Florida Field Naturalist

PUBLISHED BY THE FLORIDA ORNITHOLOGICAL SOCIETY

VOL. 25, NO. 2 MAY 1997 PAGES 33-84

Fla. Field Nat. 25(2):33-41, 1997.

PESTICIDE AND HEAVY METAL LEVELS OF WATERBIRDS IN THE EVERGLADES AGRICULTURAL AREA OF SOUTH FLORIDA

JAMES A. RODGERS, JR.
Florida Game and Fresh Water Fish Commission
4005 South Main Street
Gainesville, Florida 32601

Abstract.—Egg and liver tissues from eight species of waterbirds collected in the Everglades Agricultural Area (EAA), Lake Okeechobee, and Lake Kissimmee were analyzed for mercury (Hg), lead, DDT, DDE, DDD, dieldrin, heptachlor, *trans*-nonachlor, chlordane, endrin, toxophene, and PCBs. Most tissues exhibited low concentrations of most of the biocides, except for elevated levels of Hg and DDE at the EAA and Lake Okeechobee. Although concentrations generally were below levels currently thought to have a significant biological effect on birds, a few birds had concentrations that were at levels that could be detrimental.

Organochlorine and heavy metal contaminants have been studied in many species of waterbirds (Faber et al. 1972, Biskup et al. 1978, Ohlendorf et al. 1978, Hoffman and Curnov 1979, Blus et al. 1980, Cheney et al. 1981, Custer et al. 1983, Fleming et al. 1984a, Henny et al. 1984, Ohlendorf et al. 1988). Most of these studies have investigated the effects of bioaccumulation of pesticide residues, but some researchers also have studied the direct poisoning of waterbirds (cf. Stickel et al. 1979, Zinkl et al. 1981). Despite having large populations of waterbirds (Ogden 1978), only a few studies have investigated pesticide and heavy metal contamination in Florida (e.g., Ohlendorf et al. 1978, Fleming et al. 1984b).

The Everglades Agricultural Area (EAA) occupies portions of Palm Beach, Hendry, and Broward counties that once constituted the Everglades slough habitat that extended from southern Lake Okeechobee to Florida Bay. Much of this area now is intensively used for growing sugar cane, sweet corn, sod, rice, and various winter vegetable crops. Many types of pesticides are used to control pests and diseases on these agricultural products in the EAA (Florida Department Agricul-

ture 1987, IFAS 1987, Johnson 1987, Kucharek et al. 1988). Currently, there are 10 species of waterbirds with an estimated 12,000-15,000 nesting pairs that breed or forage in the EAA and adjacent wetlands (Runde et al. 1991). There is the potential for pesticide contamination to have an impact on the regional waterbird population. No data on pesticide or heavy metal contamination in waterbirds from the EAA or nearby wetlands are available. A study of pesticide levels for Fulvous Whistling-Ducks (*Dendrocyna bicolor*) in the EAA found a wide array of residues, including the banned pesticide aldrin (Florida Game and Fresh Water Fish Commission, unpubl. data). The dearth of available data precludes the development of recommendations to protect avian species in the EAA from exposure to pesticides. The objective of this study was to establish a contamination data base and allow detection of possible hazardous contaminant levels in selected species of waterbirds in and around the EAA.

Methods

The initial study design called for collecting eggs and nestlings of waterbirds from one or more breeding sites in the EAA and Lake Okeechobee (see Nesbitt et al. 1982, Runde et al. 1991). However, I was not able to gain access to most private properties with colonies in the EAA region because the landowners did not want to cooperate with a pesticide study. Prolonged drought conditions further reduced the number and location of breeding waterbirds in the EAA in 1991, 1992, and 1993. Therefore, I also decided to collect waterbirds as they foraged in the EAA during the months of May through July as an indication of pesticide and heavy metal contamination of resident birds. A single egg was removed from nests of Great Egrets (*Ardea alba*) and Little Blue Herons (*Egretta caerulea*) at a small colony of waterbirds in the EAA during 1993. Addled eggs of Snail Kites (*Rostrhamus sociabilis*) were collected from nests along the southern edge of Lake Okeechobee in 1992 and 1993. As a control to compare contaminant concentrations elsewhere in Florida, a single egg was collected from waterbird nests at a colony on Bird Island, Lake Kissimmee. Whereas, Lake Kissimmee potentially receives agricultural runoff, I deemed the lake less susceptible to large influxes of contaminants as occurs in the EAA.

All egg volumes first were measured in order to calculate contaminant concentrations with loss of moisture and volume during incubation and storage. Then the contents were removed, stored in chemically cleaned jars, labelled, and frozen for later laboratory analysis. Liver tissues were removed from the collected waterbirds, placed in aluminum foil, tagged, and also frozen for later laboratory analysis. All concentrations in Tables 1-2 and the text are in parts per million (ppm: mg/kg) wet weight of tissue. Because the data for heavy metal and pesticide concentrations were generally skewed, all data were first log-transformed before statistical analyses. Mean values in Tables 1-2 represent geometric means.

Results

Levels of PCBs (<0.05 ppm), chlordane (<0.5 ppm), endrin (<0.5 ppm), toxophene (<0.5 ppm), heptachlor (<0.05 ppm), and *trans*-nonachlor (<0.05) concentrations were found at the minimum limit of de-

tection for most species (Tables 1-2). Some pesticides and heavy metals were found at higher concentrations that allowed comparison within and between the EAA, Lake Okeechobee, and Lake Kissimmee sites.

Mercury (Hg).—Mean and maximum concentrations among waterbirds at all three sites were generally low (Tables 1-2). However, White Ibis (*Eudocimus albus*) and a single Great Blue Heron (*A. herodias*) had elevated levels suggesting possible effects. No significant difference (*t*-test, P>0.05) was detected in Hg concentrations of Anhingas (*Anhinga anhinga*), Little Blue Herons, Snowy Egrets (*E. thula*), and Snail Kites between the EAA/Lake Okeechobee and Lake Kissimmee.

Lead.—White Ibis exhibited higher levels of lead than that of other species of waterbirds (Table 1).

DDT/DDE/DDD.—As expected, most tissues exhibited low concentrations of DDT. However, its metabolites (DDE and DDD) were found in higher concentrations in most tissues. No significant difference (*t*-test, P>0.05) was detected between DDD concentrations between EAA/Lake Okeechobee and Lake Kissimmee. However, DDE concentrations were significantly greater in Anhingas (t=1.82, P=0.01) and Little Blue Herons (t=1.77, P=0.01) in the EAA/Lake Okeechobee compared to Lake Kissimmee.

Dieldrin.—A single Great Egret egg contained an elevated concentration of 1.60 ppm.

DISCUSSION

The results of this study indicate only DDE was present in higher concentrations in egg and liver tissues of waterbirds collected from the EAA and Lake Okeechobee compared to Lake Kissimmee. However, the concentrations of DDE and other contaminants found in tissues from each of the three sites were generally low and probably do not pose a hazard for most individuals at this time. Many pesticides (e.g., chlordane, endrin, toxaphene, heptachlor, PCBs) were not found at their minimum limits of detection in most samples.

It is generally acknowledged that Hg and pesticide concentrations are highest in species that eat fish and other birds (Custer et al. 1983, Ohlendorf et al 1988). In addition, Hg interacts with elevated temperatures and some pesticides (e.g., DDE) to produce synergistic toxicity (Eisler 1987). For comparison with the values in Tables 1-2, Hg concentrations in animal tissues are usually <1.0 ppm at sites not affected by human activities, and body loads of Hg in experimentally poisoned (LD 50) birds usually exceed 20 ppm (Eisler 1987). Hg concentrations of ≥2.0 ppm for eggs and ≥3.0 ppm for organ tissues and DDE concentrations of ≥10 ppm for eggs and ≥25 ppm for organ tissues are generally considered to represent minimum thresholds deemed hazardous to

Table 1. Concentrations of pesticides and heavy metals in waterbird tissues collected in the Everglades Agricultural Area and Lake Okeechobee of south Florida during the breeding seasons of 1992 and 1993. All concentrations are given as ppm (mg/kg) of wet weight.

Species	Contaminant	Number	Mean±Std	Range
Anhinga[a]	Mercury	9	0.13±0.14	0.04-0.85
	Lead	9		<0.01-0.15
	PCBs[b]	9	<0.05	
	DDT	9		<0.01-0.12
	DDE	9	0.44±0.41	0.08-1.30
	DDD	9	<0.05	
	dieldrin	9	<0.05	
	chlordane	9	<0.5	
	endrin	9	<0.5	
	toxaphene	9	<0.5	
	heptachlor	9	<0.05	
	trans-nonachlor	9	<0.05	
Great Blue Heron[c]	Mercury	1	12.00	
	Lead	1	0.08	
	PCBs[b]	1	<0.05	
	DDT	1	<0.01	
	DDE	1	1.60	
	DDD	1	<0.05	
	dieldrin	1	<0.05	
	chlordane	1	<0.5	
	endrin	1	<0.5	
	toxaphene	1	<0.5	
	heptachlor	1	<0.05	
	trans-nonachlor	1	0.07	
Great Egret[a]	Mercury	6	0.08±0.04	0.04-0.18
	Lead	6	<0.01	
	PCBs[b]	6	<0.05	
	DDT	6		<0.05-0.17
	DDE	6	0.08±0.40	<0.05-7.00
	DDD	6	0.04±0.22	<0.05-7.00
	dieldrin	6	0.10±0.38	<0.05-1.60
	chlordane	6	<0.5	
	endrin	6	<0.5	
	toxaphene	6	<0.5	
	heptachlor	6	0.02±0.06	<0.05-0.27
	trans-nonachlor	6	0.14±0.19	<0.05-0.42
Little Blue Heron[a]	Mercury	6	0.09±0.08	0.04-0.30
	Lead	6	<0.01	
	PCBs[b]	6	<0.05	

[a]Tissue source was eggs.
[b]Polychlorinated biphenyl isomers were 1016, 1221, 1232, 1242, 1248, 1254, and 1260.
[c]Tissue source was liver.

Table 1. (Continued) Concentrations of pesticides and heavy metals in waterbird tissues collected in the Everglades Agricultural Area and Lake Okeechobee of south Florida during the breeding seasons of 1992 and 1993. All concentrations are given as ppm (mg/kg) of wet weight.

Species	Contaminant	Number	Mean±Std	Range
	DDT	6	<0.05	
	DDE	6	0.34±0.52	0.05-1.70
	DDD	6	<0.05	
	dieldrin	6		<0.05-0.20
	chlordane	6	<0.5	
	endrin	6	<0.5	
	toxaphene	6	<0.5	
	heptachlor	6	<0.05	
	trans-nonachlor	6		<0.05-0.26
Snowy Egret[c]	Mercury	5	0.47±0.44	0.18-1.80
	Lead	5	0.01±0.05	<0.01-2.40
	PCBs[b]	5	<0.05	
	DDT	5		<0.05-0.15
	DDE	5	0.57±0.93	<0.05-4.60
	DDD	5		<0.05-0.15
	dieldrin	5		<0.05-0.14
	chlordane	5	<0.5	
	endrin	5	<0.5	
	toxaphene	5	<0.5	
	heptachlor	5	<0.05	
	trans-nonachlor	5		<0.05-0.32
Cattle Egret[c]	Mercury	8	0.02±0.06	<0.01-0.18
	Lead	8	0.01±0.01	<0.01-0.62
	PCBs[b]	8	<0.05	
	DDT	8	<0.05	
	DDE	8		<0.10-1.30
	DDD	8		<0.05-1.00
	dieldrin	8		<0.05-0.31
	chlordane	8	<0.5	
	endrin	8	<0.5	
	toxaphene	8	<0.5	
	heptachlor	8	<0.05	
	trans-nonachlor	8	<0.05	
White Ibis[c]	Mercury	3	0.72±0.89	0.35-3.00
	Lead	3	0.22±0.29	0.05-0.71
	PCBs[b]	3		<0.05-0.63
	DDT	3	<0.05	
	DDE	3	1.92±0.53	1.40-2.30
	DDD	3	<0.05	

[a]Tissue source was eggs.
[b]Polychlorinated biphenyl isomers were 1016, 1221, 1232, 1242, 1248, 1254, and 1260.
[c]Tissue source was liver.

Table 1. (Continued) Concentrations of pesticides and heavy metals in waterbird tissues collected in the Everglades Agricultural Area and Lake Okeechobee of south Florida during the breeding seasons of 1992 and 1993. All concentrations are given as ppm (mg/kg) of wet weight.

Species	Contaminant	Number	Mean±Std	Range
	dieldrin	3		<0.05-0.33
	chlordane	3	<0.5	
	endrin	3	<0.5	
	toxaphene	3	<0.5	
	heptachlor	3		<0.05-0.09
	trans-nonachlor	3	<0.05	
Snail Kite[a]	Mercury	7	0.08±0.07	0.02-0.35
	Lead	7		<0.01-0.17
	PCBs[b]	7	<0.05	
	DDT	7	<0.05	
	DDE	7		<0.05-0.05
	DDD	7		<0.05-0.05
	dieldrin	7	<0.05	
	chlordane	7	<0.5	
	endrin	7	<0.5	
	toxaphene	7	<0.5	
	heptachlor	7	<0.05	
	trans-nonachlor	7	<0.05	

[a]Tissue source was eggs.
[b]Polychlorinated biphenyl isomers were 1016, 1221, 1232, 1242, 1248, 1254, and 1260.
[c]Tissue source was liver.

cause disruption of the behavior and physiology of sensitive avian species (Faber et al. 1972, Blus et al. 1980, Cheney et al. 1981, Eisler 1987). Only a single Great Blue Heron collected in the EAA exhibited Hg concentration (12 ppm) that exceeded the critical value for Hg. The elevated Hg levels in White Ibis warrant further study to determine if this heavy metal is affecting the species in south Florida. The highest concentration of DDE in tissues from the EAA was from a Great Egret egg (7.0 ppm). Dieldrin concentrations of 1-5 ppm can cause eggshell thinning. Though low in most of the species studied, dieldrin contamination was of concern with one Great Egret egg containing 1.60 ppm dieldrin, suggesting possible problems associated with this pesticide.

ACKNOWLEDGMENTS

Several people assisted me with this study. S. Schwikert assisted with the collection of tissues from waterbirds. Analysis of pesticide and heavy metal concentrations in collected tissues were performed by Thorton Laboratory (Tampa, Florida) in 1992 and Savannah Laboratories (Tallahassee, Florida). T. Custer and D. White provided comments and interpretation of the residue concentrations from the laboratory analysis. The com-

Table 2. Concentrations of pesticides and heavy metals in waterbird tissues collected in Lake Kissimmee of central Florida during the breeding seasons of 1992 and 1993. All concentrations are given as ppm (mg/kg) of wet weight.

Species	Contaminant	Number	Mean±Std	Range
Anhinga[a]	Mercury	4	0.05±0.03	0.03-0.13
	Lead	4	<0.01	
	PCBs[b]	4	<0.05	
	DDT	4	<0.01	
	DDE	4	0.14±0.04	0.09-0.18
	DDD	4	<0.05	
	dieldrin	4	<0.05	
	chlordane	4	<0.5	
	endrin	4	<0.5	
	toxaphene	4	<0.5	
	heptachlor	4	<0.05	
	trans-nonachlor	4	<0.05	
Little Blue Heron[a]	Mercury	5	0.16±0.03	0.03-0.13
	Lead	5	<0.01	
	PCBs[b]	5	<0.05	
	DDT	5	<0.05	
	DDE	5	<0.05	
	DDD	5	<0.05	
	dieldrin	5		<0.05-0.20
	chlordane	5	<0.5	
	endrin	5	<0.5	
	toxaphene	5	<0.5	
	heptachlor	5	<0.05	
	trans-nonachlor	5		<0.05-0.26
Snowy Egret[a]	Mercury	5	0.22±0.05	0.16-0.27
	Lead	5	<0.01	
	PCBs[b]	5	<0.05	
	DDT	5	<0.05	
	DDE	5	<0.05	
	DDD	5	<0.05	
	dieldrin	5	<0.05	
	chlordane	5	<0.5	
	endrin	5	<0.5	
	toxaphene	5	<0.5	
	heptachlor	5	<0.05	
	trans-nonachlor	5	<0.05	
Snail Kite[a]	Mercury	3	0.06±0.06	0.03-0.18
	Lead	3	<0.05	
	PCBs[b]	3	<0.05	
	DDT	3	<0.05	

[a]Tissue source was eggs.

[b]Polychlorinated biphenyl isomers were 1016, 1221, 1232, 1242, 1248, 1254, and 1260.

Table 2. (Continued) Concentrations of pesticides and heavy metals in waterbird tissues collected in Lake Kissimmee of central Florida during the breeding seasons of 1992 and 1993. All concentrations are given as ppm (mg/kg) of wet weight.

Species	Contaminant	Number	Mean±Std	Range
	DDE	3	<0.05	
	DDD	3	<0.05	
	dieldrin	3	<0.05	
	chlordane	3	<0.5	
	endrin	3	<0.5	
	toxaphene	3	<0.5	
	heptachlor	3	<0.05	
	trans-nonachlor	3	<0.05	

[a]Tissue source was eggs.
[b]Polychlorinated biphenyl isomers were 1016, 1221, 1232, 1242, 1248, 1254, and 1260.

ments of S. A. Nesbitt, W. K. Taylor, and W. B. Robertson greatly improved the manuscript. This paper is derived in part from Florida Game and Fresh Water Fish Commission study number 7510.

Literature Cited

Biskup, M. L., R. W. Risebrough, and J. L. Dusi. 1978. Eggshell measurements and organochlorine residues in Little Blue Herons. Pp. 113-116. *In:* Wading birds. A. Sprunt, J. C. Ogden, and S. Winckler (eds.). Natl. Aud. Soc. Res. Rept. No. 7, New York.

Blus, L. J., C. J. Henny, and T. E. Kaiser. 1980. Pollution ecology of breeding Great Blue Herons in the Columbia Basin, Oregon and Washington. Murrelet 61:63-71.

Cheney, M. A. C. S. Hacker, and G. D. Schroder. 1981. Bioaccumulation of lead and cadmium in the Louisiana Heron (*Hydranassa tricolor*) and Cattle Egret (*Bubulcus ibis*). Ecotoxicol. Environ. Safety 5:211-224.

Custer, T. W., G. L. Hensler, and T. E. Kaiser. 1983. Clutch size, reproductive success, and organochlorine contaminants in Atlantic Coast Black-crowned Night-Herons. Auk 100:699-710.

Eisler, R. 1987. Mercury hazards to fish, wildlife, and invertebrates: a synopsis review. U.S. Fish and Wildl. Serv. Biol. Rept. 85, Washington, D.C.

Faber, R. A., R. W. Risebrough, and H. M. Pratt. 1972. Organochlorines and mercury in Common Egrets and Great Blue Herons. Environ. Pollution 3:111-122.

Fleming, W. J., B. P. Pulling, and D. M. Swineford. 1984a. Population trends and environmental contaminants in herons in the Tennessee Valley, 1980-81. Colon. Waterbirds 7:63-73.

Fleming, W. J., J. A. Rodgers, Jr., and C. J. Stafford. 1984b. Contaminants in Wood Stork eggs and their effects on reproduction, Florida, 1982. Colon. Waterbirds 7:88-93.

Florida Department Agriculture. 1987. Restricted use pesticide random sample survey: county totals 1985-86. Bur. Product Data Evaluation, Tallahassee.

Henny, C. J., L. J. Blus, A. J. Krynitsky, and C. M. Bunck. 1984. Current impact of DDE on Black-crowned Night-Herons in the intermountain west. J. Wildl. Manage. 48:1-13.

HOFFMAN, R. D., AND R. D. CURNOV. 1979. Mercury in herons, egrets, and their foods. J. Wildl. Manage. 43:85-93.

IFAS. 1987. Insect control guide: Vol. I. Inst. Food Agricult. Sci., Univ. Fla., Gainesville.

JOHNSON, F. 1987. Insect control guide: Vol. II. Inst. Food Agricult. Sci., Univ. Fla, Gainesville.

KUCHAREK, T., G. SIMONE, AND R. S. MULLIN. 1988. Florida plant disease control guide. Inst. Food Agricult. Sci., Univ. Fla., Gainesville.

NESBITT, S. A., J. C. OGDEN, H. W. KALE, II, B. W. PATTY, AND L. A. ROWSE. 1982. Florida atlas of breeding sites for herons and their allies: 1976-78. U.S. Fish & Wildl. Serv., Off. of Biol. Serv., FWS/OBS-81/49, Washington, D.C.

OGDEN, J. C. 1978. Recent population trends of colonial wading birds on the Atlantic and Gulf coastal plains. Pp. 137-154. *In:* Wading birds. A. Sprunt, J. C. Ogden, and S. Winckler (eds.). Natl. Aud. Soc. Res. Rept. No. 7, New York.

OHLENDORF, H. M., E. E. KLAAS, AND T. E. KAISER. 1978. Environmental pollutants and eggshell thinning in the Black-crowned Night Heron. Pp. 63-82. *In:* Wading birds. A. Sprunt, J. C. Ogden, and S. Winckler (eds.). Natl. Aud. Soc. Res. Rept. no. 7, New York.

OHLENDORF, H. M., T. C. CUSTER, R. W. LOWE, M. RIGNEY, AND E. CROMARTIE. 1988. Organochlorine and mercury in eggs of coastal terns and herons in California, USA. Colon. Waterbirds 11:85-94.

RUNDE, D. E., J. A. GORE, J. A. HOVIS, M. S. ROBSON, AND P. D. SOUTHALL. 1991. Florida atlas of breeding sites for herons and their allies: update 1986-89. Nongame wildlife program technical report no. 10, Fla. Game and Fresh Water Fish Comm., Tallahassee.

STICKEL, L. F., W. H. STICKEL, R. A. DYRLAND, AND D. L. HUGHES. 1979. Oxychlordane, ACS-3260, and nonachlor in birds: lethal residues and loss rates. J. Toxicol. Environ. Health 12:611-622.

ZINKL, J. G., D. A. JESSUP, A. I. BISCHOFF, T. E. LEW, AND E. B. WHEELDON. 1981. Fention poisoning of wading birds. J. Wildl. Diseases 17:117-119.