	1.0-1.68	0.20-0.34	0.10-0.22	0.33-0.61	--	0.28-0.55	--	2.92-4.21	0.12-0.27
Range	0.82-2.58	0.17-0.52	ND-0.32	0.30-0.79	ND-0.24	0.12-0.82	NI	2.30-6.40	0.11-0.29
1973 (21)									
G.M.	1.31 a	0.19 d	0.16	0.64 b	0.15	0.49	0.32	2.89 a	0.16 a
C.L.	1.08-1.85	0.16-0.24	0.12-0.20	0.56-0.73	0.13-0.17	0.42-0.57	0.27-0.39	2.44-3.44	0.12-0.21
Range	0.58-2.09	ND-0.60	ND-0.31	ND-0.31	ND-0.35	0.33-1.10	0.12-0.58	1.10-5.30	0.03-0.46
1974 (25)									
G.M.	0.68 b	0.41 b	--	0.84 c	0.10	0.27	--	2.65 a	0.30 b
C.L.	0.55-0.85	0.32-0.53	--	0.75-0.95	0.08-0.12	0.20-0.36	--	2.08-3.37	0.25-0.37
Range	0.22-1.79	ND-0.86	ND-0.20	0.49-1.61	ND-0.28	ND-0.61	ND	0.69-6.96	ND-0.73
1975 (30)									
G.M.	0.78 b	0.76 a	--	1.08 d	0.16	0.41	0.16	3.03 a	0.50 c
C.L.	0.63-0.96	0.69-0.84	--	0.97-1.20	0.14-0.18	0.32-0.50	0.11-0.22	2.63-3.50	0.44-0.57
Range	0.18-2.36	0.48-1.59	ND-0.41	0.64-2.25	0.09-0.38	ND-1.31	ND-0.73	1.49-8.02	0.29-1.06
1976 (25)									
G.M.	0.92 a	0.36 bc	--	0.94 cd	0.17	0.32	0.11	3.63 a	0.29 b
C.L.	0.80-1.07	0.31-0.41	--	0.79-1.11	0.14-0.21	0.26-0.39	0.09-0.14	3.12-4.21	0.23-0.36
Range	0.48-2.66	0.21-1.00	ND-0.10	0.44-3.03	ND-0.51	0.17-1.05	ND-0.27	2.06-8.90	ND-1.47

* Sample size in parentheses.

** Chlordanes include cis-chlordane, cis-nonachlor, trans-chlordane, and oxychlordane.

*** Abbreviations: G.M. = geometric mean, C. L. = 95% confidence limits, ND = no residue detected, and NI = residues not identified by chemical methodology used.

**** See footnotes in Table 2 for explanation of letters.

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