INSECTICIDE RESIDUES IN WHITE PELICAN EGGS FROM UTAH

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In 1972, we collected eggs of White Pelicans (*Pelecanus erythrorhynchos*) from Gunnison Island, Great Salt Lake, Utah, to be analyzed for insecticide residues. These analyses were performed to obtain information on a regional population of pelicans not previously surveyed for such residues and to provide background information for a study of reproductive success of the species in Utah.

METHODS

Twenty eggs of White Pelicans were collected from Gunnison Island on each of five days (15, 20, 30 April and 12, 24 May), spaced through the nesting period. On each date, eggs were taken from only those nests with incomplete clutches (full clutch size is 2), i.e. one egg. Thus, each egg collected represented the first laid in the clutch, and had not undergone substantial incubation and possible alteration of eggshell calcium (see Rothstein, 1972). Collected eggs were replaced in the nest with an egg from a 2 egg nest to minimize disturbance to any one nest. Collected eggs were individually wrapped in aluminum foil and immediately frozen.

All eggs were sectioned, and yolk samples were removed while the eggs were still frozen. From each of the five collections, 11 yolk samples were selected at random to be analyzed by electron-capture gas chromatography. Each yolk sample was desiccated with anhydrous sodium sulfate, the dried mass extracted five-times with hexane (glass distilled Skelly Solve B), and the extracts were concentrated over steam in a modified Kudena-Danish assembly. The concentrated extract was purified by chromatography on a deactivated Florisil column, with the residues collected in a single fraction eluted with 20 percent dichloromethane in hexane.

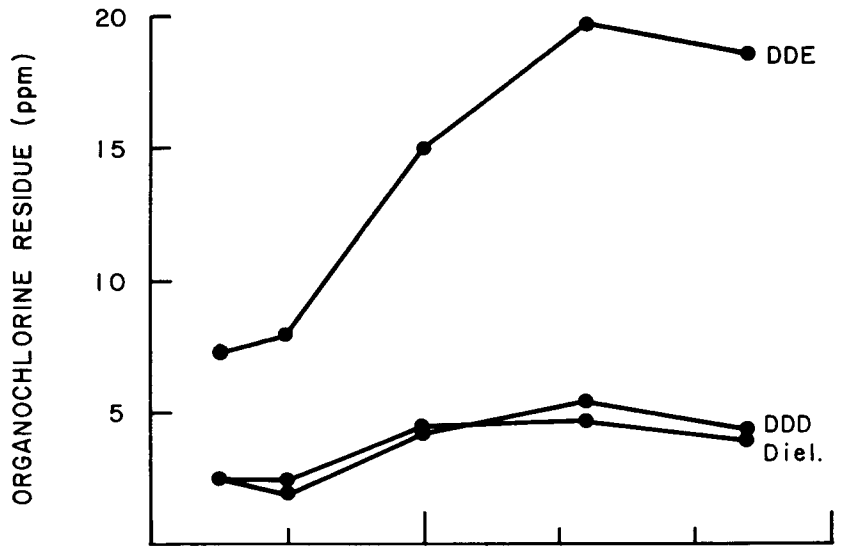
GLC analysis of the reconcentrated, purified extract was performed using a Tracor MT-220 instrument equipped with Ni^{63} electron capture detector. Residues sought included dieldrin, DDD (p,p'–), and DDE (p,p'–). Spot checking for PCB residues yielded negligible to trace quantities of these compounds in the samples. No effort was made to separate the trace PCB residues from dieldrin and DDD, the values of which may therefore be biased upwards in some cases by PCB components. DDE values were not subject to PCB interference.

Eggshells, including shell membranes, were measured for thickness using a Starrett No. 1010 micrometer. Eight lateral readings, taken midway between the caps, were averaged to give a mean thickness value for each shell.

In 1972, an estimated 5,000 to 5,200 White Pelicans nested on Gunnison Island. The first birds began laying about 1 April, and 1,010 nests (40 percent of the population) contained a complete clutch of eggs prior to our initial collection of eggs on 15 April. Approximately 95 nests (4 percent) were begun after the last collection date. Thus, collected eggs did not entirely span the laying period of this pelican population.

RESULTS

Measurable quantities of organochlorine residues were detected in all 55 egg yolks analyzed. Residue levels ranged from 0.50 to 9.88 ppm (parts per million, wet weight) dieldrin, 0.52 to 16.79 ppm DDD, and 2.01 to 57.39 ppm DDE. Mean (± standard error) residue levels of each compound were: 3.64 ± 0.46 ppm dieldrin, 3.70 ± 0.31 ppm DDD, and 13.62 ± 1.46 ppm DDE.



		April		May		
DDE	$\bar{X}$	7.21	7.97	15.00	19.76	18.63
	se	1.22	0.94	1.83	4.79	3.67
Diel.	$\bar{X}$	2.53	2.47	4.60	4.74	3.95
	se	0.63	0.30	0.68	0.90	0.72
DDD	$\bar{X}$	2.64	1.94	4.30	5.44	4.35
	se	0.40	0.47	0.86	1.24	1.41

FIG. 1. Relationship between organochlorine residues in egg yolk and date of egg-laying in White Pelicans. Plotted values represent the mean of 11 yolks analyzed separately.

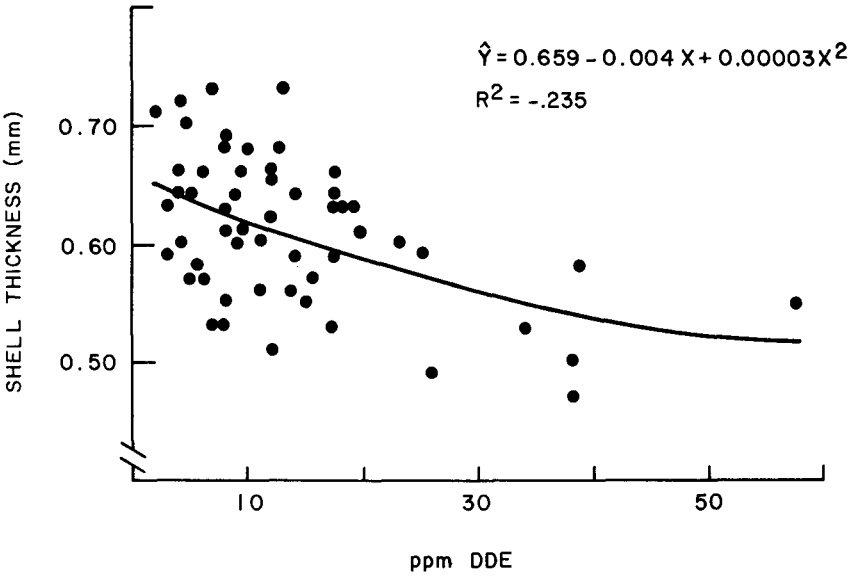


FIG. 2. Relationship between shell thickness and DDE residues in yolks of White Pelican eggs.

Mean levels of total insecticide residues in the yolk varied significantly ($F = 4.69$ $P < 0.01$) between the five collection dates (Fig. 1). Greater total insecticide loads in eggs from the later collections reflected significant increases in levels of dieldrin ($F = 2.61$, $P < 0.05$) and DDE ($F = 4.03$, $P < 0.01$). Increases in mean levels of DDD were not significant ($F = 2.13$, $P > 0.05$). The greatest one-step increase in residue levels occurred between 20 and 30 April, when mean concentrations of each residue approximately doubled. Between 12 and 24 May mean residue levels decreased slightly, but such declines were not significant.

Based upon collections from many regions of central North America, normal (pre-1940) shell thickness for White Pelican eggs, with egg membranes, is 0.686 mm (Anderson et al., 1969). Shell thickness of the 100 eggs that we collected in 1972 was 0.620 ± 0.0063 mm, the difference between the pre-1940 shells and the Gunnison Island shells being significant ($t = 6.86$, $P < 0.001$). Shell thickness of the Gunnison Island eggs decreased with increasing levels of DDE in the yolk (Fig. 2).

DISCUSSION

Some of the highest levels of insecticide residues reported in avian eggs have been in those of Brown Pelicans (*P. occidentalis*) and Double-crested

Cormorants (*Phalacrocorax auritus*) (Anderson et al., 1969; Keith et al., 1970; Gress et al., 1973; Jehl, 1973). However, residue levels in eggs of the White Pelican have remained comparatively low throughout North America (Keith, 1966b; Anderson et al., 1969; Vermeer and Reynolds, 1970; Greichus et al., 1973). Our data represent some of the first available for a Rocky Mountain population of White Pelicans and indicate that eggs of Utah birds contain levels of organochlorine residues comparable to those in eggs from other regions. The seemingly higher values in our study reflect yolk-only analyses, versus whole-egg analyses performed in the other surveys. For comparative purposes, yolk-only residue levels can be reliably converted to whole-egg values by multiplying percent yolk of total egg weight (without shell) by the wet weight residue level observed in the yolk (D. W. Anderson, pers. comm.). Expressed as whole-egg values, mean residue levels observed in Utah eggs were 0.78 ppm dieldrin, 0.79 ppm DDD, and 2.90 ppm DDE. Keith (1966b) reported mean levels of 0.20 ppm dieldrin, 0.67 ppm DDD, and 1.48 ppm DDE in eggs from northern California. Greichus et al. (1973) found 0.10 ppm dieldrin, 0.18 ppm DDD, and 2.07 ppm DDE in South Dakota. Eggs from many regions of central North America averaged 1.90 ppm DDE in 1965 (Anderson et al., 1969), while eggs collected from 16 colonies in Alberta and Saskatchewan in 1969 averaged between 0.05 and 0.38 ppm dieldrin and 0.83 and 4.76 ppm DDE (Vermeer and Reynolds, 1970).

We are uncertain whether the organochlorine residues observed in the pelican eggs were acquired in northern Utah. Local applications of DDT for large-scale insect abatement programs were illegal in 1972 and probably did not occur the preceding three to four years, according to R. Roberts (pers. comm.), Extension Entomologist, at Utah State University. A 1971 survey (Smith et al., 1974) of many Utah wildlife species found only trace residue levels in carp (*Cyprinus carpio*), the principal food item of White Pelicans in Utah (Behle, 1958:111). On the other hand, Keith (1966a) found some of the highest DDE levels reported for any marsh system yet studied at Tule Lake, California, and those levels persisted six years after DDT applications there were terminated (J. O. Keith, pers. comm.). Conceivably, localized areas of cycling high residues may still be present in some of the marshes of northern Utah.

The higher mean residue loads in eggs laid late in the nesting season probably did not reflect a cause-and-effect relationship between the residue level in the tissues of an adult and the time it laid the initial egg. Many eggs laid in May contained residue levels comparable to those in eggs laid in mid-April. In experimental studies, Jeffries (1967) and Peakall (1970) found an abnormal delay between the time of pair formation and laying of the initial egg in Bengalese Finches (*Lonchura striata*) and Ring Doves (*Streptopelia*

risoria) fed DDT in the diet. Although we were unable to determine exactly when pairing occurred in White Pelicans, all birds laid the first egg about five days after selecting a nest site. Pelican numbers on Gunnison Island increased continually throughout the breeding season, indicating that birds breeding late probably also arrived on the breeding grounds late.

The higher residue levels in eggs laid late in the season may reflect the presence of first-time breeders. Younger birds of many species breed later in the reproductive season than older birds (Lack, 1966). We are puzzled as to why younger pelicans would be carrying greater residue loads in the body tissues. Perhaps younger birds feed in those segments of the habitat containing higher levels of insecticide contamination, e.g. sewer outlets, which is suggested in the case of Brown Pelicans (J. R. Jehl, pers. comm.). An alternative explanation is that birds arriving late on the breeding grounds experience a greater exposure to insecticide residues just prior to egg formation. Such exposure would result from local applications of insecticides during the nesting season, or an increased rate of transfer through the food chain of those residues already in the marsh system. Admittedly, these are speculations. Causes for the three-fold increase in DDE residues (Fig. 1) merit investigation. The design of egg collecting in future insecticide surveys of avian populations should consider the possible occurrence of a similar pattern of increasing levels through time.

Renesting birds tend to lay eggs with lower residue loads than birds nesting for the first time in a season (Ludwig and Tomoff, 1966; Anderson et al., 1969). In our study, the slight decrease in mean residue levels between 12 and 24 May may be due to the presence of renesting pelicans in the latter collection.

The higher residue levels in late-nesting birds did not appear to have a significant impact upon the reproductive success of the pelican population. Residue levels were low in the 20 April collection, at which time 60 percent of the pelicans had laid. During the egg collections only one of 791 nests checked contained a broken egg, and that shell did not appear thin. Observations in 1973 (unpublished data) indicate that the incidence of egg mortality, especially through nest desertion, is low among birds breeding in April but approaches 50 percent among those breeding in June. Such mortality may reflect the inexperience of birds breeding for the first time, rather than the presence of higher insecticide loads in individuals.

SUMMARY

White Pelican eggs were collected at the time of laying on Gunnison Island, Great Salt Lake, Utah. Egg yolks were analyzed for the presence of dieldrin, DDD, and DDE, and shells were measured for thickness. Wet weight concentrations of residues averaged 3.64 $\pm$ 0.46 ppm dieldrin, 3.70 $\pm$ 0.31 ppm DDD, and 13.62 $\pm$ 1.46 ppm DDE. These levels

are comparable to those reported for the species from other regions of North America. Concentrations of dieldrin and DDE were significantly higher in eggs laid late in the reproductive season, but reasons for this are not known. Our data suggest that the residue levels observed in the eggs of free-living avian populations may depend on the time of collections.

Shells of pelican eggs were significantly thinner than for pre-1940 eggs. Shell thickness of an egg decreased with increasing levels of DDE in the yolk.

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1st	1914	Chicago, Illinois
2nd	1914	Chicago, Illinois
3rd	1915	Columbus, Ohio
4th	1916	Chicago, Illinois
5th	1917	Pittsburgh, Pennsylvania
6th	1919	St. Louis, Missouri
7th	1920	Chicago, Illinois
8th	1921	Chicago, Illinois
9th	1922	Chicago, Illinois
10th	1923	Cincinnati, Ohio
11th	1924	Nashville, Tennessee
12th	1925	Kansas City, Missouri
13th	1926	Chicago, Illinois
14th	1927	Nashville, Tennessee
15th	1928	Ann Arbor, Michigan
16th	1929	Des Moines, Iowa
17th	1930	Cleveland, Ohio
18th	1931	New Orleans, Louisiana
19th	1932	Columbus, Ohio
20th	1934	Pittsburgh, Pennsylvania
21st	1935	St. Louis, Missouri
22nd	1936	Chicago, Illinois
23rd	1937	Indianapolis, Indiana
24th	1938	Ann Arbor, Michigan
25th	1939	Louisville, Kentucky
26th	1940	Minneapolis, Minnesota
27th	1941	Urbana, Illinois
28th	1946	Omaha, Nebraska
29th	1947	Columbus, Ohio
30th	1949	Madison, Wisconsin
31st	1950	Jackson's Mill, West Virginia
32nd	1951	Davenport, Iowa
33rd	1952	Gatlinburg, Tennessee
34th	1953	Cheboygan, Michigan
35th	1954	Cape May, New Jersey
36th	1955	Stillwater, Oklahoma
37th	1956	Buffalo, New York
38th	1957	Duluth, Minnesota
39th	1958	Wheeling, West Virginia
40th	1959	Rockland, Maine
41st	1960	Gatlinburg, Tennessee
42nd	1961	Huntsville, Ontario, Canada
43rd	1962	Lafayette, Indiana
44th	1963	Charleston, South Carolina
45th	1964	Kalamazoo, Michigan
46th	1965	Sylvan Lake, South Dakota
47th	1966	University Park, Pennsylvania
48th	1967	Crawford Notch, N. Hampshire
49th	1968	Carbondale, Illinois
50th	1969	Williamsburg, Virginia
51st	1970	Fort Collins, Colorado
52nd	1971	Dauphin Island, Alabama
53rd	1972	Cape May, New Jersey
54th	1973	Chapel Hill, North Carolina
55th	1974	Cheboygan, Michigan