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PESTICIDES, POLYCHLORINATED BIPHENOLS AND HEAVY METALS IN UPPER FOOD CHAIN LEVELS, EVERGLADES NATIONAL PARK AND VICINITY

John C. Ogden, et al

Everglades National Park

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16. Abstracts

A general concern over possible environmental pollution by man-made poisons prompted the extensive survey of chlorinated insecticides, polychlorinated biphenyls, and metals in upper trophic levels of material collected in and adjacent to Everglades National Park. Collections were made between 1971 and 1973, and analyses conducted by WARF, Inc., Madison, Wisconsin. The resulting analyses provides a base line for future analyses, and clues for particular poisons or particular species in need of more intensive study. These data revealed that DDT, DDE, DDD, Dieldrin and PCBs appear to exist in concentrations well below amounts known to have either acute or chronic effect. Less is known of the significance of the various metal concentrations reported here, although levels of mercury in freshwater vertebrates and arsenic in marine species are great enough to deserve more intensive study.

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I

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SOUTH FLORIDA ECOLOGICAL STUDY

Pesticides, Polychlorinated Biphenols and Heavy Metals in upper food chain levels, Everglades National Park and vicinity

Final Report

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Everglades National Park

March, 1973

Revised August, 1974

II

FORWARD

A potentially serious threat to southern Florida wildlife is poisoning by certain human-produced toxic insecticides, industrial compounds or metals which escape or are released into the environment. Serious population declines in species of wildlife due to such poisoning have previously been documented in many other regions of the world, particularly among carnivorous species of vertebrates at the top of aquatic food chains (for example: Ames 1965, Blus et al, 1974, Herman et al 1969, Wurster and Wingate 1968). The poisons are absorbed or ingested at various levels of food chains, and become concentrated upward at highter trophic levels as each contaminated individual is consumed by a larger animal. In strong concentrations these poisons cause direct death to adult animals. Of equal concern, lesser concentrations may result in embryonic mortality, thinning of bird eggshells, or chromosomal alterations in first generation young produced by contaminated adults.

INTRODUCTION

Southern Florida supports a good many species of aquatic vertebrates potentially endangered by environmental poisons. Field studies and surveys of some of the species (eagles, ospreys, wading birds, pelicans, and alligators) by National Park Service biologists have revealed levels of reproductive success during the 1960s and early 1970s which appear adequate for maintaining stable populations. Scattered samples of south Florida sediments, plants, water, vertebrate tissue, and avian eggs, which have previously been analysed for various environmental pollutants have generally contained quite low concentrations of these poisons, as one would expect from the successful vertebrate reproduction observed. However, it was apparent that at least small concentrations of various environmental poisons were distributed throughout south Florida ecosystems. The total number of samples from south Florida which had been previously analysed, however, was altogether inadequate for a thorough understanding of this entire problem. This present project was designed to improve the knowledge of the distribution of the environmental pollutants which are known to, or strongly suspected of, adversely affecting upper trophic level vertebrates and invertebrates, and/or are known to be present in south Florida environments.

STUDY AREA AND METHODS

In all, 95 samples were collected and submitted for chemical analyses by WARF, Inc., Madison, Wisconsin. This collection of samples represented an extensive rather than intensive look at local environmental contaminants in an effort to determine which contaminants and which species may be in need of further study. These samples were collected primarily between June, 1971 and January, 1973, as follows:

*1. 5 Osprey eggs from western Florida Bay, 3 collected January 1969, 2 collected February-March 1972.

2. 8 Brown Pelican eggs from western Florida Bay, collected March 1972.

3. 5 Common Egret eggs from central Shark Slough everglades, collected March 1972.

4. 5 Common Egret eggs from western Florida Bay, collected March 1972.

*5. Breast and brain tissue (total 6 samples) from 3 White Ibis, collected Chokoloskee Bay, June 1971.

6. 4 White Ibis eggs from western Florida Bay, collected April 1972.

7. 5 White Ibis eggs from Conservation Area 3B everglades, collected April 1972.

8. 5 Double-crested Cormorant eggs from western Florida Bay collected March 1972.

*9. Breast and brain (total 6 samples) from 3 Sooty Terns from the Dry Tortugas, collected August 1971.

*10. 5 Cattle Egret eggs from Taylor Slough everglades, collected June 1972.

*11. Combined breast and brain tissue from 1 Red-shouldered Hawk, near Mahogany Hammock, collected November 1972.

12. Combined breast and brain from 1 White Ibis, 40-mile Bend, collected September 1972.

*13. 4 American Alligator eggs from central Shark Slough everglades collected June 1972.

14. 5 American Crocodile eggs from eastern Florida Bay, collected May 1972.

15. 2 samples of Pinfish (3 and 4 fish respectively) from Florida Bay, collected December 1971, and September 1972.

16. 1 sample of 7 Pinfish from south Biscayne Bay, March 1972.

17. 2 samples of Stone Crabs (4 and 4) from Florida Bay, collected December 1971, and May 1972.

18. 1 sample of 3 Stone Crabs from south Biscayne Bay, collected October 1972.

19. 2 samples of Sea Catfish (3 and 3) from Florida Bay, collected January 1972, and September 1972.

20. 2 samples of Crevalle Jacks (4 and 3) from Florida Bay, collected December 1971, and June 1972.

21. 2 samples of Silver Mullet (4 and 4) from Florida Bay, collected January 1972, and June 1972.

22. 1 sample of 3 Silver Mullet from south Biscayne Bay, collected November 1972.

23. 2 samples of Spiny Lobsters (4 and 7) from Florida Bay, collected December 1971 and May 1972.

24. 1 sample of 2 Spiny Lobsters from south Biscayne Bay, collected October 1972.

25. 1 sample of 6 Spiny Lobsters from Dry Tortugas, collected March 1972.

26. 2 samples of Gray Snapper (5 and 3) from Florida Bay, collected December 1971, and June 1972.

27. 1 sample of 2 Gray Snapper from south Biscayne Bay, collected January, 1972.

28. 1 sample of 18 Pink Shrimp from south Biscayne Bay, collected March 1972.

29. 1 sample of 2 Blue Crab from south Biscayne Bay, collected October 1972.

30. 1 sample of 4 Bluegill from the upper Shark Slough everglades, collected July 1972.

31. 1 sample of 4 Bluegill from Taylor Slough everglades, collected November 1972.

32. 1 sample of 2 Florida Gar from upper Shark Slough everglades, collected August 1972.

33. 1 sample of 3 Largemouth Bass from Taylor Slough everglades, collected October 1972.

*34. 1 sample of 3 Leopard Frogs from upper Shark Slough everglades, collected October 1972.

*35. 1 sample of 87 Mosquito Fish from upper Shark Slough everglades, collected October 1972.

*36. 1 sample of 50 Mosquito Fish from Taylor Slough everglades, collected January 1973.

*37. 1 sample of 9 Everglades Crayfish (Procambarus) from upper Shark Slough everglades, collected October 1972.

All samples were analysed for residues of certain persistent chlorinated insecticides (DDT, DDE, DDD, and Dieldrin), and for the persistent chlorinated industrial compounds known as Polychlorinated Biphenols. Each sample was also tested for residues of arsenic, mercury, cadmium, lead, zinc and copper, with the exception of some of the samples in the groups marked with an asterisk (*) which lacked sufficient volume for total analyses. The analyses were done on whole eggs (excluding shells) of birds and crocodilians, breast and brain tissue of White Ibis and a Red-shouldered Hawk, and from homogenates of whole animals in the fish, frog and invertebrate samples. The results of these analyses are presented in Table 1, and are expressed in parts per million, whole wet weight basis.

DISCUSSION

The egg analyses provide both a measure of residue levels present in the adult females of each species, and a means for comparing residues in the eggs with a measure of shell thickness. Several research studies have previously shown that sufficient amounts of DDE, and possibly Dieldrin, affect calcium metabolism in birds, resulting in production of thin-shelled eggs (Birman et al 1970, Lockie et al 1969, Wiemeyer and Porter 1970). Increased breakage of these eggs during incubation, in some cases to the point of eliminating all successful reproduction in a population or colony of contaminated birds, has been documented (Keith et al 1970). Other studies of laboratory or field contaminated populations of birds generally showed adversely altered hatching success when egg shell thickness was reduced by approximately 10-20 percent from normal thickness (Wiemeyer and Porter 1970, Wiemeyer et al 1972). We measured shell thickness for the eggs collected during this project and present these data in Table II. Although no great amount of shell-thickness data from normal, non-contaminated populations of birds are available in the literature, it appears that for at least two species, Osprey and Brown Pelicans, the shell measurements from Florida Bay eggs are similar to shell measurements from eggs collected prior to 1947 from non-contaminated populations of these same two species (Anderson and Hickey 1972, Blus et al 1974). We believe it quite likely, therefore, that 1971-1972 eggs produced in the south

Florida everglades region did not contain sufficient contaminants to produce a degree of shell-thinning that would reduce productivity for any species.

The factors which determine rates and patterns of distribution, as well as toxicity of the various environmental pollutants, are extremely complex and only partially understood. Various studies have shown that temperature, turbidity, and flow rate of water, age and size of animals, presence of other chemicals in local environments, and rates of input of toxic chemicals into ecosystems are only some of the factors which determine distribution and toxicity of chemical pollutants in local areas (for example: Durham 1969, Gish and Chura 1969, Kearney et al 1969). An additional difficulty in interpreting residue data is that many potentially toxic metals occur naturally in small amounts in most environments. The natural levels of these metals are not well known in various tissues of most animals, making it difficult to understand the significance of concentrations detected during spot sampling. The metal residues revealed by WARF analyses, while representing a considerable increase in our knowledge of the distribution of these potential pollutants in south Florida, are still insufficient to allow definitive interpretation of the origins, rates of concentration, distribution or toxicity with the local conditions where they are found. Somewhat better understanding of the significance of insecticides and PCB residues can be made from the WARF analyses, primarily because of the voluminous amounts of background information that have accumulated as a result of world wide attention and study of these chlorinated hydrocarbon compounds.

Where WARF analyses proved most useful was in: 1) providing additional data on distribution and concentration of several potential environmental poisons, including the first information from several local species not previously tested; 2) by providing base-line data for future measurements of these same contaminants in the same species obtained by similar collecting procedures; and 3) by providing clues for where there is need for intensive investigation of particular contaminants that may be at or near dangerous concentrations. Following is a summary of the apparent significance of levels of DDT and its metabolites, Dieldrin, PCBs, Arsenic, Mercury, Cadmium, Zinc, Lead and Copper revealed by the WARF analyses.

ANALYTICAL INTERPRETATION

1. DDT and Metabolites (DDE, DDD). An import comment on DDT and it's break-down products, DDE and DDD, is that various species of vertebrates have been shown to exhibit widely different sensitivities to these poisons, so that a lethal amount for one species cannot be assumed to be lethal for other similar sized species. In general, concentrations between 25 and 50 ppm in brain tissue can be considered approaching probably lethal levels for large aquatic and raptorial birds (for example: Belisle et al 1972, Blus et al 1974). The residues of DDT, DDE and DDD revealed by WARF analyses, however, are at quite low concentrations in all species tested, and it probably is true that no significant mortality or impaired reproduction in the Everglades National Park region is occurring due to these poisons. DDE in bird eggs at concentrations greater than 10 ppm might result in enough egg

shell thinning to depress reproductive success on some species (Cade et al 1971, Wiemeyer and Porter 1970), but the highest concentrations of DDE detected by WARF in bird eggs were slightly above 1 ppm in three Osprey eggs. No other fish eating bird eggs, including pelican, cormorant, and Common Egret eggs collected from the same portion of Florida Bay as were the Osprey eggs, contained concentrations as high as 1 ppm. Two of five Cattle Egret eggs contained DDE greater than 1 ppm, including one egg with about 5.5 ppm DDE. Cattle Egrets are not fish eaters, but feed on large insects captured in fields (Fogerty and Hetrick 1973), and individual egrets may accumulate relatively high concentrations by repeatedly feeding in agricultural fields recently sprayed with DDT. Tissues from Dry Tortugas Sooty Terns were particularly clean of these compounds.

The highest concentrations of DDE were found in eggs of American Alligators, (mean value for four eggs, 2.42 ppm; range 1.79-3.00 ppm), and American Crocodiles (mean for five eggs, 1.85 ppm; range 0.78-3.23 ppm). So little is known of the affects of DDT, and its metabolites, on crocodilians that it is difficult to interpret these date. It is interesting that the freshwater fish or invertebrate sample with highest DDE residues was the Florida Gar, a species thought to be important as food for alligators. Where crocodiles obtained high DDE concentrations is more puzzling, for residues of DDE in silver mullet and crabs, two important crocodile foods, were particularly low.

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None of the species analyzed by WARF contained concentrations that approach residue levels known to produce chronic damage to these species. We also recognize, however, that the low levels in decapod crustaceans could reflect the extreme sensitivity these animals have for these compounds (Butler 1969). Greater concentrations, in the range of 1 to 10 ppm, tend to be lethal in some species. All samples submitted to WARF were from live, presumably healthy, individuals, and would almost have to be clean of these poisons. This sensitivity is not surprising since these compounds were designed for destruction of closely related arthropod pests.

2. Dieldrin. In general, fairly low levels of Dieldrin in the range of 10-20 ppm in brain tissues, may result in death or abnormal behavior in some birds, particularly in combination with relatively high levels of other insecticides (Stickel et al 1969). Concentrations as low as 1-5 ppm in bird eggs have been reported to cause egg shell thinning in some species (Lockie et al 1969 and Stoewsand et al 1971). These concentrations are considerably greater than any detected by the WARF analyses.

All samples tested by WARF contain concentrations of Dieldrin less than 1 ppm. Bird eggs generally contained less than 0.10 ppm, except for Cattle Egrets, where 5 eggs contained a meal level of 0.18 ppm (range: none detected to 0.66 ppm). The relatively high concentrations in Cattle Egret eggs is a reflection of this species' food habits in south Florida of large insects captured by farmland fields, including fields where local applications of Dieldrin may occur.

3. Polychlorinated Biphenols. PCBs occurring in the environment are industrial compounds used as plasticizers in the production of paints, resins, and electrical insulators, and they may be applied with pesticides to extend the kill-life of the poisons (Hammond 1972, Peakall and Lincer 1970). PCBs have been found to be approximately 1/4 to 1/5 as toxic as DDT in some birds studied, and two or three orders of magnitude less toxic to fish than DDT. Like DDT, PCBs which escape into the environment remain as persistent poisons. A steady diet of PCBs to adult birds, in concentrations of approximately 10 ppm, may result in chromosomal alteration in young produced by these adults, and concentrations of about 50 ppm in the eggs laid by these adults (Peakall et al 1972). PCB concentrations revealed by the WARF analyses were highest in fish eating birds from Florida Bay (mean value 1.43 ppm in Osprey eggs; 1.21 ppm in Common Egret eggs; and 0.84 ppm in pelican eggs). Highest concentrations in freshwater samples were from Common Egret eggs (mean 0.33 ppm) and Alligator eggs (mean 0.30 ppm), from the Shark Slough. These concentrations are well below those known to cause serious adverse effects on wildlife. Samples from several other fresh-water and marine vertebrates (White Ibis, cormorant, and crocodile eggs; Sooty Tern tissue) contained no detectable PCB residues. Marine and freshwater fish and invertebrate samples generally contained less than 0.10 ppm PCBs, considerably below concentrations thought to affect these species (Hammond 1972).

4. Mercury. The U. S. Food and Drug Administration has declared that fish and other food which contain more than 0.5 ppm mercury are unsafe for human consumption. Recent studies of wildlife in the United States and Canada have revealed that several species of fish and game birds contain concentrations of mercury at or above this 0.5 ppm level (for example: Adley and Brown 1972, Fimreite 1974). In fact, it appears that such concentrations may not be rare in wildlife, indicating that there is widespread mercury pollution, particularly in freshwater ecosystems. There is little information on whether these mercury concentrations have chronic effects on the species.

Highest concentrations revealed by the WARF analyses were, as in other regions, primarily invertebrates which live or feed in freshwater. Brain and breast tissue from White Ibis ranged between approximately 1 and 2.5 ppm mercury, combined breast and brain from a Red-shouldered Hawk contained 0.78 ppm, 4 alligator eggs had a mean 0.69 ppm, two bluegill samples averaged 0.58 ppm, and a sample of Florida gar contained 0.60 ppm. Common Egret eggs from the Shark Slough contained a mean 0.37 ppm mercury, compared with a mean 0.16 ppm in Common Egret eggs from Florida Bay. The same relationship was not apparent between White Ibis eggs collected in the everglades and Florida Bay, where the values were only slightly higher in the freshwater region.

Highest mercury concentrations in marine species were a mean of 0.59 ppm from the seven carnivorous Crevalle Jack samples, and 0.36 ppm in cormorant eggs. The relatively high concentrations of 0.24 ppm in bottom feeding Sea Catfish seemed to reflect their higher trophic position than the similar bottom feeding Silver Mullet, with mercury concentrations of 0.05 ppm. Species with similar feeding methods may be expected to contain more nearly similar amounts of various residues, but the fact that they do not points out the possibility of different rates of assimilation of these poisons by different species.

The mercury concentrations reported here apparently are too low to have acute effects on wildlife, but there is no certainty that chronic problems do not occur. The relatively high concentrations in some freshwater vertebrates deserves further monitoring and study, with emphasis on sources of the mercury, and the possible effects on productivity in these freshwater species.

Of particular interest are the seemingly high concentrations of arsenic, zinc, lead and copper in more marine species. Many marine organisms are known to selectively accumulate heavy metals, a phenomenon that has been reported for over 50 years (Harvey, 1957). It has been established that marine biological systems accumulate arsenic, zinc, lead, copper and cadmium concentrations several thousand times greater than ambient sea water (FWPCA 1968, Goldberg 1970). Zinc and copper concentrations are well within a range considered normal for estuarine fish. The WARF samples contain concentrations of these metals, other than arsenic, less than could be expected by biological accumulation from average sea water concentrations. Arsenic concentrations

in some marine fish (7.5 ppm) and invertebrates (18.8 ppm) are slightly higher than expected by accumulation, but probably not by a significant amount. The levels of arsenic found in this study approached the present tolerance of 7 ppm for combined lead arsenate on food crops, and may constitute a health hazard (Pakhala et al., 1972).
The possibility of arsenic at concentrations great enough to have adverse affects is real, and this situation deserves further investigation. We also recommend that monitoring of the other metals be scheduled on some regular basis, particularly in conjunction with any studies undertaken of the population dynamics of marine species in Everglades National Park.

SUMMARY AND RECOMMENDATIONS

A general concern over possible environmental pollution in southern Florida by man-made poisons prompted this extensive survey of chlorinated insecticides, polychlorinated biphenols, and metals in upper trophic level samples. The resulting analyses provide a base line for future analyses, and clues fo. particular poisons or particular species in need of more intensive study. These data revealed that DDT, DDE, DDD, Dieldrin, and PCBs appear to exist in concentrations well below amounts known to have either acute or chronic effects on local species. Less is known of the significance of the various metal concentrations reported here, although levels of mercury in freshwater vertebrates, and arsenic in marine species are great enough to deserve more intensive study. We recommend the following:

1. A regular program to monitor amounts of environmental poisons in upper trophic level species in the southern everglades and adjacent estuaries should be established. Not less than 50 samples representing select freshwater and marine species, primarily those tested in this present study, should be tested for insecticides, PCBs, and metals, on a routine basis every 2 or 3 years. Some effort should be made to collect samples from areas where little sampling has been done thus far, for example in the west coast rivers and bays south of Everglades City, the lower cypress sloughs, and in Conservation Area 3.

2. Concentrations of mercury in freshwater vertebrates, and arsenic in marine animals were high enough to warrent further investigations soon. Some money and time should be programmed for further analyses for mercury and arsenic to determine percent of methyl mercury present in total mercury reported, obtain a better understanding of distribution and source of mercury and arsenic in these ecosystems, and for further literature review to provide interpretation of significance of mercury and arsenic concentrations being detectud locally.

TABLE I. Pesticide, Polychlorinated Biphenyls, and heavy metal concentrations (ppm) in south Florida animals 1971-72.

Sample Number	Location	Sample Material	DDE	DDD	DDT	Dieldrin	PCB	As	Hg	Cd	Zn	Pb	Cu
1	Florida Bay	Osprey Egg**	1.94	0.30	ND*	0.037	2.27	--	--	--	--	--	--
2	Florida Bay	Osprey Egg**	0.96	0.21	0.080	0.011	0.64	--	--	--	--	--	--
3	Florida Bay	Osprey Egg	1.24	0.29	ND	0.016	1.35	--	--	--	--	--	--
4	Florida Bay	Osprey Egg	0.86	0.13	0.016	0.010	1.50	<0.10	0.07	<.05	4.6	<0.2	0.78
5	Florida Bay	Osprey Egg	1.09	0.078	0.016	0.010	1.37	<0.10	0.21	<.05	6.5	<0.2	0.54
6	Florida Bay	Brown Pelican egg	0.12	0.056	0.047	0.030	0.31	<0.10	0.29	<.05	7.6	<0.2	1.36
7	Florida Bay	Brown Pelican egg	0.09	0.047	0.047	0.020	0.25	<0.10	0.35	<.05	4.7	<0.2	0.72
8	Florida Bay	Brown Pelican egg	0.11	0.053	0.078	0.025	0.37	<0.10	0.50	<.05	7.3	<0.2	1.02
9	Florida Bay	Brown Pelican egg	0.08	0.016	0.016	0.012	0.31	<0.10	0.33	<.05	5.4	<0.2	1.14
10	Florida Bay	Brown Pelican egg	0.12	0.053	0.053	0.030	0.69	<0.10	0.44	<.05	6.6	<0.2	1.06
11	Florida Bay	Brown Pelican egg	0.65	0.110	0.110	0.230	3.24	<0.10	0.45	<.05	7.9	<0.2	0.92
12	Florida Bay	Brown Pelican egg	0.20	0.075	0.047	0.030	1.00	<0.10	0.12	<.05	6.2	<0.2	0.54
13	Florida Bay	Brown Pelican egg	0.14	0.084	0.047	0.030	0.62	<0.10	0.28	<.05	9.3	<0.2	1.04

TABLE I. Continued

Sample Number	Location	Sample Material	DDE	DDD	DDT	Dieldrin	PCB	As	Hg	Cd	Zn	Pb	Cu
14	Shark Valley	Common Egret egg	0.47	0.041	0.062	0.010	0.25	<0.10	0.28	<0.05	8.7	<0.2	0.85
15	Shark Valley	Common Egret egg	0.29	0.022	0.041	ND	0.19	<0.10	0.19	<0.05	6.3	<0.2	0.74
16	Shark Valley	Common Egret egg	0.42	0.022	0.047	0.075	0.31	<0.10	0.26	<0.05	6.5	<0.2	1.26
17	Shark Valley	Common Egret egg	0.52	0.022	0.047	0.010	0.28	<0.10	0.91	<0.05	6.7	<0.3	1.02
18	Shark Valley	Common Egret egg	0.89	0.031	0.062	ND	0.56	<0.10	0.21	<0.05	9.8	<0.4	0.81
19	Florida Bay	Common Egret egg	0.14	0.022	0.016	ND	ND	<0.10	0.19	<0.05	8.4	<0.2	1.08
20	Florida Bay	Common Egret egg	0.14	ND	0.016	ND	ND	<0.10	0.17	<0.05	5.9	<0.2	1.16
21	Florida Bay	Common Egret egg	0.52	0.016	0.047	0.025	0.87	<0.10	0.13	<0.05	8.3	<0.2	1.00
22	Florida Bay	Common Egret egg	0.94	0.031	0.094	0.030	5.00	<0.10	0.17	<0.05	8.1	<0.2	1.08
23	Florida Bay	Common Egret egg	0.097	ND	0.016	0.025	0.19	<0.10	0.13	<0.05	6.5	<0.2	0.94
24	Taylor Slough	Cattle Egret egg***	0.18	0.016	0.073	ND	ND	<0.20	0.05	—	—	—	—
25	Taylor Slough	Cattle Egret egg***	5.49	0.11	0.21	0.660	0.35	<0.10	0.05	—	—	—	—
26	Taylor Slough	Cattle Egret egg	0.19	0.008	0.040	0.110	ND	<0.07	0.05	—	—	—	—
27	Taylor Slough	Cattle Egret egg	1.63	0.035	0.035	0.120	ND	<0.20	0.05	—	—	—	—
28	Taylor Slough	Cattle Egret egg	0.12	0.047	0.051	0.034	ND	0.3	0.05	—	—	—	—

TABLE I. Continued

Sample Number	Location	Sample Material	DDE	DDD	DDT	Dieldrin	PCB	As	Hg	Cd	Zn	Pb	Cu
29	Florida Bay	White Ibis egg	0.031	0.031	ND	0.037	ND	<0.10	0.05	<.05	7.0	<0.2	[illegible]
30	Florida Bay	White Ibis egg	0.062	0.031	0.031	ND	ND	<0.10	[illegible]	<.05	6.6	<0.2	1.00
31	Florida Bay	White Ibis egg	0.16	0.016	0.016	0.020	0.19	<0.10	0.07	<.05	9.6	<0.2	[illegible]
32	Florida Bay	White Ibis egg	0.14	0.016	0.016	0.005	ND	0.24	0.05	<.05	5.5	<0.2	1.24
33	Cons. Area 3B	White Ibis egg	0.077	0.015	0.015	0.020	ND	<0.10	<0.05	<.05	7.0	<0.5	0.96
34	Cons. Area 3B	White Ibis egg	0.80	0.019	0.037	0.010	ND	<0.10	0.09	<.05	6.6	<0.2	1.00
35	Cons. Area 3B	White Ibis egg	0.14	0.016	ND	0.012	ND	<0.10	0.07	<.05	[illegible]	<0.2	[illegible]
36	Cons. Area 3B	White Ibis egg	0.16	0.031	0.031	ND	ND	<0.25	[illegible]	.05	10.3	0.4	1.15
37	Cons. Area 3B	White Ibis egg	0.062	ND	0.015	0.020	ND	<0.10	<0.05	<.05	9.6	<0.5	1.35
38	Florida Bay	Cormorant egg	0.031	0.031	ND	ND	ND	<0.10	0.44	.05	7.3	0.2	[illegible]
39	Florida Bay	Cormorant egg	0.031	ND	ND	ND	ND	<0.10	0.31	.05	7.4	0.2	[illegible]
40	Florida Bay	Cormorant egg	0.047	ND	ND	ND	ND	<0.10	0.46	.05	[illegible]	[illegible]	[illegible]
41	Florida Bay	Cormorant egg	0.047	ND	ND	ND	0.25	<0.10	0.34	.05	8.4	0.3	[illegible]
42	Florida Bay	Cormorant egg	0.053	ND	ND	ND	ND	<0.10	0.44	.05	7.2	0.2	0.90
43a	Chokoloskee Bay	White Ibis breast	0.094	ND	ND	0.010	ND	—	0.97	—	—	—	—

TABLE I. Continued

Sample Number	Location	Sample Material	DDE	DDD	DDT	Dieldrin	PCB	As	Hg	Cd	Zn	Pb	Cu
43b	Chokoloskee Bay	White Ibis brain	0.69	ND	ND	ND	ND	--	--	--	--	--	--
44a	Chokoloskee Bay	White Ibis breast	0.041	ND	ND	ND	0.37	1.76	0.05	9.0	0.2	9.0	3.4
44b	Chokoloskee Bay	White Ibis brain	0.092	0.092	ND	ND	ND	--	--	--	--	--	--
45a	Chokoloskee Bay	White Ibis breast	0.14	ND	ND	ND	ND	--	2.62	--	--	--	--
45b	Chokoloskee Bay	White Ibis brain	0.32	ND	ND	ND	1.28	--	--	--	--	--	--
46	Mahogany Hammock	Red-shouldered Hawk***	0.091	0.005	0.005	0.005	0.78	0.15	0.78	--	--	--	--
47	40-Mile Bend	White Ibis	0.010	0.005	0.005	0.025	0.050	0.07	1.40	0.05	10.	0.2	7.2
48a	Dry Tortugas	Sooty Tern breast	0.039	ND	ND	ND	ND		.05	--	--	--	--
48b	Dry Tortugas	Sooty Tern brain	ND	ND	ND	0.13	ND	--	--	--	--	--	--
49a	Dry Tortugas	Sooty Tern breast	0.031	ND	ND	0.015	ND	--	.05	--	--	--	--
49b	Dry Tortugas	Sooty Tern brain	ND	ND	ND	0.080	ND	--	--	--	--	--	--
50a	Dry Tortugas	Sooty Tern breast	0.062	ND	ND	0.020	ND	--	0.06	--	--	--	--
50b	Dry Tortugas	Sooty Tern brain	0.16	ND	ND	0.10	1.92	--	--	--	--	--	--
51	Shark Valley	Alligator egg	2.51	0.053	0.18	0.064	0.40	0.05	0.41	--	--	--	--
52	Shark Valley	Alligator egg	1.79	0.047	0.047	ND	0.25	0.2	0.71	--	--	--	--
53	Shark Valley	Alligator egg	2.38	0.044	0.044	0.019	0.22	0.2	0.51	--	--	--	--

TABLE I. Continued

Sample Number	Location	Sample Material	DDE	DDD	DDT	Dieldrin	PCB	As	Hg	Cd	Zn	Pb	Cu
54	Shark Valley	Alligator egg	3.00	0.042	0.060	ND	0.36	0.05	0.53	--	--	--	--
55	Florida Bay	Crocodile egg	3.23	0.16	0.59	0.019	ND	0.08	0.14	0.05	8.2	0.3	0.9
56	Florida Bay	Crocodile egg	1.64	0.11	0.33	0.024	ND	0.08	0.08	0.05	9.8	0.5	1.02
57	Florida Bay	Crocodile egg	1.72	0.15	0.29	ND	ND	0.08	0.05	0.05	7.2	0.3	0.94
58	Florida Bay	Crocodile egg	1.87	0.062	0.31	0.011	ND	0.06	0.10	0.05	8.6	0.4	0.62
59	Florida Bay	Crocodile egg	0.78	0.055	0.15	ND	ND	0.06	0.07	0.05	11.	0.2	15.0
60	Shark Valley	Bluegill (4)	0.013	0.006	0.006	ND	ND	0.09	0.94	0.05	23.	0.5	0.67
61	Shark Valley	Florida Gar (2)	0.20	0.063	0.052	ND	0.047	0.5	0.60	0.05	26.	0.6	0.57
62	Taylor Slough	Bluegill (4)	0.050	0.014	0.027	0.006	0.075	0.09	0.22	0.09	24.	0.5	0.5
63	Taylor Slough	Largemouth Bass (3)	0.062	0.032	0.037	0.005	0.055	0.05	0.31	0.05	16.	0.5	0.5
64	Shark Valley	Leopard Frog (5)	0.029	0.010	0.010	0.010	0.082	0.07	0.07	----	--	--	--
65	Shark Valley	Mosquitofish (87)	0.013	0.010	0.010	0.010	0.19	0.07	0.15	----	--	--	--
66	Shark Valley	Crayfish (9)	0.006	0.006	0.006	0.006	0.10	0.38	0.05	----	--	--	--
67	Taylor Slough	Mosquitofish (50)	0.037	0.008	0.008	0.008	0.12	0.07	0.17	----	--	--	--
68	Florida Bay	Crevalle Jack (4)	0.006	ND	0.005	ND	ND	0.55	0.39	0.05	13.	0.4	0.81

TABLE I. Continued

Sample Number	Location	Sample Material	DDE	DDD	DDT	Dieldrin	PCB	As	Hg	Cd	Zn	Pb	Cu
69	Florida Bay	Gray Snapper (5)	ND	ND	ND	ND	ND	1.4	0.13	0.07	19.[illegible]	1.5	0.73
70	Florida Bay	Silver Mullet (4)	0.008	0.005	0.006	ND	ND	1.5	0.07	0.05	30.	0.6	1.16
71	Florida Bay	Sea Catfish (3)	0.032	0.095	0.005	0.005	0.18	3.12	0.38	0.12	119.	0.5	0.5
72	Florida Bay	Pinfish (8)	0.008	0.005	0.006	0.005	0.049	2.05	0.06	0.12	22.	0.5	0.9
73	Florida Bay	Pinfish (4)	0.009	0.005	0.008	0.005	0.11	3.52	0.12	0.05	19.2	0.2	0.66
74	Florida Bay	Sea Catfish (3)	0.036	ND	0.005	0.005	0.06	7.47	0.24	0.15	126.	0.2	0.58
75	Florida Bay	Crevalle Jack (3)	0.029	0.017	0.014	0.006	0.12	0.50	0.60	0.05	12.2	0.2	0.78
76	Florida Bay	Silver Mullet (4)	0.037	0.037	ND	0.015	0.79	2.51	0.05	0.05	25.5	0.2	2.4
77	Florida Bay	Gray Snapper (3)	0.012	0.005	0.005	0.005	0.05	2.23	0.29	0.08	17.1	0.2	0.96
78	Biscayne Bay	Pinfish (7)	0.006	0.005	0.006	ND	ND	2.7	0.06	0.03	22.	0.2	0.73
79	Biscayne Bay	Gray Snapper (2)	0.11	0.059	0.036	ND	0.047	1.6	0.14	0.11	31.	0.4	0.39
80	So. Bisc. Bay	Silver Mullet (3)	0.037	0.017	0.010	0.012	0.073	1.22	0.05	0.06	23.	0.5	0.9
81	S. Bisc. Bay	Stone Crabs (3)	0.005	0.005	0.005	0.005	0.024	11.8	0.08	0.76	39.	0.5	26.7
82	So. Bisc. Bay	Blue Crab (2)	0.005	0.005	0.005	0.005	0.023	7.68	0.05	0.42	27.	0.5	17.1
83	So. Bisc. Bay	Spiny Lobster (2)	0.005	0.005	0.005	0.005	0.024	15.5	0.08	0.17	26.	0.5	32.2

TABLE L Continued

Sample Number	Location	Sample Material	DDE	DDD	DDT	Dieldrin	PCB	As	Hg	Cd	Zn	Pb	Cu
84	So. Bisc. Bay	Pink Shrimp (18)	ND	ND	ND	ND	ND	--	0.05	0.09	15.	0.3	31.0
85	Florida Bay	Stone Crab (4)	0.012	0.005	0.005	0.005	0.04	8.97	0.11	0.15	24.5	1.0	16.0
86	Florida Bay	Stone Crab (4)	0.005	ND	0.005	ND	ND	9.1	0.13	0.05	1.0	1.7	3.2
87	Florida Bay	Spiny Lobster (4)	ND	ND	ND	ND	ND	15.7	0.05	0.21	[illegible]	1.4	12.0
88	Florida Bay	Spiny Lobsters (7)	ND	ND	ND	0.005	ND	15.5	0.05	0.09	11.5	0.2	13.0
89	Dry Tortugas	Spiny Lobsters (6)	ND	ND	ND	ND	ND	18.8	0.05	0.10	17.	0.4	12.0

*ND denotes no detectable amount
** Endrin concentration in No. 1 = 0.011 ppm, and No. 2 = ND
*** Oxychlordane concentration No. 24 = 0.035 ppm, and No. 25 = 0.037 ppm
**** Combined breast and brain tissue
***** Number in ( ) indicates the number of whole animals combined for analysis

TABLE II

Eggshell thickness measurements pesticides and heavy metal monitoring
South Florida Environmental Study

Species	Location	Number	Mean (mm)	Range (mm)
Osprey	Florida Bay	2	.590	.575 - .605
Brown Pelican	Frank Key	4	.576	.545 - .621
Brown Pelican	Palm Key	4	.566	.536 - .640
Common Egret	Frank Key	5	.336	.287 - .351
Common Egret	Shark Slough	5	.346	.335 - .371
Double-crested Cormorant	Frank Key	5	.436	.410 - .490

Literature Cited

Adley, F. E., and D. W. Brown. 1972. Mercury concentrations in game birds, State of Washington -.1970 and 1971. Pesticides Monit. Jour. 6:91-93.

Ames, P. L. 1965. DDT residues in the eggs of the Osprey in the north-eastern United States and their relation to nesting success. Suppl. to Jour. Appl. Ecol. June 1966, 87-97.

Anderson, D.W., and J. J. Hickey. 1972. Eggshell changes in certain North American birds. Proc. XV Internat. Ornithol. Cong.., 514-540.

Belisle, A. A., W. L. Reichel, L. N. Locke, T. G. Lamont, B. M. Mulhern, R. M. Prouty, R. B. DeWolf, and E. Cromartie. 1972. Residues of organchlorine pesticides, polychlorinated biphenyls, and mercury and autopsy data for Bald Eagles, 1969 and 1970. Pesticides Monit. Jour. 6:133-138.

Bitman, J., H. C. Cecil, and G. F. Fries. 1970. DDT-induced inhibition of avian shell gland carbonic anhydrase: a mechanism for thin eggshells. Science 168:594-596.

Blus, L. J., A. A. Belisle, and R. M. Prouty. 1974. Relations of the Brown Pelican to certain environmental pollutants. Pesticides Monit. Jour. 7:181-194.

Butler, P. A. 1969. The significance of DDT residues in estuarine fauna. In: Chemical fallout (Eds.: M. W. Miller and G. G. Berg). Springfield, Ill., Charles C. Thomas, pp. 205-220.

Cade, T. J., J. L. Lincer, C. M. White, D. G. Roseneau, and L. G. Swart.. 1971. DDE residues and eggshell changes in Alaskan falcons and hawks. Science 172:955-957.

Durham, W. F. 1969. The influence of other factors on the toxicity of pesticides. In: Chemical fallout (Eds.: M. W. Miller and G. G. Berg). Springfield, Ill. Charles C. Thomas, pp. 433-446.

Federal Water Pollution Control Administration. 1968. Water Quality Criteria. U. S. Dept. Int. Wash. D.C.

Fimreite, N. 1974. Mercury contamination of aquatic birds in northwestern Ontario. Jour. Wildlife Manag. 38:120-131.

Fogarty, M. J., and W. M. Hetrick. 1973. Summer foods of Cattle Egrets in north central Florida. Auk 90:268-280.

Gish, C. D., and N. J. Chura. 1969. Toxicity of DDT to Japanese Quail as influenced by body weight, breeding conditions and sex. Toxicology and Appl. Pharmacology 17:740-751

Goldberg, E. D. 1957. Biogeochemistry of trace elements. In: Treatise on marine ecology and paleoecology, Vol. 1 Ecology Ed. J. W. Hedgpeth. Geol. Soc. Amer. Mem. 67. 1296 p.

Hammond, A. L. 1972. Chemical pollution: polychlorinated biphenyls. Science 175:155-156.

Harvey, H. W. 1957. The chemistry and fertility of sea water, 2nd ed. Cambridge Univ. Press. Cambridge, England.

Herman, S. G., R. L. Garrett, and R. L. Rudd. 1969. Pesticides and the Western Grebe. In: Chemical fallout (Eds.: M. W. Miller and G. G. Berg). Springfield, Ill. Charles C. Thomas, pp. 24-53.

Kearney, P. C., R. G. Nash, and A. R. Isensee. 1969. Persistence of pesticide residues in soils. In: Chemical fallout (Eds.: M. W. Miller and G. G. Berg). Springfield, Ill. Charles C. Thomas, pp. 54-67.

Keith, J. O., L. A. Woods, Jr., and E. G. Hunt. 1970. Reproductive failure in Brown Pelicans on the Pacific coast. Trans. 31st North Am. Wildl. Natur. Resour. Conf. 190-200.

Lockie, J. D., D. A. Ratcliffe, and R. Balharry. 1969. Breeding success and organo-chlorine residues in Golden Eagles in west Scotland. Jour. Appl. Ecol. 6:381-389.

Peakall, D. B., and J. L. Lincer. 1970. Polychlorinated biphenyls [:] Another long-life widespread chemical in the environment. BioScience 20:958-964.

Peakall, D. B., J. L. Lincer, and S. E. Bloom. 1972. Embryonic mortality and chromosomal alterations caused by Aroclor 1254 in Ring Doves. Environmental Health Perspectives, April 1972:103-104.

Pakhala, I., G. E. Burdick, E. J. Harris, D. J. Lisk, and M. N. White. 1972. Arsenic content of fish from New York State waters. N. Y. Fish and Game J. 19(1)12-31.

Stickel, W. H., L. F. Stickel, and J. W. Spann. 1969. Tissue residues of dieldrin in relation to mortality in birds and mammals. In: Chemical fallout (Eds.: M. W. Miller and G. G. Berg). Springfield, Ill. Charles, pp. 174-204.

Stickel, W. H., L. F. Stickel, and J. W. Spann. 1969. Tissue residues of dieldrin in relation to mortality in birds and mammals. In: Chemical fallout (Eds.: M. W. Miller and G. G. Berg). Springfield, Ill. Charles, pp. 174-204.

Stoesand, G. S., J. L. Anderson, W. H. Gutenmann, C. A. Bache, and J. D. Lisk. 1971. Eggshell thinning in Japanese quail fed mercuric chloride. Science 173130-131.

Wiemeyer, S. N., and R. D. Porter. 1970. DDE thins eggshells of captive American Kestrels. Nature 227:737-738.

Wiemeyer, S. N., B. M. Mulhern, F. J. Ligas, R. J. Hensel, J. E. Mathisen, F. C. Robards, and S. Postupalsky. 1972. Residues of organochlorine pesticides, polychorinated biphenyls, and mercury in Bald Eagle eggs and changes in shell thickness - 1969 and 1970. Pesticides Monit. Jour. 6:50-55.

Wurster, C. F., Jr. and D. B. Wingate. 1968. DDT residues and declinging reproduction in the Bermuda Petrel. Science 159:979-981.

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