The Brown Pelican and Certain Environmental Pollutants in Louisiana

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The recent history of the eastern brown pelican (Pelecanus occidentalis carolinensis) in Louisiana has involved the extirpation of a once flourishing population; a small breeding population has now been reestablished from birds taken from the stable Florida population. The elimination of the pelican as a breeding bird in Louisiana came about with little publicity, and the process was complete by the early 1960's.

The pelican population in Louisiana was a large one, but it is difficult to determine the thoroughness and accuracy of the early counts. BAILEY (1920) reported 50,000 brown pelicans on the Mud Lumps, which are small islands at the mouth of the Mississippi River. PEARSON (1919) reported 65,000 brown pelicans on the Gulf Coast from Texas to Florida. OBERHOLSER (1938) listed about 5,000 breeding pairs for the entire State and estimated only 4,550 pelicans on the Mud Lumps. The last record of nesting brown pelicans in Louisiana was in 1961 when VAN TETS (1965) found 200 breeding pairs and 100 nestlings on North Island. We do not know the reasons for the population decline, although JOANEN and DUPUIE (1969) theorized that hurricanes, diseases, and pesticides were the major causes. Pelicans have been exposed to hurricanes and diseases throughout their existence, but the addition of adverse effects induced by pesticides or other pollutants may have been enough to push them into extinction in Louisiana. Now that transplanted pelicans from Florida have established a small breeding population, it it important to determine the levels of environmental pollutants in these pelicans and to determine the effects of these pollutants.

METHODS

Field work involved collecting eggs from the colony, counting nests and young, and transplanting the young. The transplanting program involved 465 nestlings imported from Florida from 1968 through 1973. Fifty of these birds were released at Rockefeller Refuge, and the remainder were released at Grand Terre. The Rockefeller release failed, but a small breeding colony has been established at Grand Terre where birds began nesting in 1971. The period of this study includes 1971 through 1973.

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In the 3 years of study, 67 eggs were collected. Freshly laid eggs and both viable and addled eggs in all stages of incubation were collected. The eggs were frozen soon after collection, and they were sent to the Patuxent Wildlife Research Center several months later. The egg contents were then removed from the shell and refrozen. The shells were thoroughly washed and allowed to dry. The eggshell thickness was measured to the nearest 0.01 mm at three points along the waist of the egg with a Starrett 1010M micrometer.

The contents of 36 eggs were analyzed individually for residues of organochlorine pesticides, their metabolites, and polychlorinated biphenyls (PCB's) at the Patuxent Center. The methodology used in analyzing the eggs collected in 1971 (MULHERN et al., 1970) was modified and improved when later samples were analyzed (BLUS et al., 1974a). Electron capture gas chromatography and several types of columns were used each year. Thin layer chromatography was used to analyze PCB residues in eggs collected in 1971 and a portion of the eggs collected in 1972 (MULHERN et al., 1971). The major change in the analytical techniques involved use of the silicic acid column in 1972 and 1973; this permitted the separation of the organochlorine residues into three fractions. DDE was quantitated by peak height to avoid errors from PCB interference; the other organochlorines were measured by digital integration of area and PCB's were estimated by comparing total area of PCB peaks with that of Aroclor 1260. Mass spectrometry was utilized in confirming residues in some of the eggs. Recoveries from eagle tissue spiked with the organochlorine pesticides and Aroclor 1254 ranged from 90% to 109%. Residues in the pelican eggs were not corrected for recovery values.

Five of the eggs analyzed for organochlorines were also analyzed for six metals by the Environmental Trace Substances Center, Columbia, Missouri. Atomic absorption was used to detect residues of mercury, zinc, copper, cadmium, and lead; neutron activation analysis was used to detect nickel. The lower limit of sensitivity in detecting residues (µg/g) was 0.01 for pesticides or their metabolites, 0.5 for the PCB's, 0.005 for cadmium, 0.01 for nickel, 0.025 for lead and mercury, and 0.05 for zinc and copper. The residues are expressed on a fresh wet weight basis. Certain external egg measurements (length x breadth^2) were significantly correlated ($P<0.01$) with weight of the contents of fresh eggs. The resulting regression equation was used to convert egg content weight to fresh wet weight (STICKEL et al., 1973). Freshly laid pelican eggs contained 85 percent moisture (determined by lyophilization) and 4.4 percent lipids.

RESULTS AND DISCUSSION

The Transplanting Program -- In 1971, transplanted brown pelicans produced eight young; this was the first indication that the program had a real potential for replenishing the brown pelican population in Louisiana. The number of nests and number of young fledged increased through 1973 (Table 1). The number of fledglings produced per nesting effort was less than the 1.2 to 1.5 young estimated as necessary to maintain a stable population (HENNY, 1972). The pelicans initially selected a low shell bank for nesting, and some nests were flooded periodically by high tides. This problem was largely alleviated when the birds selected another island and constructed their nests in low black mangroves (Avicenna nitida).

TABLE 1

Reproductive success of brown pelicans transplanted in Louisiana.

Year	Number of Nests	Number of Young Fledged	
		Total	Per Nest
1971	13	8	0.62
1972	28	14	0.50
1973	50	26	0.52

The current increase in the breeding population (Table 1), is related to transplanted pelicans attaining breeding status rather than to recruitment of the young reared in Louisiana into the breeding population. Because of current subnormal reproductive success, the long-term outcome of the transplanting program is still somewhat in doubt. The continued growth and future of the brown pelican population in Louisiana is dependent upon the identification and alleviation of the agent or agents that induced the extirpation of this species. Population growth may be affected adversely by numerous factors including pollution, loss of nesting habitat, or other adverse alteration of the ecosystem that either played a role in the demise of the pelican or have emerged since its extirpation.

Eggshell thickness -- On the basis of eggshell thickness measurements obtained from 24 brown pelican eggs located in museums, the mean pre-1947 eggshell thickness of Louisiana eggs was 0.554 mm (ANDERSON and HICKEY, 1970). The shell thickness of contemporary eggs averaged 0.517 mm in 1971, 0.486 mm in 1972, and 0.488 mm in 1973 (Table 2). The pre-1947 eggshell thickness

was significantly greater ($P<0.05$) than that measured in either of the 3 later years, but the 1971 thickness was significantly greater ($P<0.05$) than either the 1972 thickness or the 1973 thickness (Table 2). Although it is not definitely established that the 7 percent eggshell thinning in 1971 and 12 percent thinning in 1972 and 1973 are affecting reproduction, thinning of 18 percent or less has been associated with lowered reproductive success in other birds used in experimental studies (HEATH et al., 1969; LONGCORE et al., 1971). Eggshells of brown pelicans are thinning in all sections of this species' range in North America (BLUS 1970; BLUS et al., 1971; KEITH et al., 1970).

TABLE 2

Eggshell thickness of brown pelican eggs from Louisiana.

Year	Number of Eggs	Thickness (mm) Mean ± standard error	Range
Pre-1947[1/]	24	0.554 ± 0.007 a[2/]	
1971	7	0.517 ± 0.007 b	0.49-0.53
1972	39	0.486 ± 0.006 c	0.41-0.57
1973	21	0.488 ± 0.009 c	0.40-0.54

1/ Pre-1947 eggshell thickness data from Anderson and Hickey (1970) range not listed.

2/ A significant difference ($P<0.05$) among thickness means is indicated for those means not sharing a common letter. Means were separated using the new multiple range test with an extension for unequal replication (KRAMER, 1956).

Residues -- Each of the 36 eggs analyzed contained measurable residues of p,p'-DDE, p,p'-DDD, dieldrin, and PCB's (Table 3). Most of the eggs contained measurable quantities of p,p'-DDT and heptachlor epoxide; none of the eggs contained mirex. Small residues of cis-nonachlor were found in all eggs analyzed in 1972 and 1973, and all but one of these eggs contained cis-chlordane and/or trans-nonachlor. Neither

TABLE 3

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

	µg/g (fresh wet weight)[1]								
Year	p,p'-DDE	p,p'-DDD	p,p'-DDT	Dieldrin	Heptachlor epoxide	Cis-chlordane[2]	Cis-nonachlor	PCB's	Toxaphene
1971	1.30	0.18	0.14	0.24	Tr	NI	NI	5.0	NI
	1.20	0.32	0.13	0.54	Tr	NI	NI	4.0	NI
	0.58	0.40	Tr	0.27	Tr	NI	NI	3.0	NI
G.M.[3]	0.97	0.28	0.10	0.33	--	--	--	3.91	--
1972	2.58	0.52	0.28	0.65	ND	0.30	0.22	3.8	NQ
	1.37	0.29	0.15	0.47	0.12	0.29	0.47	3.5	NQ
	0.99	0.17	0.16	0.31	ND	0.13	0.16	2.7	NQ
	1.12	0.18	0.16	0.36	ND	0.20	0.18	3.2	NI
	1.30	0.27	0.26	0.63	0.11	0.21	0.28	3.7	NI
	1.61	0.27	0.26	0.46	ND	0.27	0.26	4.6	NI
	1.27	0.09	0.13	0.41	ND	0.16	0.14	3.3	NI
	2.25	0.35	0.32	0.79	0.24	0.46	0.36	6.4	NI
	0.83	0.17	ND	0.30	ND	ND	0.12	2.5	NI
	1.65	0.45	ND	0.50	0.19	0.25	0.28	4.7	NI
	1.27	0.22	0.12	0.35	0.10	0.12	0.17	3.1	NI
	0.98	0.21	0.15	0.36	ND	0.10	0.17	2.3	NQ
G.M.	1.36	0.26	0.15	0.45	--	0.18	0.22	3.51	--
C.L.	1.10-1.68	0.20-6.32	0.10-0.22	0.33-0.61	--	0.13-0.27	0.17-0.28	2.92-4.21	--
Range	0.82-2.58	0.17-0.52	ND-0.32	0.30-0.79	--	ND-0.46	0.12-0.47	2.3-6.4	--

1/ Tr=trace; ND = no residue detected; NI = residues were not identified by the chemical methodology; NQ = not quantified. 2/ and/or trans-nonachlor. 3/ G.M. = geometric mean; C.L. = 95% confidence limits.

Year	p,p'-DDE	p,p'-DDD	p,p'-DDT	Dieldrin	Heptachlor epoxide	Cis-chlordane[2]	Cis-nonachlor	PCB's	Toxaphene
				µg/g (fresh wet weight)[1]					
1973	1.34	0.24	0.27	0.71	0.16	0.37	0.22	2.7	0.44
	1.29	0.17	0.13	0.59	0.11	0.28	0.17	2.6	0.28
	0.78	0.14	0.14	0.53	0.12	0.16	0.20	1.8	0.27
	0.91	0.12	0.11	0.47	0.11	0.21	0.14	1.9	0.23
	0.99	0.15	0.11	0.57	0.13	0.25	0.17	3.7	0.25
	0.89	0.24	ND	0.42	0.15	0.18	0.20	1.8	0.12
	1.80	0.27	0.22	0.70	0.14	0.34	0.25	3.1	0.45
	2.09	0.13	0.12	0.54	0.12	0.21	0.16	4.7	0.52
	1.06	0.34	0.25	0.96	0.25	0.46	0.30	2.2	0.22
	1.54	0.19	0.21	0.74	0.14	0.28	0.21	3.6	0.38
	1.79	0.60	0.22	0.72	0.19	0.38	0.23	5.3	0.38
	1.18	0.13	0.13	0.50	0.11	0.23	0.17	2.5	0.25
	1.14	0.15	0.14	0.64	0.16	0.26	0.18	2.8	0.28
	1.61	0.16	0.20	0.67	0.18	0.30	0.23	3.1	0.41
	1.98	0.24	0.29	0.86	0.17	0.31	0.29	4.1	0.53
	0.58	Tr	Tr	0.30	ND	0.13	0.10	1.1	0.17
	1.44 [4]	0.25	0.26	0.98	0.18	0.34	0.22	3.1	0.43
	1.17 [4]	0.18	Tr	0.61	0.13	0.27	0.16	2.8	0.28
	1.84	0.16	0.31	0.83	0.20	0.36	0.27	4.3	0.43
	1.90	0.22	0.17	0.12	0.24	0.33	0.28	4.3	0.41
	1.74 [4]	0.31	0.27	0.55	0.21	0.82	0.28	3.2	0.58
G.M.	1.31	0.19	0.16	0.64	0.15	0.28	0.20	2.89	0.32
C.I.	1.08-1.85	0.16-0.24	0.12-0.20	0.56-0.73	0.13-0.17	0.24-0.34	0.18-0.23	2.44-3.44	0.27-0.39
Range	0.58-2.09	Tr-0.60	ND-0.31	0.30-1.12	ND-0.25	0.13-0.82	0.10-0.30	1.1-5.3	0.12-0.58

[4] Trace of hexachlorobenzene

cis-chlordane nor cis-nonachlor would have been identified by the residue analysis techniques used for the 1971 eggs. Toxaphene was identified in all of the eggs collected in 1973. The residue methodology employed in analyzing the eggs collected in 1971 did not permit the identification of toxaphene. Toxaphene was present in 1972 eggs, but not quantified. A trace of hexachlorobenzene was found in a few of the eggs collected in 1973.

The heavy metals listed in Table 4 do not seem to be of sufficient magnitude to pose a threat to the pelicans in Louisiana, but our knowledge of the potential hazard of such low levels is incomplete. The mercury levels are much lower than those found in eggs from Florida, South Carolina or California (BLUS et al., 1974a). Otherwise, the residues of the other metals are similar to those found in the other areas.

TABLE 4

Residues of six heavy metals in eggs of the brown pelican from Louisiana, 1972.

	ug/g (fresh wet weight)					
	Cd.	Cu.	Zn.	Ni.	Hg.	Pb.
	Tr	1.20	6.0	0.044	0.08	Tr
	Tr	1.06	5.6	Tr	0.06	Tr
	0.008	1.49	6.8	0.035	0.07	Tr
	Tr	1.04	6.2	0.044	0.10	0.040
	0.006	1.03	5.1	0.022	0.08	Tr
G.M.	0.004	1.15	5.9	0.024	0.08	0.016

The PCB's in the pelican eggs resembled Aroclor 1260 or those Aroclors lying near 1260. The PCB's occurred at higher levels than the other residues followed by DDE and dieldrin. The DDE:PCB ratio was 0.4:1.0. One of the most encouraging findings was the absence of endrin. This highly toxic insecticide caused massive fish kills in the lower Mississippi River in the early 1960's (MOUNT and PUTNICKI, 1966) -- about the time that the pelicans disappeared in Louisiana. According to LONG et al. (1961), the use of endrin in Louisiana became widespread by 1958.

ROWE et al. (1971) found that residues of endrin and dieldrin had greatly declined in oysters and in water from the Mississippi River in Louisiana from 1964-1966 to 1968-1969. Whether endrin was related to the extirpation of the brown pelican in Louisiana is unknown because tissues or eggs of these birds were never analyzed for residues. Endrin was not detected in tissues or eggs of brown pelicans collected from Florida, California, and South Carolina from 1969 through 1972 (BLUS et al., 1971).

Relationships between residues in the egg and biological effects -- The relationship of DDE to shell thinning of the Louisiana brown pelican eggs followed that described in an earlier study in which DDE accounted for all or most of the shell thinning of brown pelican eggs from South Carolina, Florida and California (BLUS et al., 1971). The relationship of DDE to eggshell thinning was significant ($P<0.05$; $r = 0.374$; $\hat{Y} = 91.16 - 16.561 \log_{10} X$ where Y is the percent of the pre-1947 eggshell thickness and X is the logarithm of the DDE residue).

The percentage thinning of eggshells of Louisiana pelicans was less than the DDE-induced thinning associated with reduced reproductive success of captive birds of other species (HEATH et al., 1969; LONGCORE et al., 1971). Furthermore, eggshell thinning and residues of the eggs of Louisiana pelicans were similar to that found in eggs of pelicans from Florida (BLUS, 1970; BLUS et al., 1971; BLUS et al., 1974a). The breeding population of brown pelicans in Florida has been stable since 1968 when the population census of the nesting colonies was originated (WILLIAMS and MARTIN, 1968; LOVETT E. WILLIAMS, JR., 1974 Personal Communication); the reproductive success of one large Florida colony is said to be normal (SCHREIBER and RISEBROUGH, 1972).

The residues of DDE in the Louisiana eggs are generally below those associated with subnormal reproductive success of the brown pelican in South Carolina (BLUS et al., 1974b). However, the level of dieldrin tends to be slightly higher in the Louisiana eggs, and 18 of the 36 eggs contain a level of dieldrin considered potentially detrimental to reproductive success (BLUS et al., 1974b). Thus, there is the possibility that dieldrin may have some influence on reproductive success in Louisiana brown pelicans, but the effects of dieldrin were not satisfactorily separated from those of DDE in the South Carolina study (BLUS et al., 1974b). The low rate of reproductive success may be influenced by the unusual conditions existing in establishment of a small breeding colony in an

area without an existing breeding population. There is some suggestive evidence (LOVETT E. WILLIAMS, JR., 1974, Personal Communication), that the pelicans in Louisiana began to breed at an earlier age than normal; none of the pelicans breeding in 1971 or 1972 were in complete adult breeding plumage.

A series of studies should be made to clarify the past, present, and future status of the brown pelican population in Louisiana. We have made a start, but many other avenues of research need to be explored -- such as effects of metals, other pollutants, and disease organisms; extent of habitat loss including nesting islands; and the possibility of food shortages or losses.

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