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Organochlorine Residues in Three Heron Species as Related to Diet and Age

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Residues of persistent organochlorine compounds are found in most living organisms throughout the world, even far removed from areas where they were applied (Freed 1970). Stickel (1968) stated "quantities of pesticide in the tissues of wild birds are related to their food habits, and presumably are primarily a reflection of contamination of the food supply." Objectives of this paper are (1) to report levels of organochlorine residues in whole body and tissue samples of 3 heron species (Ardeidae), collected in northeastern Louisiana, in relation to differences in their diets and (2) to compare organochlorine residues in adult and immature birds of the same species.

MATERIALS AND METHODS

Twenty-six green-backed herons (*Butorides striatus*), 21 little blue herons (*Egretta caerulea*), and 17 yellow-crowned night-herons (*Nycticorax violaceus*) were collected between 15 July and 15 September 1980 in the Mississippi River lowlands of northeastern Louisiana. Collection sites were Lake Providence (32°50'N, 91°12'W) in East Carroll Parish, Lake Bruin (32°00'N, 91°13'W) in Tensas Parish, and Lake St. John (31°42'N, 91°26'W) in Concordia Parish. Herons were collected by shotgun and frozen soon after collection.

Organochlorine analyses were conducted by Hazleton Raltech Inc., Madison, Wisconsin; before shipment to the laboratory, the herons were skinned, and the feet, beaks, wingtips, and gastrointestinal tracts removed. All samples were then refrozen and shipped on dry ice to the Hazleton laboratory where each sample was ground until homogeneous. A 10-g portion of homogenized carcass was thoroughly blended with sodium sulfate. Extraction, cleanup, and separation were as described by Niethammer et al. (1984). The pesticides in each fraction were identified and quantified by injecting 10 µl of each eluate into a Hewlett Packard Model 5710A gas chromatograph equipped with a linearized Ni63 detector, automatic injector, and 3352C data system. Instrument and operating conditions were as described by Niethammer et al. (1984).

The lower limits of detection were 0.10 ppm for PCB's and toxaphene and 0.05 ppm for the remaining organochlorine compounds. Residues in 10% of the samples were confirmed on a Finnigan 4021T gas chromatograph/mass spectrometer by using an INCOS data system.

Residue levels were expressed as ppm wet weight and geometric means calculated. When no residues were detected in samples, values of 1/2 the lower limit of detection were used to calculate geometric means. Statistical comparisons were conducted on log-transformed data.

In addition to whole body analyses, brains, livers, breast muscle, and body fat from an additional 4 green-backed herons and 3 yellow-crowned night-herons, collected at Lake Providence, were analyzed for organochlorine residues. Composite samples of each tissue for each species were analyzed by the same procedures as whole body analyses.

RESULTS AND DISCUSSION

Every heron analyzed contained at least 1 organochlorine contaminant; DDT and its metabolites (DDE, DDD, and DDMU), toxaphene, and PCB's were the principal organochlorine residues detected (Table 1). DDE was the predominant compound, occurring in every heron. In addition to the compounds shown in Table 1, residues of benzene hexachloride were detected in 4 adult green-backed herons (3 with 0.05 and 1 with 0.15 ppm), 2 immature green-backed herons (0.06 and 0.14 ppm), and 3 adult little blue herons (0.07, 0.09, and 0.10 ppm). Residues of oxychlordane were detected in 2 adult green-backed herons (0.08 and 0.45 ppm) and in 1 adult little blue heron (0.07 ppm). Nonachlor (0.06 ppm) and heptachlor epoxide (0.29 ppm) were detected in 1 adult green-backed heron.

Interspecific comparisons show that residues of DDE, DDE, DDMU, toxaphene, and PCB's in green-backed herons were significantly higher than those in little blue herons which, in turn, contained residue levels of these compounds significantly higher than those of yellow-crowned night-herons (ANOVA, $p<0.05$). Statistical comparisons of other organochlorine compounds were not attempted because few individual herons contained detectable residues of these compounds and geometric means approached the lower detection limit. However, residues of these other compounds were encountered more often in green-backed herons than in little blue herons and were only occasionally detected in yellow-crowned night-herons.

Although Stickel (1968) pointed out, "differences in abilities of species to absorb and metabolize pesticides may produce differences in residue accumulation that cannot be fully separated from differences due to food habits," the differences in residue levels among the 3 heron species examined in our study seem related to differences in feeding habits. The green-backed heron feeds primarily on fish; the diet of the little blue heron is more

Table 1. Geometric means of organochlorine residues in 3 heron species from northeastern Louisiana, 1980.

Age	N	$\bar{x}$ % lipid	DDE	DDD	DDT	DDMU	Toxaphene	PCB's	Dieldrin	Mirex	Endrin
			Residues, ppm wet weight								
							Green-backed heron				
Adult	12	16.2	16.38[a] (12)[b] 2.08-71.2[c]	0.49 (12) 0.06-2.54	0.13 (6) ND-2.91	0.31 (10) ND-1.51	3.88 (12) 0.51-13.4	0.72 (12) 0.24-4.79	0.05 (6) ND-0.20	0.10 (10) ND-0.45	0.04 (4) ND-0.27
Immature	14	14.8	7.93 (14) 0.54-38.7	0.39 (12) ND-2.26	0.07 (6) ND-1.22	0.40 (13) ND-1.78	2.10 (13) ND-24.0	0.43 (13) ND-1.97	0.10 (10) ND-0.91	0.04 (5) ND-0.27	0.04 (5) ND-0.25
							Little blue heron				
Adult	6	10.8	9.65 (6) 3.03-27.9	0.40 (6) 0.13-1.78	0.29 (4) ND-2.23	0.16 (4) ND-1.04	3.78 (6) 0.76-18.1	0.50 (5) ND-2.22	0.07 (4) ND-0.21	0.12 (6) ND-0.51	0.06 (3) ND-0.38
Immature	15	8.2	2.49 (15) 0.97-9.90	0.11 (12) ND-0.62	ND	0.07 (9) ND-0.34	0.62 (14) ND-3.44	0.17 (10) ND-0.62	0.03 (4) ND-0.29	ND	0.03 (2) ND-0.15
							Yellow-crowned night-heron				
Adult	4	18.7	2.46 (4) 0.98-6.94	ND	ND	ND	0.16 (2) ND-0.53	0.27 (3) ND-1.07	ND	0.04 (2) ND-0.12	ND
Immature	13	8.6	1.36 (13) 0.09-7.94	0.03 (2) ND-0.18	0.04 (3) ND-0.24	ND	0.10 (5) ND-0.44	0.09 (4) ND-0.55	0.03 (2) ND-0.19	0.03 (1) ND-0.07	ND

NOTE: ND = not detected.

[a]Geometric mean; [b]values in parentheses are actual number of samples containing detectable residues; [c]extreme values.

diverse, containing substantial amounts of fish, crustaceans, insects, and spiders; the yellow-crowned night-heron feeds mostly on crayfish (Table 2).

Crayfish collected from 2 of the same study sites in northeastern Louisiana (Lake Providence and Lake Bruin) contained only low levels of DDE (Table 3). Thus, low contaminant levels in tissue and whole body samples of yellow-crowned night-herons probably reflect the low level of contamination of their food supply. Small fishes, which make up the major portion of the diets of both the green-backed heron and little blue heron, contained higher levels of organochlorine contaminants than crayfish (Table 3). Organochlorine residues detected in these 2 heron species reflect this increased level of contamination of their food supply. Compared with the little blue heron, the green-backed heron's diet contains more fish and fewer invertebrates. This difference in diet may at least partially explain the higher contaminant levels in the green-backed heron, as fish tend to accumulate higher levels of organochlorine contaminants than invertebrates. For example, Meeks (1968) reported that residues of DDT in small fish (2-10 cm) were higher than those in most invertebrates throughout a 15-month study of a 1.62-hectare marsh treated with radio-labeled DDT.

Although differences were not statistically significant (Mann-Whitney U Test, $P>0.10$), mean concentrations of organochlorine contaminants tended to be lower in immature herons than adults of the same species (Table 1). Immature green-backed herons collected at Lake Providence were an exception to this trend. They contained mean residue levels of DDT and its derivatives, toxaphene, and dieldrin that were slightly (not significantly, $P>0.10$) higher than those of adults taken from Lake Providence. Higher residues in adults might be due to their being exposed to contaminated food for a longer period. It is also possible that adult herons could have accumulated organochlorine contaminants elsewhere, as they are migratory. However, as shown by the immature green-backed herons collected at Lake Providence, immature herons can accumulate organochlorine contaminant levels comparable to those of adults within the first few months of their lives from food items acquired locally.

Organochlorine residues in selected tissues of the green-backed heron and yellow-crowned night-heron also showed the dichotomy of contaminant levels between these 2 species and reflected levels of contamination of their foods. Residues of 9 organochlorine compounds were detected in tissues from green-backed herons, whereas only 2 organochlorine contaminants were found in tissue samples from yellow-crowned night-herons (Table 4). Residues of DDE were detected in all 4 tissues from both species; however, residues were much higher in green-backed heron tissues. As expected, fatty tissues contained the highest concentrations of these lipophilic compounds. Body fat of green-backed herons contained residue concentrations 18-35 times higher than

Table 2. Composition of diets of the green-backed heron, little blue heron, and yellow-crowned night-heron, as reported in selected studies.

Species	Percent of diet					Authority and location
	Fishes	Crustaceans	Insects	Spiders	Other	
Green-backed heron	75(93)[a]	4(1)	18(6)	3(1)	-	Niethammer and Kaiser (1983)-Louisiana
	79	7	4	-	10	Kaiser (1982)-southern Missouri
Little blue heron	41(61)	22(11)	23(13)	14(14)	1(2)	Niethammer and Kaiser (1983)-Louisiana
	80(70)	7(9)	7(1)	-	6(21)	Graber et al. (1978)-Illinois
Yellow-crowned night-heron	11(22)	66(74)	21(2)	-	1(2)	Niethammer and Kaiser (1983)-Louisiana
	1	99	-	-	-	Cottam and Uhler (1936)-various locations

NOTE: - = none reported.

[a] % diet by numbers; in parentheses, % diet by weights.

Table 3. Mean levels of organochlorine chemical residues in selected heron food items from Lakes Providence and Bruin, northeastern Louisiana, 1980.[a]

Species	Residues, ppm wet weight[b]					
	DDE	DDD	DDT	DDMU	Toxa-phene	PCB's
Blacktail shiner (*Notropis venustus*)	3.36	0.96	*	0.30	1.85	0.06
Bluegill (*Lepomis macrochirus*)	2.34	0.47	0.51	0.20	0.94	0.11
Threadfin shad (*Dorosoma petenense*)	0.90	0.38	*	0.35	1.57	0.06
Mosquitofish (*Gambusia affinis*)	1.45	0.28	0.11	0.13	0.23	ND
Crayfish (*Orconectes lancifer*)	0.06	ND	ND	ND	ND	ND

NOTE: ND = not detected, * = unable to quantitate due to toxaphene interference.

[a]Adapted from Niethammer et al. (1984).

[b]Values presented are geometric means of 10 composite samples.

residues in liver (the tissue with the next highest contaminant concentrations) for all compounds detected in more than 1 tissue except toxaphene. Residues of toxaphene were high in both body fat and liver, and fat had only 3 times the residue concentration of the liver sample. Compounds detected in only 1 tissue were always in body fat.

In general, the levels of organochlorine residues detected in many heron species seem closely linked to differences in their diets and specifically to the amount of fish they consume. Ohlendorf et al. (1981) reported that all herons in their study having hazardous or lethal concentrations of organochlorine compounds in the brain were adults. Most were great blue herons (*Ardea herodias*), a species that feeds on large fish of kinds that tend to accumulate relatively high concentrations of organochlorine residues. Significant eggshell thinning also has been reported in herons (King et al. 1978; Ohlendorf et al. 1978, 1979; Blus et al. 1980). Herons showing the most eggshell thinning were species relying heavily on fish in their diets.

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Table 4. Organochlorine residues in selected tissues of green-backed herons and yellow-crowned night-herons from Lake Providence, northeastern Louisiana, 1980.

	Residues, ppm wet weight						
Tissue	DDE	DDD	DDT	DDMU	PCB's	Toxa-phene	Dieldrin
			Green-backed heron[a]				
Brain	1.50	0.05	ND	ND	ND	0.54	ND
Muscle	2.92	0.14	ND	0.10	0.12	1.02	ND
Liver	6.13	0.37	ND	0.23	0.21	21.70	ND
Fat[b]	183.00	6.62	6.28	8.00	5.95	65.40	0.42
			Yellow-crowned night heron[c]				
Brain	0.12	ND	ND	ND	ND	ND	ND
Muscle	0.40	ND	ND	ND	ND	ND	ND
Liver	0.40	ND	ND	ND	ND	ND	0.06
Fat	4.12	ND	ND	ND	ND	ND	0.30

ND = not detected.

[a]Samples were composites of tissues from 4 birds.

[b]Sample also contained Mirex (0.40 ppm) and Endrin (0.10 00m).

[c]Samples were composites of tissues from 3 birds.

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