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Implications of the Uropygial Gland and Skin in the Excretion of Insecticides from Birds

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IMPLICATIONS OF THE UROPYGIAL GLAND AND SKIN IN THE EXCRETION OF INSECTICIDES FROM BIRDS

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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ABSTRACT

Dieldrin-^{14}C was administered to chickens, ducks, and cormorants to determine: (1) the accumulation and excretion of dieldrin, (2) the importance of the uropygial gland as an organ of excretion of the insecticide. Analysis of all samples was by liquid scintillation counting (^{14}C-analysis).

Samples of whole body, uropygial glands, and feathers were taken for analysis. In addition eggs from chickens, feces from ducks and cormorants, and ectoparasites from cormorants were analyzed. Modes of excretion included eggs, feces, uropygial glands, and skin.

Chickens, ducks, and cormorants with uropygial glands averaged 3.2, 6.3, and 1.8 times more radioactivity per gram, respectively on their feathers than those whose uropygial gland had been surgically removed. Use of the uropygial gland as an organ of excretion of the insecticide was indicated.

Radioactivity on the feathers of birds without uropygial glands indicated that the insecticide might have been secreted through lipoid bodies in the skin of the birds.

That ingested pesticides are transferred to ectoparasites was shown when radioactivity was found on ectoparasites from cormorants. These pesticides may have an effect on ectoparasite numbers.

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INTRODUCTION

Chlorinated hydrocarbon insecticides are used extensively in the control of many agricultural pests. It has been well established that residues of these pesticides are picked up by non-target organisms and subsequently introduced into ecological food chains. Many scientific studies have demonstrated the accumulation of pesticides in the ecosystem. Meeks (1968) related the overall accumulation of DDT residues with higher trophic levels. Hannon et al. (1970) in a study of the Lake Poinsett ecosystem of South Dakota, reported an organochlorine pesticide concentration factor of 18 times in bottom sediment and crayfish, 37 times in plankton-algae, and 790 times in fish over those in water. Fish-eating birds, which occupy the highest trophic level in this food chain, concentrated these pesticides an average of 270 times over fish (Greichus and Greichus, 1972).

Studies have shown that chlorinated hydrocarbon insecticides are present in tissues, eggs, and feces of birds that ingest these chemicals. In a study by Dindahl (1970) to determine the accumulation and excretion of DDT in mallard and scaup ducks, only one experimental tissue, the testes of a lesser scaup, was free of detectable residues during all exposure periods. Residues were found in all other tissues at some time during the experiment.

In 1970 a multidisciplinary research program was initiated at South Dakota State University to determine the effects of DDT and its metabolites, DDD and DDE, on penned double-crested cormorants (Phalacrocorax

auritus). One objective of the research was to determine the levels and tissue distribution of organochlorine pesticides in these birds and to relate these to the pathological and clinical findings and to the individual and social behavior of these birds. An additional objective proposed to relate these findings to the number and types of endo- and ecto- parasites found in and on these birds.

A special area of interest in these experiments was centered around the uropygial gland and its role in the excretion of DDT and its metabolites. Dindahl (1970) reported that the uropygial gland of two species of ducks were generally higher in DDT residues than all other tissues, with the exception of leg and neck fat. He also stated that relatively high levels of DDT residues in uropygial glands corresponded with maximum residue concentration in the feathers. To examine this finding, three experiments using white leghorn chickens, mallard ducks, and double-crested cormorants were run at South Dakota State University to compare insecticide residues on the feathers as an indication of their excretion from the uropygial gland.

It has been speculated that chlorinated hydrocarbon insecticides may have the effect of reducing the population of bird parasites, and in this sense are of benefit to the bird. Although Linder and Atkins (1971) reported that an infestation by the endoparasite, Heterakis, evidently was not greatly affected by dieldrin, and that the helminths did not affect the weight gain in pheasants on 2 mg of dieldrin per week, other researchers have observed instances of reduced numbers of

parasites in birds which have been exposed to insecticides. It was noted by Locke et al. (1964) that during a die-off of red-breasted mergansers caused by a parasitic nematode, a male bird having the highest level of DDT in its liver exhibited no damage to liver, heart, or kidney, and had only minor involvement of the air sacs by this parasite. In another interesting observation, Keith (1966) noted that both endo- and ectoparasites were practically eliminated from white pelicans exposed to insecticides. It is possible that ectoparasites on the feathers of these birds were reduced in numbers as a result of exposure to pesticide residues. To obtain more information regarding this possible effect of pesticides, an experiment was conducted by the author in which double-crested cormorants were fed a fish which had been injected with dieldrin-^{14}C. The purpose of this experiment was to determine if the ingested dieldrin would eventually be transferred to the ectoparasites of the bird via the uropygial gland and feathers.

The purpose of this study on chickens, ducks, and cormorants was to: (1) determine the accumulation and excretion of dieldrin-^{14}C in the treated birds, (2) compare insecticide residues on the feathers as an indication of their excretion from the uropygial gland, and (3) determine any possible effect upon ectoparasite numbers due to the ingested insecticide.

METHODS AND MATERIALS

Chickens

Six adult white leghorn chickens were placed in plexiglass cages (15" x 7" x 11½"). Design of the cages allowed for collection of feces and eggs, and also provided the birds with access to drinking water. The six birds included: (1) two with uropygial glands, (2) three whose uropygial glands had been surgically removed, and (3) a control bird Injections of 6.187 μc of uniformly labeled dieldrin-^{14}C in one ml of 80 percent ethanol were made into the breast muscle of five of the birds. The control bird was injected with one ml of 80 percent ethanol.

After 48 hours all birds were sacrificed, and samples were taken of whole body, eggs, uropygial glands, and feathers. Feather samples were taken from three areas: (1) shoulder, (2) left hip, and (3) uropygial area. All fecal samples in this experiment were accidentally destroyed, and therefore no analysis of these samples was possible.

Ducks

Seven adult mallard ducks were placed in large wire cages with ample room for movement and access to drinking water. Aluminum foil placed under the cages allowed for collection of feces. The seven birds included: (1) three with uropygial glands, (2) three whose uropygial glands had been surgically removed, and (3) a control bird. Six of the birds were each injected with 6.198 μc of uniformly labeled dieldrin-^{14}C in one ml of 80 percent ethanol. The control bird was injected with one ml of 80 percent ethanol.

After 48 hours all birds were sacrificed, and samples of whole body, feces, uropygial glands, and feathers were taken for analysis. Feather samples were taken from five areas: (1) tips of primaries, (2) calami of primaries, (3) shoulder-back, (4) breast, and (5) uropygial area.

Cormorants

Five double-crested cormorants were used in this study. Two had been captured at a rookery at Dry Lake, South Dakota, and three had been captured at South Waubay Lake, South Dakota. Each bird was placed on a heavy wire mesh platform which had been placed in a glass carboy 15" in diameter by 20" in depth. Removing the bottom and inverting the jar facilitated collection of the fecal material through the spout. This arrangement allowed little fecal contamination of the feathers and provided access for collection of feces. The five cormorants included: (1) two with uropygial glands, (2) two whose uropygial glands had been surgically removed, and (3) a control bird. Four of the birds were each fed a fish which had been injected with 10.363 μc of uniformly labeled dieldrin-^{14}C in two ml of 80 percent ethanol. The control bird was fed a fish which had been injected with two ml of 80 percent ethanol.

After 24 hours the birds were sacrificed, and samples of whole body, feces, feathers, uropygial glands, and ectoparasites were taken for analysis. Feather samples were taken from four areas: (1) head, (2) shoulder-back, (3) breast, and (4) uropygial area. Ectoparasites were obtained by immediately washing the sacrificed birds in a plastic

wash basin with a mild detergent solution. To collect the ectoparasites, the birds were then washed a second time, in clear water, and the two washings were poured through two sieves with mesh sizes of 1.68 mm and 149 μ. The material remaining on the smaller screen was washed with water into a small glass collection bottle. The ectoparasites were later air dried, ground, and analyzed for dieldrin-^{14}C.

Eggs, feces, uropygial glands, and samples of whole body and feathers were stored in a deep freeze (-20°C) for later analysis. Whole body samples consisted of the entire bird minus the uropygial gland, except in the case of the ducks in which the feathers were not included.

The efficiency of extraction was determined by adding a known amount of dieldrin-^{14}C to samples of control tissue and comparing this to recovered activity. The efficiency of the procedure for whole bodies, uropygial glands, and eggs was 93 ± 4 percent. The efficiency for feathers and feces was 97 ± 2 percent.

Five-gram samples of whole body and eggs, and one-gram samples of uropygial glands were analyzed for radioactive dieldrin. Whole bodies were prepared by finely grinding the entire frozen carcass in a Toledo meat chopper (Toledo Scale Corporation, Toledo, Ohio). Several five gram aliquots from each bird were analyzed, and the values were averaged. Egg samples from each bird were homogenized in a Sorvall Omni-Mixer (Ivan Sorvall, Inc., Norwalk, Connecticut) before sampling. These samples were extracted and purified for dieldrin using the Florisil column cleanup method of Stemp et al. (1964) as modified by Greichus

et al. (1968). The samples were mixed thoroughly with 10 grams of Florisil and placed on top of 40 grams of Florisil in a 20 x 400 mm column. The dieldrin was then eluted with 750 ml of 20 percent v/v dichloromethane in petroleum ether. The extracted samples were brought to dryness, dissolved in 15 ml of scintillation fluid, and saved for liquid scintillation counting (^{14}C analysis).

Feathers, cut into small pieces and mixed, and feces, air dried and ground, were subsampled prior to extraction. The method of extraction was that of Greichus et al. (1968). The samples were thoroughly mixed with 10 grams of Florisil, placed on 20 grams of anhydrous sodium sulphate in a small column and eluted with 250 ml of a mixture of dichloromethane and petroleum ether (1 : 1 v/v). Extracted samples were saved for liquid scintillation counting.

All ectoparasites were ground using a small marble mortar and pestle. The equipment was rinsed with a small amount of dichloromethane and petroleum ether (1 : 1 v/v). The rinses and ground sample were collected in a scintillation bottle. They were brought to dryness and 15 ml of scintillation fluid was added. The ground bodies were suspended in Thixotrophic Gel Powder (Packard Instrument Company, Inc.) and saved for liquid scintillation counting.

Dieldrin-^{14}C with a specific activity of 2.36 mc/mmole was obtained from Shell Development Company, Modesto, California. Examination of the radioactive dieldrin by electron capture gas chromatography revealed no extraneous peaks. Thin-layer chromatography indicated that more than 95 percent of the activity of the dieldrin-^{14}C was in the dieldrin spot.

Florisil, 60/100 mesh, activated at 650°C (Fisher Scientific Company) was prepared for use by heating at 130°C for 16 hours, mixing in 3 percent distilled water, and sealing in an airtight container.

Hexane, petroleum ether (boiling range 30° to 60°C), and dichloromethane were Nanograde (Mallinckrodt Chemical Works).

The scintillation fluid consisted of 100 mg of 1,4-bis-2-(5-phenyloxazole)-benzene (POPOP) and 3 gm of 2,5-diphenyloxazole (PPO) in a liter of toluene. The POPOP and PPO were scintillation grade from Packard Instrument Company, Inc.

The instrument used for liquid scintillation analysis was a Packard Tri-Carb Series 3375, Liquid Scintillation Spectrometer.

RESULTS AND DISCUSSION

An average of 62.9 percent of the radioactive dieldrin injected into chickens was accounted for at the end of the experiment (Table 1). Average recoveries from ducks and cormorants were 61.8 and 73.4 percent, respectively (Tables 2 and 3).

Radioactivity in samples of whole body, eggs, uropygial glands, feces, and feathers of control birds was essentially the same as background (Appendix A).[1]

Most of the recovered activity in each experiment was found in the whole body samples. The average recovery from these samples was 62.5 percent in chickens, 61.4 percent in ducks, and 64.8 percent in cormorants.

Eggs

All eggs laid by chickens during the 48 hour experiment were analyzed for radioactive dieldrin residues. All ducks and cormorants, and one chicken laid no eggs during the term of the experiment. Whole egg samples (excluding shells) for each bird were pooled, and subsamples were analyzed. The average excretion of dieldrin via the eggs was 0.4 percent of the total injected into the chickens (Table 1).

The egg seemed to be an important means of excretion of dieldrin. In an experiment in which lindane, heptachlor epoxide, dieldrin, endrin, and DDT in combination were fed to white leghorn chickens, Cummings *et al.* (1966) reported that dieldrin and heptachlor epoxide showed the

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[1]Background radiation is naturally occurring radioactivity.

Table 1. Distribution and recovery of radioactivity after injection of dieldrin-^{14}C into chickens with and without uropygial glands.

Bird No.	1		2		3		4		5	
	dpm[1]	%	dpm	%	dpm	%	dpm	%	dpm	%
Activity administered	13,735,000	100	13,735,000	100	13,735,000	100	13,735,000	100	13,735,000	100
Activity recovered										
Whole body	9,273,000	67.52	6,384,000	46.48	6,371,000	46.39	9,078,000	66.09	11,815,000	86.02
Egg[2]	-----	---	26,680	0.19	58,400	0.43	64,210	0.47	82,820	0.60
Uropygial gland	1,710	0.01	7,950	0.06	-----	---	-----	---	-----	---
Feathers[3]	1,560	0.01	270	<0.01	190	<0.01	380	<0.01	300	<0.01
Total recovery	9,276,270	67.54	6,418,900	46.73	6,429,590	46.82	9,142,590	66.56	11,898,120	86.62

[1]disintegrations per minute
[2]whole egg minus shells
[3]three samples of one gram

Table 2. Distribution and recovery of radioactivity after injection of dieldrin-^{14}C into ducks with and without uropygial glands.

Bird No.	1		2		3	
	dpm[1]	%	dpm	%	dpm	%
Activity administered	13,760,000	100	13,760,000	100	13,760,000	100
Activity recovered						
Whole Body[2]	8,058,000	58.56	8,844,000	64.27	8,672,000	63.02
Feces	2,980	0.02	9,050	0.07	3,700	0.03
Uropygial Gland	-----	---	-----	---	-----	---
Feathers[3]	1,010	<0.01	10,150	0.07	13,950	0.10
Total recovery	8,061,990	58.59	8,863,200	64.41	8,689,650	63.15

[1]disintegrations per minute
[2]minus feathers
[3]total activity on feathers

Table 2. (Continued)

Bird No.	1		2		3	
	dpm[1]	%	dpm	%	dpm	%
Activity administered	13,760,000	100	13,760,000	100	13,760,000	100
Activity recovered						
Whole Body[2]	8,649,000	62.86	8,657,000	62.91	7,772,000	56.48
Feces	13,250	0.10	7,520	0.05	7,200	0.05
Uropygial Gland	38,600	0.28	41,440	0.30	29,210	0.21
Feathers[3]	86,890	0.63	29,640	0.22	42,780	0.31
Total recovery	8,787,740	63.87	8,735,600	63.48	7,851,190	57.05

[1]disintegrations per minute
[2]minus feathers
[3]total activity on feathers

Table 3. Distribution and recovery of radioactivity after injection of dieldrin-^{14}C into cormorants with and without uropygial glands.

Bird No.	1		3		2		4	
	dpm[1]	%	dpm	%	dpm	%	dpm	%
Activity administered	23,006,000	100	23,006,000	100	23,006,000	100	23,006,000	100
Activity recovered								
Whole Body	17,827,000	77.49	12,128,000	52.72	16,479,000	71.63	13,206,000	57.40
Feces	147,200	0.64	4,745,000	20.62	154,800	0.67	2,587,000	11.24
Uropygial Gland	117,900	0.51	82,640	0.36	-----	---	-----	---
Feathers[2]	3,490	0.02	69,150	0.30	2,500	0.01	38,170	0.16
Total recovery	18,095,590	78.66	17,024,790	74.00	16,636,300	72.31	15,830,170	68.80

[1]disintegrations per minute
[2]four samples of one gram

greatest propensity for storage in eggs. Lamb, et al. (1967) reported that from 19 to 37 percent of the total dieldrin given to hen pheasants in capsule form was excreted via the egg yolk over a thirteen week experimental period. In this study, excretion of dieldrin via the eggs ranged from 0.2 to 0.6 percent of the total administered to each bird. This method of excretion would be important during the spring egg-laying period. Egg samples of all chickens without uropygial glands contained more radioactivity than did the eggs of the chicken with the uropygial gland (Table 4); however, because of the samll sample size it is difficult to draw conclusions from this data.

Feces

Radioactivity recovered in the feces of individual ducks varied from 0.02 to 0.1 percent, and averaged 0.05 percent of the total dieldrin administered (Table 2).

Cormorants excreted an average of 8.3 percent of all activity received, via the feces (Table 3). Radioactivity excreted in the feces of individual cormorants varied from 0.6 to 20.6 percent of the doses administered. Birds of different ages and from different areas were used in this experiment. Two cormorants, approximately 14 weeks of age, were collected from an island at South Waubay Lake, South Dakota. Two others, approximately 11 weeks of age, were collected from a rookery at Dry Lake, South Dakota. The older birds excreted nearly equal amounts of dieldrin-^{14}C, 0.64 and 0.67 percent of the total injection. The younger birds had not yet adjusted to captivity and were very

Table 4. Distribution of radioactivity per gram after injection of dieldrin-^{14}C into chickens with and without uropygial glands.

Bird No.	1	2	3	4	5
	dpm[1]	dpm	dpm	dpm	dpm
Whole Body	8340	4480	4820	7030	7560
Eggs[2]	--	300	530	480	770
Uropygial Gland	4040	6040	--	--	--
Feathers					
Shoulder Area	180	120	29	64	97
Left Hip	110	54	53	100	31
Uropygial Area	1270	94	100	210	170

[1]disintegrations per minute
[2]whole eggs minus shells

excitable during the experiment. This condition may have decreased digestion and absorption of the insecticide, resulting in higher than usual amounts of radioactivity in the feces. Average activity in the feces of the younger birds was 24.3 times the average excreted in the feces of the older birds.

Uropygial Gland

The uropygial gland secretes an oily substance which in many birds is used to groom the feathers during preening behavior. In other birds such as the bustards, many pigeons, parrots, and ostriches, it is entirely absent. The oil gland serves at least three important functions, though usage and need may vary greatly in different species: (1) it helps keep the plumage water-repellent, particularly in water birds which have the largest oil glands; (2) it lubricates the beak and tarsi, thus preventing chafing; and (3) in some species it may provide a source of Vitamin D.

At the termination of the experiments, uropygial glands had more radioactivity per gram of tissue than did whole body samples in all but one chicken (Tables 4, 5, and 6). The average cormorant uropygial gland, even after compensating for the larger dosage of dieldrin-^{14}C, contained more radioactivity per gram than did the average duck uropygial gland. This gland in chickens had the least activity. The data may indicate the relative activity of the various uropygial glands. If the uropygial gland is primarily an organ for use in water-proofing the feathers, it would be needed least by the chickens.

Table 5. Distribution of radioactivity per gram after injection of dieldrin-^{14}C into ducks with and without uropygial glands.

Bird No.	1	2	3	4	5	6
	dpm[1]	dpm	dpm	dpm	dpm	dpm
Whole Body[2]	5730	4780	7160	4700	6380	4780
Feces	480	640	770	970	1560	1460
Uropygial Gland	--	--	--	8230	8920	6120
Feathers						
Tips of Primaries	9	8	7	120	21	10
Calami of Primaries	7	8	10	11	160	110
Uropygial Area	11	240	300	2480	1030	1460
Shoulder and Back	3	55	89	160	24	25
Breast	8	8	220	330	48	110

[1]disintegrations per minute
[2]minus feathers

Table 6. Distribution of radioactivity per gram after injection of dieldrin-^{14}C into cormorants with and without uropygial glands.

Bird No.	1	3	2	4
	dpm[1]	dpm	dpm	dpm
Whole Body	12,550	12,330	12,440	12,380
Feces	5,060	213,740	3,410	147,800
Uropygial Gland	37,670	22,480	----	----
Feathers				
Head	1,000	30,790	440	16,980
Shoulder-Back	1,810	11,590	1,540	8,990
Breast	360	13,460	100	6,320
Uropygial Area	330	13,310	420	6,180

[1]disintegrations per minute

Feathers

Use of the uropygial gland as an organ of excretion of dieldrin was indicated by the presence of radioactivity on the feathers. Chickens, ducks, and cormorants with uropygial glands had an average of 3.2, 6.3, and 1.8 times more radioactivity per gram, respectively on their feathers than those whose uropygial gland had been surgically removed.

Feather samples in each experiment were taken from several areas, (shoulder-back, uropygial area, breast, head, and primaries) in an attempt to determine patterns of distribution of the insecticide onto the feathers. The highest levels of radioactivity were usually found in the uropygial area. In all but one chicken, more residue was detected on the uropygial feathers than on either the shoulder or hip feathers (Table 4). Feathers from the uropygial area of ducks were always higher in radioactivity than those from the breast, shoulder-back, and primaries (Table 5). The pattern of distribution of radioactivity on the feathers of cormorants differed from those of chickens and ducks, in that insecticide residues did not accumulate in greater amounts in the uropygial area than in the other areas sampled. In two of the four birds radioactivity in the uropygial area was less than that on other regions of the body.

Samples were taken from the tips and calami of the primary feathers of ducks to determine if some of the insecticide found on these feathers may have been in the vanes, or possibly was rubbed from the feather follicle onto the calami during growth. The primary feathers were growing on only two of the six ducks, as indicated by the presence of

Table 7. Comparison of distribution and average radioactivity per gram on the feathers of chickens, ducks, and cormorants with and without uropygial glands, after injection of dieldrin-^{14}C.

CHICKENS	with uropygial	without uropygial	DUCKS	with uropygial	without urogygial		with uropygial	without uropygial
	dpm[1]	dpm		dpm	dpm		dpm	dpm
Shoulder Area	150	63	Tips of Primaries	50	8	Head	15,900	8,710
Left Hip	82	61	Calami of Primaries	94	8	Shoulder-Back	6,700	5,260
Uropygial Area	680	160	Shoulder-Back	70	49	Breast	6,910	3,210
			Breast	160	80	Uropygial Area	6,820	3,300
			Uropygial Area	1,660	180			
Calculated total activity on all feathers	26,200	15,800		159,300	25,100		1,008,000	541,800

[1]disintegrations per minute

vascular tissue. The amount of radioactivity on the tips of primary feathers seemed to be due to the presence of the uropygial gland, as there was more radioactivity on primary feather samples of birds with uropygial glands (Table 5). The calamus portion of the growing primary feathers (birds 5 & 6) had more radioactivity than did the samples of other calami. The activity found in these two calami may have been in the circulatory system, or it may have been rubbed onto the calami from the follicle. Lucas and Stettenheim (1972) concluded in a study using white leghorn chickens, that lipoid material occurs where the outer surface of the calamus presses against the inner surface of the feather follicle.

A wide range of activity was found on all feather samples of cormorants. The younger of the cormorants (birds 3 & 4) had 18 times more radioactivity on their feathers than did the other two.

Skin

In each experiment the presence of radioactivity on the feathers of birds without uropygial glands indicated that another means of excretion was in operation. It appeared that the method of excretion was from lipid secretions through the skin. Lucas (1968) has suggested that the sebaceous substance from the uropygial gland was applied primarily to the plumage, and that secretion from lipoid bodies in the skin epidermis was the chief source of fatty material in the corneum and on the surface of the skin. In this study, it appeared

that insecticides were secreted through these lipoid bodies in the skin and then transferred to the feathers by direct contact.

Ectoparasites

Three species of mites, (Michaelichus urile Dubinin, Alloptes ferrandi Gaud and Mochchet, and Megniniella sp.), and two species of chewing lice, (Eidmanniella pellucida Rudow, 1869 and Pectinopygus faralloni Kellogg, 1896), have been found in South Dakota cormorants. These ectoparasites are associated with the wing and body feathers and the skin of their hosts.

Data from other studies at South Dakota State University have indicated a decrease in numbers of ectoparasites on the feathers of experimental cormorants with increased dosages of insecticides (Greichus and Greichus, 1972). Radioactive dieldrin residues found on the ectoparasites of cormorants 1, 2, 3, and 4, counted 180, 3, and 90 disintegration per minute, respectively. All feather samples from cormorants contained dieldrin-^{14}C, and it can be assumed that the radioactivity was transferred to ectoparasites by means of the uropygial gland and/or the skin and feathers.

SUMMARY

Radioactivity was found in all samples of whole body, eggs, feces, uropygial glands, and feathers, except in control samples where radioactivity was essentially the same as background.

Average recoveries from whole bodies were 62.5 percent in chickens, 61.4 percent in ducks, and 64.8 percent in cormorants.

Chickens excreted 0.4 percent of the administered dieldrin via the egg during a 48 hour experiment.

Excretion of dieldrin in the feces of ducks and cormorants averaged 0.05 and 8.3 percent, respectively. Larger than usual amounts of radioactivity in the feces of two cormorants may have been due to excitability during the experiment which may have caused decreased digestion and absorption of the insecticide.

Use of the uropygial gland as an organ of excretion of the insecticide was indicated. Chickens, ducks, and cormorants with uropygial glands averaged 3.2, 6.3, and 1.8 times more radioactivity per gram, respectively on their feathers than those whose uropygial glands had been surgically removed.

Radioactivity on the feathers of birds without uropygial glands indicated the presence of another means of excretion of the insecticide. This means of excretion appeared to be through lipoid bodies in the skin of the birds (Lucas, 1968).

It was assumed that radioactivity found on the ectoparasites of cormorants was transferred to them by means of the uropygial gland and/or the skin and feathers. These pesticides may have an effect on ectoparasite numbers.

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Appendix A. Distribution of Radioactivity in Control Birds.

	Chickens dpm[1]	Ducks dpm	Cormorants dpm
Whole Body[2]	10,400	1,700	1,500
Eggs[3]	81	--	--
Feces	--	8	120
Uropygial Gland	7	16	12
Feathers	27[4]	222[5]	25[6]

[1]disintegrations per minute
[2]minus feathers in ducks
[3]whole eggs minus shells
[4]three samples of one gram
[5]total activity on feathers
[6]four samples of one gram