Comparative Residues of PCB Components in the Bald Eagle and White Leghorns

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INTRODUCTION

A bald eagle (Haliaeetus leucocephalus) found dead near a Springfield, Illinois lake was necropsied and several body tissues were analyzed for the presence of organochlorine insecticide and polychlorinated biphenyl (PCB) residues. Research with chickens fed PCB's for 10 weeks has shown that under chronic conditions residues accumulate in the fat with slow elimination.[2] Chronic studies of PCB's in swine and sheep (BORCHARD et al. 1975a; and HANSEN et al. 1975a) have shown this accumulation-elimination pattern to be similar for other species. The residues found in the eagle could be attributed to biomagnification through the food chain resulting in slow accumulation as in the chronic studies.

Bioaccumulation of PCB's and organochlorine insecticides in cormorants and pelicans as reported by GREICHUS et al. (1973) was most evident in the fat with the greatest contaminant being p-p'-DDE. Body fat in this eagle however was virtually non-existent, probably due to stress conditions of wintering, so no fat analysis was conducted.

Analysis of liver tissue in a chronic chicken study[2] revealed an increase in concentration after being removed from treated feed for 4 weeks. The residue levels of the chicken livers after 4 weeks on non-treated feed are in line with liver residue levels of the cormorant and pelican (GREICHUS et al. 1973).

MATERIALS AND METHODS

Tissue Extraction

Tissue samples of 1.0 g were ground with 35 g of anhydrous Na_2SO_4 and packed into a 19 x 300 mm chromatography column. The column is eluted with 175 ml of hexane/ether into a Kuderna-Danish evaporation flask. The solvent was taken to 5.0 ml for further cleanup on a microcolumn before GLC assay.

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[1] To whom correspondence should be addressed.
[2] Unpublished results from this laboratory.

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Microcolumn Chromatography

A 1.0 ml aliquot of the tissue extracts was pipetted directly onto the bed of a 6 x 200 mm chromatography column containing 2 g dry alumina which has been deactivated 5% (w/w) with distilled H_2O. Elution is performed with 11 ml of hexane, the first ml acting as a wash to complete sample transfer directly into the bed. Samples are taken to adequate volume for electron capture gas chromatography.

Gas-Liquid Chromatography

Tissue extracts were analyzed on a Tracor-550 gas chromatograph equipped with a ^{63}Ni electron capture detector. The chromatograph was equipped with a 6' x 2 mm id. glass column packed with 4% SE-30 + 6% OV-210 on 100-120 mesh Chromabsorb W (AW-DMCS). The column and detector temperatures were 200° C and 280° C respectively.

Quantitation of Residues

Pesticide peak height measurements were taken and quantitated on the basis of standard linear regressions. PCB calculations were made as previously described (BORCHARD et al. 1974; WELBORN et al. 1974). Although retention times given in Figures 1 A through D are referenced to OV-1 separation, the elution pattern distinctive to SE-30 + OV-210 is the same; however finer separation results and pesticides such as Dieldrin, p,p'DDE, DDT and DDD may be resolved. Purified PCB analogs were also run parallel to Aroclor 1242 and 1254 to insure proper assignment compared to OV-1. Peaks with retention times 21-57 (p,p' DDE = 100) were quantitated on the basis of Aroclor 1242 and peaks 70-286 quantitated using Aroclor 1254. This modification allows total PCB by weight to be calculated on the basis of thermal conductivity data (HIRWE et al. 1974).

RESULTS

On April 2, 1975, an immature female bald eagle (Haliaeetus leucocephalus) was found dead near Lake Sangchris in Christian County, Illinois, and submitted to the Illinois Natural History Survey. It weighed 2500 gms and appeared to be in good condition.

A fluoroscopic examination revealed two number 4 lead shot buried just beneath the skin. One was located at the base of the tail, the other was in the region of the thoracic inlet. Necropsy showed that neither wound was more extensive than mere penetration of the skin and local tissue reaction.

The eagle had no deposits of subcutaneous, mesenteric, coronary or abdominal fat. There were no lesions indicating injury or disease process other than the two subcutaneous lead pellets previously discussed. The circulatory, respiratory and musculoskeletal systems, and the gastrointestinal and urinary tracts all appeared to be normal.

The concentrations of heavy metals found in the eagle tissues were below toxic levels (Table I). COOK and TRAINER (1966) found lead concentrations ranging from 6 to 32 ppm in Canada geese dying of lead intoxication. Lethal levels of methyl mercury have not been established for bald eagles. However, ranges of from 0.38 to 44.56 ppm methyl mercury (≈79.6% of the total mercury) were found in bald eagles not known to have died of mercury intoxication (BELISLE et al. 1972). The levels of copper found in the tissues appear to be within normal limits for various avian species (Biology Data Handbook, 1973).

Table I.

Metal Residues in Eagle Tissues[1)]

	Heavy Metal Concentration (ppm)		
	Total Mercury	Lead	Copper
Muscle	ND[2)]	0.90	1.25
Lung	0.04	0.88	1.02
Brain	ND	0.05	0.18
Heart	0.15	0.84	1.10
Kidney	--[3)]	--	--
Liver	0.21	1.05	2.80
Duodenum	ND	1.80	2.10

1) M.K.G. Rao, College of Veterinary Medicine, University of Illinois, personal communication.
2) Not detectable.
3) Not analyzed because of small sample size.

Organochlorine insecticide residues detected were dieldrin, p,p'-DDE, DDD and DDT. The liver contained the greatest amount of dieldrin, DDD and DDT while p,p'-DDE was most concentrated in the muscle (Table 2). Lung and brain residues had a similar profile which was lower than the other tissues.

Table 2

Eagle Tissue Residues

	Pesticide Concentration (ppm)				
	Dieldrin	DDE	DDD	DDT	PCB[1)]
Muscle	2.94	3.04	2.66	2.21	63.10
Lung	1.11	0.66	0.57	0.63	17.16
Brain	1.48	0.90	0.83	0.56	21.21
Heart	2.05	1.24	1.44	0.97	33.97
Kidney	2.87	1.87	1.99	1.31	52.77
Liver	3.12	2.30	3.01	2.30	74.09
Duodenum	3.02	2.25	2.76	2.30	61.98

1) Total PCB.

The PCB's were analyzed by individual component concentration as well as total PCB concentration. A similar profile of contamination by organochlorine insecticides in each tissue can be seen with PCB contamination. Lung and brain tissues again have lower levels of PCB's than do the other tissues. Liver again contains the highest concentration of PCB's (Table 2,3).

Components 149 and 253, a mixture of penta- and hexachlorobiphenyl, and a mixture of hexa- and heptachlorobiphenyl, respectively (HIRWE et al. 1974) are concentrated at levels[3] of 93.5 and 1083.4 ppm, respectively in the liver and are also at very high levels in all other tissues analyzed (Table 3). These components contribute an average of 20.2% and 22.2%, respectively to the total concentration of PCB of all tissues.

[3] Concentration of Aroclor required for equivalent detector response; absolute concentrations are 12.8 and 20.6 ppm, respectively.

Table 3

Eagle Tissue Residues of PCB Components

RRT[1]	PCB Concentration (ppm relative to Aroclors)						
	Muscle	Lung	Brain	Heart	Kidney	Liver	Duod.
21[2]	3.8	--	0.8	2.2	4.4	5.8	2.7
26	0.4	--	--	0.2	0.2	0.7	0.5
31	0.6	--	--	0.3	--	0.8	0.8
37	5.7	1.2	1.5	3.1	3.9	6.2	3.3
41	7.1	--	--	--	--	5.3	2.1
48	18.6	3.9	5.9	10.3	18.4	19.7	12.3
53	9.9	2.0	3.3	4.6	9.9	12.4	3.8
57	12.9	3.1	4.2	7.0	13.1	15.7	6.6
70[3]	24.6	7.0	9.5	14.4	23.4	26.2	20.3
84	33.3	9.8	14.0	20.5	30.9	34.6	31.4
99	43.1	9.6	14.2	23.5	35.1	43.3	39.0
105	27.2	7.2	11.2	15.7	24.6	30.8	29.1
127	21.4	6.4	7.8	11.4	16.7	23.6	21.5
149	85.9	28.9	32.8	54.5	73.0	93.5	91.0
176	55.2	18.9	21.2	33.6	46.0	58.7	58.1
208	50.9	18.2	14.6	32.7	29.6	68.2	56.8
253	760.0	186.7	200.0	306.7	583.4	1083.4	916.7
286	360.0	66.7	80.0	173.3	233.3	533.3	333.3

1) *p,p'*-DDE = 100 on 3% OV-1.
2) Components 21-57 calculated as Aroclor 1242 required for equivalent detector response.
3) Components 70-286 calculated as Aroclor 1254 required for equivalent detector response.

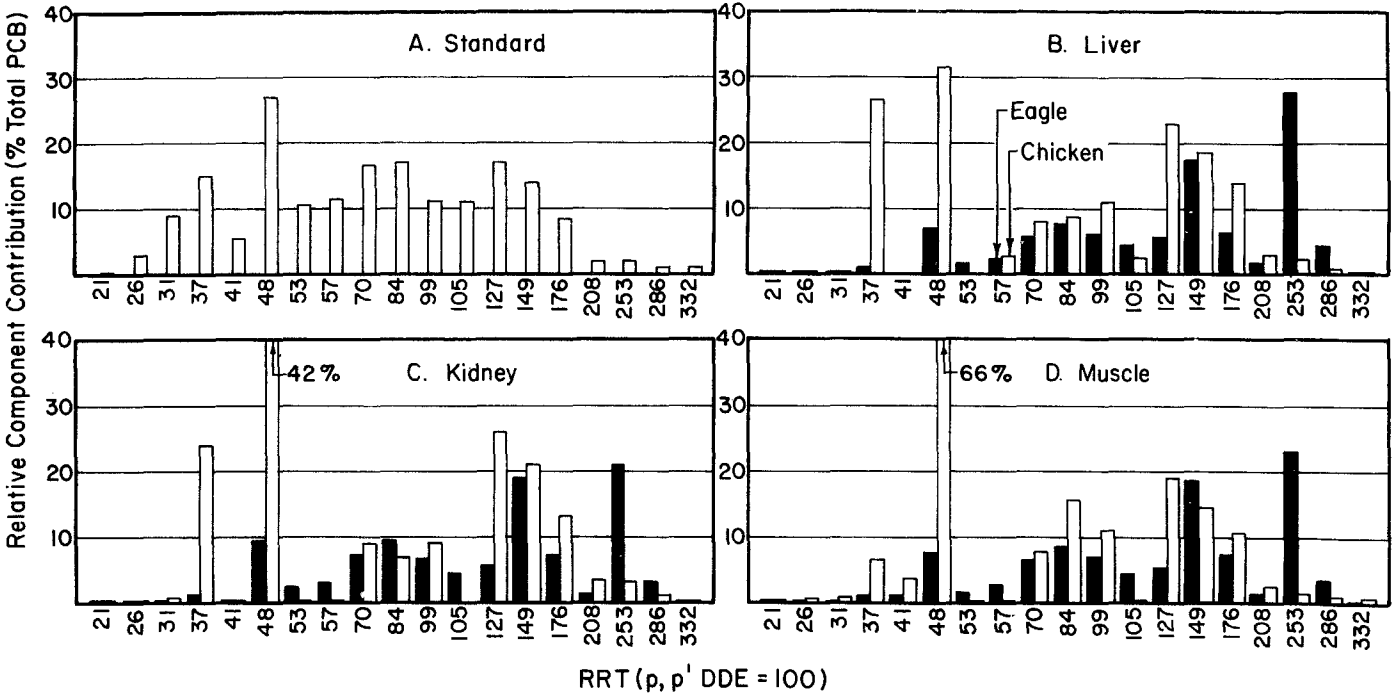

Figure 1. Relative component contribution as a percent of total PCB occurring in the eagle (solid bar) and chicken (open bar) liver, kidney and muscle compared to a standard of combined Aroclors 1242 and 1254.

Component 286, a heptachlorobiphenyl (HIRWE et al. 1974) is concentrated at over 500 ppm in liver tissue and is higher in all other tissues than component 149 (Table 3); however, it contributes an average of only 3% to the total PCB concentration in all tissues. All components of Aroclor 1242 and Aroclor 1254 were detectable in at least one tissue except component 332 which was less than the detectable level of 0.5 ppb.

Profiles by individual PCB components of the tissues appear almost identical. A comparison of eagle liver, kidney and muscle with layer chicken liver, kidney and muscle[2] demonstrates similar patterns of sequestering (Figure 1).

Two GLC peaks which appeared between components 208 and 253 were not identifiable.

DISCUSSION

The profiles of PCB residue percent composition occurring in the eagle and chicken are shown in Figure 1 B, C, and D for liver, kidney and muscle respectively. Figure 1 A illustrates a standard combined from Aroclor 1242 (components 21-57) and Aroclor 1254 (components 70-332). In studies now completed,[2] it has been shown that chickens cannot appreciably metabolize peaks 37, 48, 149 and 253. The same profile can be seen in the eagle with very good correlation occurring with peaks 70, 84 and 99. Since fish, which are the bulk of an eagle diet, cannot metabolize PCB's to a great extent (HANSEN et al. 1975b) it follows that the eagle tissue profile would closely approximate an oral dose of unchanged Aroclor, assuming contamination was via the fish diet. The great concentrating ability at peaks 149 and 253 is not only found in fowl but swine and sheep also exhibit this phenomenon (BORCHARD et al. 1974; 1975a; 1975b).

The low percentage of peak 48 in the eagle indicates exposure to higher chlorinated PCB such as Aroclor 1254 or 1260. The largest percentage of total PCB is attributed to peaks 70-286 (Table 3) which is also indicative of higher chlorinated PCB (HIRWE et al.1974, and WEBB and McCALL 1973).

The chicken study, to which the eagle is compared (Figure 1), was conducted as chronic exposure to 20 ppm PCB. Considering the similarities of the sequestering pattern, one may conclude that this eagle, too, received chronic exposure to PCB's, probably via the food chain.

The average of residue levels in chicken fat were quite high (124 ppm) while chicken liver concentrations were only 1.8 ppm.[2] With the absence of body fat in this eagle, the probable high concentrations that were in the fat may have passed into the liver, kidney or muscle; thus, the high total PCB's in these tissues.

Organochlorine pesticide residues are similar in comparison to the levels found in eagle carcasses and brains by MULHERN et al. (1970) and BELISLE et al. (1972). Considering the number of birds analyzed by MULHERN and BELISLE, this eagle is well within the range of contamination they reported. The lowest lethal brain dieldrin residue level is about 4 or 5 ppm (STICKEL et al. 1959); this eagle is well below these levels and we may conclude that dieldrin alone was not the cause of death.

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