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# Lindane Distribution and Fatty Acid Profiles of Uropygial Gland and Liver of *Columba livia* after Pesticide Treatment

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In the study reported here the effect of lindane accumulation and its effect on fatty acid composition and lipid content of the uropygial gland and liver of the rock dove, *Columba livia,* was studied. There were no alterations in the weight, lipid content, and fatty acid composition of the gland when the lindane and control groups were compared. The insecticide was not present in the gland of control birds; however, it was found in the lindane group, 12.6 μg/mg lipid. The liver weight of the lindane-exposed group increased significantly when compared with control groups. Lindane was not detected in the liver. Lipid content liver in lindane-exposed doves was approximately 2–4 times higher than in control birds. No significant differences in the fatty acid composition of the total lipids of the gland were observed. The major difference in the fatty acid profile of liver lipids was found in the arachidonic acid (20:4) contents; this increase was significantly higher in the lindane group than in the control group. We found marked differences when the unsaturation index of fatty acids isolated from gland and liver were compared. Our results seem to suggest that the uropygial gland could be considered as an indicator of specific accumulation of the pesticide. 

## INTRODUCTION

The uropygial gland is a dorsal structure in birds which is found in the region of the last caudal vertebrae (1), is a sebaceous gland which secretes a complex mixture of lipids (2), and is highly specialized in that lipid synthesis (3). There is disagreement with respect to its physiological role, but functions attributed to it include water repellent action, production of pheromones, prevention of growth of skin microorganisms, and preservation of the physical structure of the feathers (4). Lindane is an organochlorine pesticide that does not accumulate in any specific tissue or organ, except in storage fat (5). Organochloride pesticides have been found in the uropygial gland and the adipose tissue depot of wild birds (6,7). Lindane can be accumulated in lipid bilayers and its accumulation could induce changes in membrane activity (8). High-dose treatment produces biochemical and functional alterations and changes in lipid metabolism (9). Many studies have shown that lindane accumulation produces changes in the membrane lipid composition of several tissues, such as liver, kidney, prostate, and intestine (8, 10–12).

Experiments performed with DDT in the rock dove, *Columba livia,* demonstrated that the insecticide appeared in the fat tissue, whereas it was not detected in the liver after 48 h (13). Recent studies have shown that lindane treatment alters both intestinal mucosa composition and brush border enzymatic activity in chickens (14). The purpose of the present work was to determine the effect of lindane on the fatty acid composition of total lipids isolated from uropygial gland and liver of the rock dove, *C. livia,* and analyze the possibility of the involvement of this gland in the uptake of this lipophylic substance.

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TABLE 1
*Lindane and Lipid Content in Uropygial Gland of the Rock Dove, Columba livia*

| Group | Lindane gland (μg/mg) | Content lipids (μg/mg) | Lipid content (mg/g tissue) | Gland weight (mg) |
|---|---|---|---|---|
| Control ($n$ = 6) | n.d. | n.d. | 301.3 ± 47.2 | 125.9 ± 11.8 |
| Ethanol ($n$ = 4) | n.d. | n.d. | 286.1 ± 36.9 | 147.5 ± 59.0 |
| Lindane ($n$ = 7) | 6.90 ± 1.32 | 12.62 ± 2.19 | 373.1 ± 140.7 | 115.8 ± 26.0 |

*Note.* Values are means ± SD; n.d., not detected (limit < 0.005 μg); *n*, number of animals.

## MATERIAL AND METHODS

Adult rock doves, *C. livia* ($n$= 17), were used. The body weight of the birds was 456 ± 45 g (mean ± SD). They were kept in single cages and fed on a mixture of grains with water *ad libitum*, at a temperature of 20–22°C. Birds were divided into three experimental groups: (a) control ($n$=6), (b) ethanol control, 7 ml/kg body wt. ($n$=4), and (c) lindane 0.23 mg/g body wt (dissolved in ethanol) ($n$=7). Ethanol and lindane were administered by intramuscular injection into the pectoral and ilio-tibial muscles. The total amount of either ethanol or lindane was administered every 48 h in three different injections. Doves were weighted the first and seventh day of the experiment, then were sacrificed and the uropygial gland and liver were immediately removal. Total lipids of uropygial gland and liver were extracted with chloroform/methanol (2:1 v/v) (15). Fatty acids were transmethylated with 5% HCl in methanol at 80°C for 60 min. Fatty acids methyl esters were analyzed as previously described (16). Lindane content was determined through gas chromatography in a Shimadzu gas chromatograph GC-14 A (30 × 0.32 mm internal diameter, I & V Scientific, Folson, CA), with nitrogen as carrier. Both the injector and the temperature detector were kept at 250°C; the temperature of the column was 90–180 (15 min), 180–200 (3 min), and 220°C (7 min). A standard

TABLE 2
*Fatty Acid Composition of Total Lipids from Uropygial Gland of the Rock Dove, Columba livia*

| Fatty acid | Control | Ethanol | Lindane |
|---|---|---|---|
| 14:0 | 14.26 ± 4.34 | 6.84 ± 1.92 | 8.47 ± 3.32 |
| 14:1 | 0.51 ± 0.08 | 0.40 ± 0.17 | 0.43 ± 0.18 |
| 16:0 | 25.44 ± 1.02 | 26.98 ± 0.81 | 31.56 ± 6.69 |
| 16:1 | 4.67 ± 0.53 | 5.90 ± 2.09 | 3.67 ± 0.86 |
| 17:0 | 7.53 ± 0.28 | 13.82 ± 3.52 | 13.76 ± 4.15 |
| 18:0 | 5.25 ± 0.39 | 5.10 ± 1.81 | 7.11 ± 0.80 |
| 18:1 | 18.95 ± 1.14 | 20.04 ± 2.91 | 10.57 ± 4.82[a] |
| 18:2 | 9.19 ± 0.40 | 8.16 ± 1.20 | 4.86 ± 2.23 |
| 18:3 | 0.83 ± 0.07 | 1.73 ± 0.97 | 1.21 ± 0.47 |
| 20:0 | 1.39 ± 0.36 | 1.72 ± 0.32 | 0.47 ± 0.22 |
| 20:4 | 5.15 ± 1.04 | 6.06 ± 2.21 | 5.05 ± 0.88 |
| Saturated | 52.57 ± 3.30 | 51.45 ± 3.40 | 60.52 ± 7.14 |
| Monounsaturated | 23.81 ± 0.32 | 26.35 ± 4.61 | 11.95 ± 6.47 |
| Polyunsaturated | 14.82 ± 1.12 | 15.37 ± 2.27 | 11.14 ± 1.51 |
| Total unsaturated | 38.63 ± 5.44 | 41.72 ± 0.79 | 23.09 ± 8.56 |
| Saturated/unsaturated | 1.17 ± 0.18 | 1.25 ± 0.11 | 2.76 ± 0.78 |
| Unsaturation index | 41.15 ± 2.28 | 46.14 ± 3.70 | 47.87 ± 8.00 |

*Note.* Data are given as the mean ± SD of independent determinations.
[a]Significantly different from ethanol group ($P$ < 0.02).

TABLE 3
*Lindane, Lipid Content and Liver Weight of the Rock Dove, Columba livia*

| Groups | Lindane content (μg/mg) | Lipid content (mg/g tissue) | Liver weight (g) |
|---|---|---|---|
| Control ($n = 6$) | n.d. | 30.3 ± 1.56 | 7.58 ± 0.82 |
| Ethanol ($n = 4$) | n.d. | 53.0 ± 11.8 | 9.35 ± 1.21 |
| Lindane ($n = 7$) | n.d. | 124.0 ± 18.8[a] | 13.36 ± 1.65[a] |

*Note.* Values are mean ± SD; n.d., not detected (limit < 0.005 μg), n, number of animals.
[a]Significantly different from control group ($P < 0.01$).

curve with different lindane concentrations (between 1 and 50 μg) was carried out. Lindane was determinated by calculating the area under the curve. All determinations were done in duplicate. Results were expressed as means ± SD of independent determinations. Data were evaluated statistically by one-way analysis of variance and Tukey test. When significant differences were found, comparisons between control and treated groups were made applying the Fisher PLSD test. In all cases $P < 0.05$ was considered the statistically significant level. Unsaturated index was determined as previously described (17).

## RESULTS AND DISCUSSION

Lindane is a lipophilic compound that can be accumulated in lipid bilayers and its accumulation could induce changes in membrane lipid composition of different tissues such as kidney, liver, prostate, and intestine (8, 18–20). However, although a great amount of information is known about the various biological effects of lindane in experimental animals, we are not aware of studies conducted with the uropygial gland. In the study reported here the effect of lindane accumulation and its effect on fatty acid composition and lipid content of uropygial gland

TABLE 4
*Fatty Acid Composition of Total Lipids from Liver of the Rock Dove, Columba livia*

| Fatty acid | Control | Ethanol | Lindane |
|---|---|---|---|
| 14:0 | 2.89 ± 0.50 | 4.73 ± 1.10 | 5.60 ± 1.50 |
| 14:1 | 0.32 ± 0.06 | 0.47 ± 0.24 | 0.17 ± 0.10 |
| 16:0 | 17.76 ± 0.36 | 15.32 ± 0.35 | 16.29 ± 1.89 |
| 16:1 | 4.79 ± 0.50 | 2.99 ± 0.49 | 2.60 ± 0.35 |
| 18:0 | 14.08 ± 2.11 | 20.06 ± 2.07[a] | 22.30 ± 1.54 |
| 18:1 | 38.13 ± 0.70 | 22.94 ± 2.43[a] | 17.99 ± 1.75[b] |
| 18:2 | 14.66 ± 0.31 | 22.08 ± 1.70[a] | 23.83 ± 1.71 |
| 20:4 | 2.05 ± 0.27 | 1.79 ± 1.10 | 7.11 ± 1.25[c] |
| Saturated | 34.61 ± 1.82 | 44.44 ± 6.09 | 44.10 ± 4.40 |
| Monounsaturated | 43.24 ± 1.08 | 28.49 ± 4.48 | 21.07 ± 2.12 |
| Polyunsaturated | 18.51 ± 0.46 | 24.82 ± 2.30 | 28.80 ± 3.41 |
| Total unsaturated | 61.75 ± 1.30 | 53.31 ± 5.11 | 50.50 ± 3.31 |
| Saturated/unsaturated | 0.55 ± 0.03 | 0.84 ± 0.20 | 0.88 ± 0.13 |
| Unsaturation index | 87.98 ± 1.98 | 79.24 ± 8.56 | 95.62 ± 6.60 |

*Note.* Data are given as the mean ± SD. Statistically significant differences between groups are indicated by superscript, italic letters.
[a]Significantly different from control group ($P < 0.001$).
[b]Significantly different from ethanol group ($P < 0.02$).
[c]Significantly different from ethanol group ($P < 0.01$).

and liver of *C. livia* was studied. Our results show that uropygial gland weight was not significantly altered in the lindane-treated birds. The pesticide was not present in the gland of control birds; however, it was found in the lindane group, 12.6 μg/mg lipid.

The lindane content in the gland of *C. livia* is in agreement with the organochlorine pesticide residues found in the uropygial gland of wild birds (6, 7).

The lipid content of the gland did not show statistical variations among the three groups (Table 1). The fatty acid composition of the total lipids extracted from uropygial gland is shown in Table 2. No significant differences in the fatty acid composition of the total lipids of the gland were observed when lindane-treated birds and the control group were compared; as a consequence the unsaturation index, a parameter based on the relative content of unsaturated fatty acids, was not modified. However, significant differences in the content of oleic acid were observed when the ethanol and lindane group were compared but these differences seem to be due only to the presence of ethanol. The liver weight of the lindane-exposed group increased significantly ($P < 0.01$) when compared with control groups (Table 3). Previous studies have demonstrated that lindane treatment increased chicken liver weight (14). The lipid content in the liver of lindane-exposed doves was approximately 2–4 times higher than in control birds ($P < 0.01$); however, lindane was not detected in the liver (Table 3). The absence of this compound in the liver could be due to its rapid rate of breakdown as has been found for other organochlorinated pesticides (13). The fatty acid composition of the total lipids extracted from liver of *C. livia* is shown in Table 4.

The major difference in the fatty acid profile of liver lipids was found in the arachidonic acid (20:4) contents; this increase was significantly higher ($P < 0.01$) in the lindane group than in the control group.

There were marked differences when the unsaturation index of gland and liver in control birds was compared, which could explain the differential effect that lindane produce on both organs (Tables 2 and 4). The data support that lindane injected was temporally accumulated and later excreted through the uropygial gland.

Moreover, the fact that the lipid content of the gland was not greatly changed could be considered as an indicator of the specific accumulation of the pesticide in the gland.

Taken together, our results and those of Johnston (6) demonstrate that it is possible that the gland could play a repository and excretory function for chlorinated hydrocarbon pesticides and pollutants.

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