Chlorinated Hydrocarbon Residues in the Diet and Eggs of the Florida Brown Pelican

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Since the late 1950's the population of Brown Pelicans (Pelicanus occidentalis) in the United States has experienced a substantial decline. The last nesting of the native Louisiana population occurred in 1961 (Williams and Martin, 1969). Schreiber and Delong (1969) described population declines and reproductive failure in California. Beckett (1966) reported a declining population in South Carolina. Hildebrand and Blacklock (unpublished report) reported a reduction in the population nesting on the Texas Coast. Only the Florida population has remained relatively stable (Williams and Martin, 1970).

Pesticide residues, especially DDE, a metabolite of DDT, have been implicated as a cause of declining Brown Pelican populations (Blus, 1970). DDE is thought to interfere with normal calcium metabolism resulting in thin eggshells in Pelicans.

Although no reproductive problems were evident with Florida Pelicans, surveys were initiated to investigate the potential instability of the population by monitoring chlorinated hydrocarbon residues in the diet and eggs of Florida Pelicans. The results of this monitoring are reported here.

Methods and Materials

Food samples were collected by disturbing nesting colonies and causing Pelicans to regurgitate bill and stomach contents. During 1970 and 1971, 92 such samples of 10 major and some minor food fish species were collected for pesticide residue analysis from 14 colony sites (Fig. 1). Samples were sorted by species and colony site and stored in aluminum foil bags until analyzed. Prior to analysis, samples were homogenized in a Hobart food cutter.

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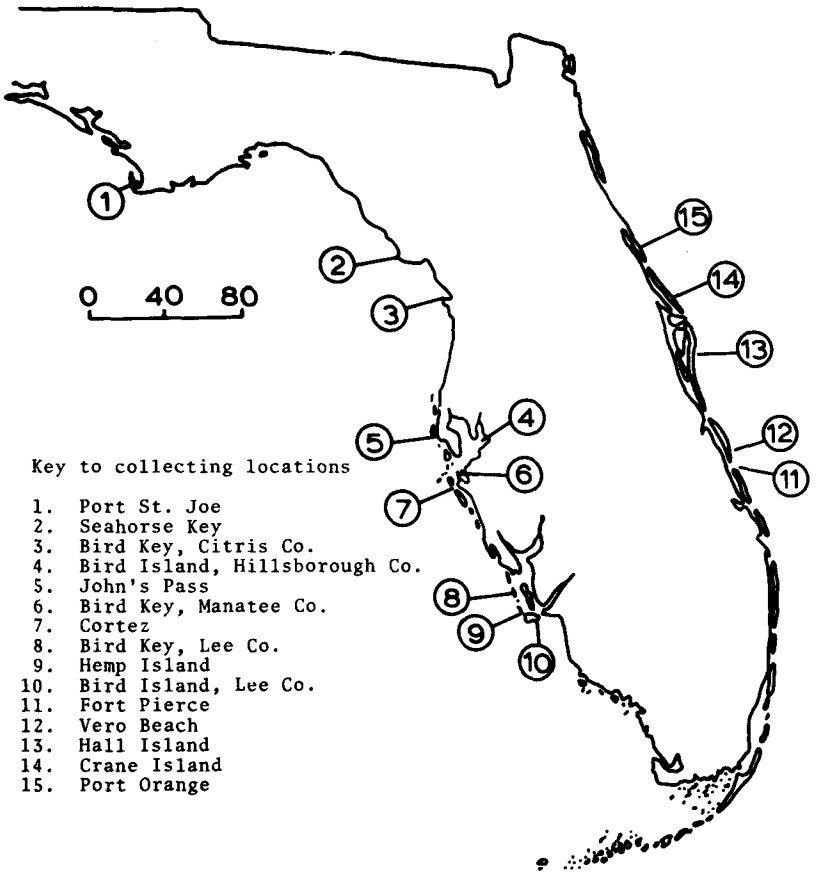

Fig. 1
Florida map listing sample collection locations

Forty apparently viable eggs were collected during 1971; 29 from Hall Island, 11 from Bird Key (Lee Co.), and 3 apparently non-viable eggs from Port St. Joe, Florida (Fig. 1). Eggs were taken from two or three egg clutch nests and were frozen until analysis. Since initial analysis established little, if any, pesticide in the albumen, only yolks were analyzed in the majority of the samples.

Ground fish or egg yolks were blended with granular anhydrous sodium sulfate to a flowing consistency and extracted with petroleum ether in a Soxhlet apparatus for six hours. After petroleum ether evaporation, lipid weights were recorded and residues were subjected to a hexane-acetonitrile partition consisting of 4 x

Table 1

Mean chlorinated hydrocarbon residue levels in all species of fish taken in 1970-1971 listed by location (ppm wet weight, whole fish)

Location	p,p'DDE	p,p'DDD	p,p'DDT	Total DDT	Dieldrin	PCB (1254)
Seahorse Key	.001	.003	.005	.009	ND*	.098
Bird Key, Citrus Co.	.015	.022	.021	.059	.010	.340
Bird Island, Hillsborough Co.	.014	.069	.042	.124	.004	.496
John's Pass	.003	.007	.008	.018	ND	.107
Bird Key, Manatee Co.	.004	.006	.007	.016	ND	.162
Cortez	.006	.007	.020	.033	.002	.188
Bird Key, Lee Co.	.014	.018	.017	.048	.005	.126
Hemp Island	.045	.034	.068	.147	.027	.362
Bird Island Lee Co.	.015	ND	ND	.015	ND	ND
Fort Pierce	.005	.010	.003	.018	ND	.182
Vero Beach	.041	.025	.037	.103	.012	.229
Hall Island	.018	.020	.013	.051	.001	.160
Crane Island	.025	.009	.010	.044	.002	.181
Port Orange	.018	.011	.021	.051	.005	.168
Mean	.016	.017	.019	.052	.007	.200

* ND = None Detected

50 ml washes with acetonitrile. The acetonitrile washings were combined and evaporated at room temperature. The residue was dissolved in hexane and placed on a column of 8% water deactivated Florisil (22 x 180 mm). After elution of the column with 200 ml of 3:1 hexane-benzene (v:v), the eluate was checked by E.C. gas chromatography to establish proper dilution for chlorinated hydrocarbon separation and future gas chromatography.

DDT and its metabolites were separated from PCB's by placing the proper concentration of sample in hexane on silica gel (10 x 70 mm) columns (Grace-Davidson grade 950) which had been washed with benzene and activated at 150° for 3 hours. Volumes of 70 ml pentane and 50 ml benzene were eluted and collected separately (Snyder and Reinert, 1971). Each eluate was injected into a Varian 2100 gas chromatograph onto a 6' x 1/4" glass column of 1:1 6.4% OV-210/1.6% OV-17 on Chromosorb W. A second column of 1.5% OV-17/1.95% QF-1 on Gas Chrom Q was used for confirmation. Instrumental parameters were injection port 210°C, column 200° and tritium E.C. detector 220° with an N_2 carrier flow rate of 40 ml/min. Data was subject to simple analysis of variance and Student's t-test.

Results and Discussion

Average pelican diet residues arranged by location are listed in Table 1. Simple analysis of variance of the diet data demonstrated no differences in the residue levels at different sampling locations. In comparing residue levels of different species, DDE was the only chemical which varied significantly (Table 2). Generally, Spot, Sardinella, Menhaden and Mullet contained significantly higher residues of p,p'DDE than other fish which averaged below 0.006 ppm. This is not unusual as laboratory experiments have shown that different species of fish will concentrate varying amounts of pesticide (Hansen and Wilson, 1970). There was no significant difference in residue levels from 1970 to 1971 in any of the chlorinated hydrocarbons with the exception of PCB's, which significantly increased (.01 level). This was true for both East and West coasts (Table 3).

In general the chlorinated hydrocarbon residues in the fish were below or comparable to other reported fish residues in the United States (Henderson et al, 1969). Table 4 compares average residue levels reported here to a comprehensive study of fish collected near Pensacola, Florida in 1964 and 1965 (Hansen and Wilson, 1970). All residues other than PCB's and

Table 2

Mean residue levels of DDE in fish samples taken in 1970-1971 listed by species (ppm wet weight, whole fish)

Species	No. Samples Averaged	Mean p,p'DDE
Weakfish	6	.004
Anchoa	10	.005
Croaker	5	.006
Pinfish	9	.006
Harangula	7	.012
All other Species	8	.017
Threadfin	11	.023
Mullet	11	.024
Menhaden	14	.032
Sardinella	5	.033
Spot	6	.033

Table 3

Comparison of 1970 and 1971 Averaged Residues (ppm wet weight, whole fish)

Pesticide	1970	1971	Mean, all fish
p,p'DDE	.030	.014	.017
p,p'DDD	.023	.014	.016
p,p'DDT	.016	.021	.020
Total DDT	.074	.047	.051
Dieldrin	.003	.005	.005
PCB (1254)*	.046	.227	.196

*Residues were significantly higher in 1971, $P \leq 0.05$

Table 4

1970-1971 average fish residue values compared with 1964-1965 average values of Hansen and Wilson (1970) (ppm, wet weight, whole fish)

Residue	1964-1965	1970-1971
p,p'DDE	.039	.017
p,p'DDD	.049	.016
p,p'DDT	.086	.020
Total DDT	.174	.051
Dieldrin	NR*	.005
PCB (1254)	NR*	.196

*NR = None Reported

Dieldrin (which were not reported) were higher in the earlier study. This could be due to a decline in the use of chlorinated insecticides between collection years or could imply higher residues in Pensicola, an area closer to Mississippi river runoff. However, it is important to realize these samples were probably quantitated before the first report of Arochlors in the environment and some PCB peaks could have been quantified as DDT or related compounds. In a study of a piscivorous raptor, the Osprey, Ames (1966) found total DDT in fish to be 0.16 ppm (wet weight) in samples taken from Maryland and 3.0 ppm in Connecticut samples. He concluded that neither group contained residues that could be causing systematic problems in adult birds. Anderson et al (1975) reported improved reproduction of Brown Pelicans off the Southern California Coast since the 4 fledglings were born from some 1125 nests built in 1969. Total DDT residues declined in anchovies, the major food of these Brown Pelicans from an average 4.27 ppm (wet weight) in 1969 to 0.15 ppm in 1974. All Pelican diet residues reported in the present study were below the 1974 level and overall the average pesticide residues in the present study do not appear to be of sufficient magnitude to be injurious to the Brown Pelicans or their young.

Residues found in 43 Pelican eggs are shown in Table 5 as averages of eggs from east and west coasts of Florida. The pelican eggs were taken from two or three clutch nests and no noticably thin eggshells were observed. Student's t-tests demonstrated that all residue concentrations except dieldrin were found to be more alike in eggs from the same nest when compared to eggs from different nests (.05 level). This finding is consistent with the data of Enderson and Berger (1970) which indicated that bird egg residues reflect the residues in females. East coast eggs contained significantly higher residues of PCB than west coast eggs (0.05 level). Generally residues were higher for east coast than west (Table 5).

Table 5

Average Residue Values for East and West Coast Pelican Eggs Collected in 1971 including all locations (ppm, wet weight)

Residue	East Coast (N = 29)	West Coast (N = 14)
p,p'DDE	0.896	0.836
p,p'DDD	0.256	0.287
p,p'DDT	0.166	0.068
Total DDT	1.318	1.191
Dieldrin	0.208	0.153
PCB (1254)*	2.241	1.038

*Residues were significantly higher for East Coast, $p \leq 0.05$.

Total DDT residues in the 43 eggs averaged 1.27 ppm and an average of 1.85 ppm PCB quantitated as Arochlor 1254 was found.* These residue levels are well below the total DDT average of 78.5 ppm found in 10 Anacapa Pelican eggs by Lamont et al. (1970) where eggshell thinning was prevalent. Other reports of

*The potential error in this quantitation was discussed by Thompson et al. (1974).

normal reproduction of birds in the wild have shown higher egg residues than reported here (Johnson et al. 1975). To our knowledge, no evidence exists implying that residues of the level reported in this study could cause reproduction problems in Florida pelicans. Although Tumasonis et al. (1973) have shown that concentrations of 10-15 ppm Arochlor 1254 in the eggs of white Leghorn chickens can cause leg, toe and neck deformities, no data exists on the effects of such levels on Brown Pelicans.

It has been somewhat difficult to correlate DDT and metabolite residues to eggshell thinning in birds. Eggs with thin shells have often been found to contain low residues and shells of normal thickness containing high residue (Tucker and Haegele, 1970). Often researchers have been unable to cause more than about 10% eggshell thinning in controlled feeding studies with large doses of chemicals while many wild birds have exhibited over 50% thinning. Tucker and Haegele (1970) demonstrated the accumulation of up to 64 ppm in Mallard eggs with little variation in shell thickness. An extensive study of declining populations of terns could establish no relationship between DDE residues and eggshell thinning, or DDE with reproductive failure even though there was a 39% variation in eggshell thickness (Switzer et al, 1971).

Bitman et al. (1969) determined that Japanese quail fed low calcium and 100 ppm DDT laid eggs with thinner shells which contained less calcium (50% of the birds laid broken eggs). Cecil et al. (1971) showed 100 ppm DDT or DDE with adequate calcium in the diet had no effect upon shell thickness. Another study (Tucker and Haegele, 1970) showed high eggshell thinning (25%) in mallard eggs upon giving a high oral dose of DDT to the birds. This might parallel a fasting condition due to stress or disease when large quantities of residues are released by mobilization of body fat. It is probable that DDE acts synergistically with other stress factors to produce thin eggshells.

It has been shown that egg yolk residues vary in chlorinated hydrocarbon content as the birds' diets vary and unless a future constant source of high levels of exposure occur, there will probably be no general danger to pelicans as a species through concentration of residues by the food chain. Since sampling was performed, DDT usage has been severely restricted. Future problems from this source are not likely and periodic sampling of fish species in an area should suffice as an indicator of possible pesticide problems.

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