Organochlorine Pesticide Residues in Uropygial Glands and Adipose Tissue of Wild Birds

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The literature contains a large body of knowledge on the avian uropygial (preen or oil) gland. Much of this information, particularly as regards its anatomy and physiology, is superbly reviewed by LUCAS and STETTENHEIM (1972). This subcutaneous gland, especially large in aquatic birds, is typically bilobed and terminates in a nipple-like projection at the base of the bird's tail. Its holocrine, oily secretions function chiefly to waterproof and condition the bird's plumage. The secretions have been analyzed chemically by a number of investigators including APANDI and EDWARDS (1964), HAAHTI and FALES (1967), SAITO and GAMO (1968), and EDKINS and HANSEN (1972); their reports generally revealed the lipophilic nature of the gland and disclosed the presence of aliphatic waxes, triglycerides, phospholipids, and other components in the gland. The lipoidal nature of this gland should make it a possible repository and excretory organ for chlorinated hydrocarbon pesticides and pollutants.

DINDAL (1970) found high concentrations of DDT and its metabolites in uropygial glands of two species of ducks. After surgically removing glands from three species of caged birds, GREICHUS and GREICHUS (1974) reported that dieldrin can be found in secretions emanating from lipoid bodies in the skin. More recently CHARNETSKI and STEVENS (1974) concluded that wild ducklings of several species (p 675) ". . . can excrete lipid soluble insecticides and their metabolites through the preen gland." The present investigations extend these earlier studies by examining pesticide contents of uropygial glands as compared with those of adipose tissue depots taken from a large variety of wild birds of diverse habits and habitats.

Materials and Methods

Bird specimens used in the present study were obtained chiefly in Florida from 1969 to 1974. All were wild birds taken in a variety of ways — shotgun, found freshly killed at TV towers, on roadsides and on beaches. The 53 birds embraced 10 orders, 15 families, 23 genera, and 28 species. They included aquatic, semi-aquatic and terrestrial species, piscivores, carnivores, insectivores, scavengers, long- and short-distance migrants, and non-migrants. From each individual a small amount (ca 1 g) of adipose tissue was removed from the subcutaneous interfurcular depot. The uropygial gland was carefully dissected out intact and any feather tuft at its opening was trimmed off prior to weighing and

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subsequent analysis. Each sample of fat and gland was separately homogenized in sodium sulfate, and the lipids extracted in a soxhlet apparatus for 10 hr using petroleum ether as a solvent. Lipid extracts were partitioned with acetonitrile and hexane and cleaned on a florisil column. For identification and quantification of chlorinated hydrocarbon pesticides a Varian 2100 gas chromatograph was used, its column containing 1:1 6.4% OV-210: 1.6% OV-17 on chromosorb W. Other instrumental parameters included injection port temperature of 210°C, column 212°C, and detector 215°C; N_2 flow rate was 45 ml/min. Recoveries for the organochlorine compounds in this study were 75-95%. Sensitivity for this procedure was greater than 0.01 ng/ul.

Results and Discussion

A summary of the chlorinated hydrocarbon pesticides (in ppm wet weight) found in the adipose tissue and uropygial gland of each specimen is presented in Table 1. PCBs were not detected in any of these samples. Several interesting facts emerge from these data. In 34 of the species-samples (77%) total DDTs (Σ p,p'-DDE, p,p'-DDD, and p,p'-DDT) were in higher concentrations in adipose tissue rather than in the gland. In only two of these samples (4%) was DDT or a metabolite absent in the adipose tissue although present in the same bird's gland. For all the species analyzed, the mean ratio of total DDTs in adipose tissue to uropygial gland was 2.2:1. It is not surprising to note that in almost every species-sample, p,p'-DDE was the DDT metabolite in the highest concentration, both in the adipose tissue and uropygial gland. Especially high concentrations of total DDTs were found in the Anhinga, three American Kestrels, a Cattle Egret, the two gulls, Caspian Tern, and a Screech Owl. Only 17 samples (38%) contained dieldrin in either the adipose tissue of gland or both. In those 17 samples the mean ratio of dieldrin in adipose tissue to uropygial gland was 2.6:1, a ratio similar to that for the total DDTs. Thus, adipose tissue (up to 90% extracted lipids, Table 1 and JOHNSTON 1970) contained higher concentrations of total DDTs and dieldrin than did the uropygial glands with their lower lipid contents (13.7% extracted lipids, Table 1).

DINDAL (1970) reported considerable variation in concentrations of DDT residues between uropygial gland and different fat depots (p 91): "With the exception of leg and neck fat, . . . residues of DDT in uropygial glands of both species [ducks] were generally and consistently higher than all other tissues." In the present study, on the other hand, where only the interfurcular fat depots were analyzed, these depots almost always had higher concentrations of total DDTs and dieldrin than did the uropygial glands. The data presented by Dindal and those in this study may not be strictly comparable for another reason, namely the fact that his ducks were at least semi-experimental. They had been exposed for varying lengths of time (up to 130 days) to pesticides applied to a marsh.

TABLE 1

Chlorinated Hydrocarbon Pesticides (in ppm) in Avian Adipose Tissue and Uropygial Glands

SPECIES, SEX	DATE	ADIPOSE TISSUE				UROPYGIAL GLAND			
		Weight[1] and percent lipid	p,p'-DDE	Total DDTs	Dieldrin	Weight[1] and percent lipid	p,p'-DDE	Total DDTs	Dieldrin
Gavia immer ♂	Jan.74	2.2018 (69.3)	0.65	0.80	0	3.8258 (25.4)	0.31	0.31	0
Gavia immer ♀ (Common Loon)	Apr.74	1.2904 (62.2)	0.23	0.28	0	3.4187 (30.1)	0.14	0.14	0.06
Gavia stellata ♀[2]	Oct.73	1.7390 (44.4)	0.55	1.17	0.15	2.8611 (16.3)	0.14	0.14	0
Gavia stellata ♂ (Red-throated Loon)	Oct.73	0.7711 (71.5)	0.03	0.97	0	2.9877 (28.8)	2.82	4.01	0.31
Phalacrocorax auritus ♂	Feb.74	2.5356 (80.6)	0.70	0.79	0	5.7285	0.73	1.23	0.34
Phalacrocorax auritus sex? (Double-cr. Cormorant)	Jun.74	1.1302 (55.7)	2.21	3.01	0	4.9050	1.38	1.68	0
Anhinga anhinga ♀ (Anhinga)	Oct.72	0.5622 (6.4)	20.01	25.61	0	1.4862 (6.9)	23.01	23.82	0
Mergus serrator ♂	? 73	2.0650 (66.1)	10.41	10.53	0	2.5421 (11.8)	7.00	7.00	0
Mergus serrator ♀ (Red-br. Merganser)	Jan.73	0.4600 (6.0)	0	0	0	2.0457 (14.2)	0.10	0.10	0
Cathartes aura ♀ (Turkey Vulture)	Jul.74	1.0215 (73.1)	4.75	4.95	0.17	0.4173 (14.5)	1.92	1.92	0
Buteo jamaicensis im.	Jul.73	8.4789 (21.8)	0.37	0.48	0.04	0.4472 (0.7)	0.39	0.50	0
Buteo jamaicensis im.♀	Jan.73	1.0422 (62.4)	3.49	3.73	0.55	0.4788 (5.9)	0.11	0.11	0
Buteo jamaicensis im. (Red-tailed Hawk)	Jan.73	1.8650 (84.1)	6.25	6.25	0	0.4830 (11.2)	0.09	0.09	0

Buteo lineatus ♀	Jan.72	1.3596	(80.5)	0.64	1.04	0.06	0.2853	(13.8)	0.18	0.18	0
Buteo lineatus im. (Red-shouldered Hawk)	Sep.73	0.3310	(26.3)	0.45	0.76	1.21	0.3104	(11.1)	0.24	0.48	0.72
Pandion haliaetus juv. (Osprey)	? 74	0.3864	(22.8)	0.13	0.26	0	2.4581	(20.1)	1.55	1.79	0
Falco sparverius ♀[2]	Feb.71	0.2063	(2.9)	17.57	22.54	0	0.0442	(4.5)	15.84	19.80	0
Falco sparverius ♀	Mar.73	0.1750	(7.4)	20.57	22.71	0	0.0972	(7.0)	4.63	4.63	0
Falco sparverius ♀	Mar.73	1.1978	(71.0)	1.77	2.08	0	0.1200	(0.4)	0.63	0.63	0
Falco sparverius ♂	Mar.73	0.2810	(24.6)	14.59	16.37	0.36	0.0954	(3.4)	3.14	3.14	0
Falco sparverius ♀ (American Kestrel)	Oct.72	0.0262	(32.1)	0.79	0.79	0	0.0788	(8.6)	0.63	0.63	0
Bonasa umbellus ♀[2]	May72	0.7051	(6.6)	0.04	0.04	0	0.3775	(16.6)	0.13	0.13	0
Bonasa umbellus ♀[2] (Ruffed Grouse)	Jun.73	0.5604	(42.4)	0.18	0.18	0	0.1515	(10.2)	2.64	3.63	0
Bubulcus ibis ♂	Apr.73	0.9590	(25.4)	0.60	0.86	0.16	0.0329	(4.3)	0	0	0
Bubulcus ibis ♀ (Cattle Egret)	Apr.74	0.6753	(66.8)	37.02	50.53	0	0.0383	(8.1)	2.61	2.61	0
Florida caerulea ♀[3] (Little Blue Heron)	May 72	1.5809	(8.9)	4.11	4.38	0	0.0687	(4.8)	0.73	0.73	0
Butorides virescens ♂[3] (Green Heron)	Jun.70	1.3459	(73.2)	6.69	7.62	0.15	0.0665	(11.7)	3.76	3.76	0
Botaurus lentiginosus ♂	Mar.73	0.3886	(53.1)	11.97	12.55	0	0.3788	(31.2)	5.08	9.24	0.46
Botaurus lentiginosus ♂ (American Bittern)	Mar.73	0.7883	(87.5)	2.41	3.17	0	0.4220	(34.4)	1.78	1.78	0
Rallus limicola ♀ (Virginia Rail)	Sep.73	0.3930	(36.8)	1.08	1.27	0	0.1213	(10.8)	0	0	0
Rallus longirostris ♀ (Clapper Rail)	Oct.74	0.7223	(38.3)	0.14	0.49	0	0.9416	(17.8)	0.11	0.27	0

Gallinula chloropus ♂ (Common Gallinule)	Sep.74	0.9201	(9.7)	0.52	0.98	0	0.3902	(1.6)	0.13	0.13	0
Fulica americana ♂[3] (American Coot)	Nov.72	0.6991	(73.0)	0	0	0	0.6880	(30.1)	0.11	0.11	0
Larus philadelphia ♀ (Bonaparte's Gull)	Jan.74	0.4214	(63.5)	10.20	19.54	0	0.3860	(28.4)	4.47	7.45	0
Larus atricilla ♀ (Laughing Gull)	Apr.74	0.6306	(63.5)	16.03	26.02	1.78	0.6894	(25.8)	2.18	3.93	0.47
Sterna hirundo ♀ (Common Tern)	Nov.73	0.6974	(6.5)	2.01	3.37	0	0.2707	(4.2)	0.55	1.10	0
Sterna anaethetus ♂ (Bridled Tern)	Aug.73	0.2762	(2.7)	0.51	0.51	0	0.5536	(2.4)	0.69	0.69	0
Hydroprogne caspia ♀ (Caspian Tern)	Sep.73	0.9902	(36.1)	52.72	52.72	0	1.2657	(23.6)	29.71	29.71	0
Tyto alba ♂ (Barn Owl)	Mar.69	0.9538	(57.6)	8.28	9.27	1.68	0.1919	(9.3)	1.31	1.31	0
Strix varia ♀[2]	73	1.4249	(57.2)	7.41	8.84	0	0.5110	(25.7)	1.79	1.89	0
Strix varia sex? (Barred Owl)	Apr.73	1.5201	(23.5)	5.76	6.90	0.21	0.7385	(8.1)	5.08	5.69	0.14
Otus asio sex?[2]	Sep.73	0.3585	(4.9)	0.26	0.26	0	0.1454	(8.1)	0	0	0
Otus asio sex?[2] (Screech Owl)	Sep.72	0.2265	(33.8)	44.15	46.47	0	0.1725	(22.1)	25.51	26.38	0
Geothlypis trichas pool of 10 im.♂ (Common Yellowthroat)	Oct.72	1.1629	(56.4)	2.15	3.28	0.19	0.1391	(3.1)	0.36	0.36	0

[1]weights of adipose tissue samples and uropygial glands in grams.
all specimens from Florida except [2]from Massachusetts and [3]from south Georgia.

From a dead bird, especially one that has been frozen, it is often difficult to squeeze sufficient oil from the gland for pesticide analysis without including tissue components with the oil. This feat was accomplished on two Shovelers (Anas clypeata), the data from which are presented in Table 2. In both individuals the oil contained higher concentrations of p,p'-DDE and dieldrin than did the gland per se.

TABLE 2

Chlorinated Hydrocarbon Pesticides[1] in Uropygial Glands and their Oil from two Shovelers

	UROPYGIAL GLAND			OIL		
	Wet weight	p,p'-DDE	Dieldrin	Wet weight	p,p'-DDE	Dieldrin
Male	1.5319 g	0.17	0.07	0.0726	0.68	1.03
Female	1.5817	0.14	0.07	0.0615	0.81	0.75

[1] all values in ppm wet weight

Migratory birds, such as most of the species analyzed here, are renowned for their extensive premigratory fat depots in which they may accumulate chlorinated hydrocarbon pesticides. When the fat stores are utilized as energy sources during protracted flights, pesticide burdens may follow one or more routes in the bird's body — (1) chemical alteration and/or detoxification in the liver (BAGLEY and CROMARTIE, 1973), (2) excretion via feces or urine or bile (HARVEY, 1967; DINDAL, 1970), (3) relocation to other tissues such as skeletal muscle (FINDLAY and DeFREITAS, 1971) or central nervous system (ECOBICHON and SASCHENBRECKER, 1969; SODERGREN and ULFSTRAND, 1972). From the present investigations, coupled with those of DINDAL (1970) and CHARNETSKI and STEVENS (1974), it is apparent that the uropygial glands of birds also function to excrete some chlorinated hydrocarbon pesticides. The relative amounts of foreign compounds excreted by the various routes under varying physiological conditions and in different ecological groups need much more detailed investigation.

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