Bull. Environ. Contam. Toxicol. 31, 407–414 (1983)


# Organochlorine Insecticide Residues and PCBs in Tissues of Woodcock, Mourning Doves, and Robins from East-Central Illinois, 1978–79

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Use of DDT in agriculture was widespread through the late 1940's, reached a peak in the mid-1950's, and declined rapidly thereafter. In the mid-1960's, aldrin was used on about half the acreage planted to corn in Illinois, but its use declined after 1966 and had effectively ceased after 1976 (D. KUHLMAN, Illinois Natural History Survey [INHS], unpublished data; and STEVENSON MOORE III, INHS, personal communication). Use of heptachlor in Illinois effectively ended in 1978. Dieldrin was apparently never used extensively and its limited use ended about 1964. Nevertheless, these chlorinated hydrocarbon and cyclodiene pesticides persist in soils (NASH and WOOLSON 1967, PIMENTEL 1971) and apparently are conserved by adsorption in the upper soil layers where they are associated with organic matter (EDWARDS 1970, MEHNER & WALLACE 1959).

Polychlorinated biphenyl compounds (PCB's) were introduced in 1929 and today are ubiquitous in the environment (DUSTMAN et al. 1971). Levels of PCB's in animals relate to food habits and may be magnified hundreds of times through food chains from prey to predator (PRICE 1977, RISEBROUGH et al. 1968). HEATH et al. (1970) concluded that the effects of PCB's and DDE are additive, not synergistic. DUSTMAN et al. (1972) reported that PCB residues above 10 ppm in eggs are cause for concern.

PRICE (1977) concluded that, although still widespread in Canadian wildlife, the incidence of DDE has apparently dropped since the use of DDT ended there in 1968-1969. The breeding population of robins on the campus of Iowa State University, Ames, was more abundant when censused by WILLSON (1978) in 1977 than when censused by WELLER (1971) in 1962-1970 at the height of a local Dutch-elm-disease eradication program utilizing DDT.

Reported here are levels in ppm of heptachlor, heptachlor epoxide, dieldrin, p,p'-DDE (DDE), and PCB residues assayed in muscle, heart, liver, brain, and fatty tissues of woodcock (Philohelo minor), mourning doves (Zenaidura macroura), and robins (Turdus migratorius) from east-central Illinois in 1978 and 1979.

## MATERIALS AND METHODS

The sample specimens (available from another study) were taken from study areas near Westville in Vermilion County and near

Shelbyville in Shelby County, in August 1978 and 1979. Samples included 9 woodcock, 5 doves, and 6 robins from Vermilion County and 5, 3, and 0, respectively, from Shelby County; the location for 1 woodcock is not known. Wet tissue samples were homogenized, saponified, and then extracted with 50 ml of nanograde hexane. The hexane extract was washed three times with ultrapure water, poured through a funnel of anhydrous $Na_2SO_4$ to remove residual water, and then placed on a steam bath and reduced to a volume of 2-5 ml under a 3-ball Snyder column. Each sample was fractionated on a 30-gm florisil column. The first fraction was eluted with 90 ml of hexane to recover the PCB's; the second fraction, eluted with 10 percent ethyl ether/hexane, contained the remaining chlorinated hydrocarbons. The samples were then reduced to a volume suitable for gas chromatographic analysis. The analyses were performed using a Varian-Aerograph Series 2100 gas chromatograph with a 63Ni electron capture detector operated at 250°C. The analytical column was a 6' x 1/4" O.D. x 2 mm I.D. glass column packed with 2.5% OV-210 and 1.0% OV-17 coated on a 100-120 mesh Supelcoport. The column temperature was maintained at 190°C and the injection port at 210°; the electrometer was operated at $4 \times 10^{-10}$ amperes. The carrier gas was $O_2$-free nitrogen at a flow rate of 40 ml/min. Detection limits were calculated to be 0.0001 ppm. Because of limited sample sizes and generally low levels of pesticides, tests of statistical differences were not attempted.

## RESULTS AND DISCUSSION

All 15 woodcock sampled contained insecticides; however, none contained either heptachlor or aldrin (Table 1). Of the 15, heptachlor epoxide was found in 12, dieldrin in all 15, DDE in 4, and PCB's in 4. Highest levels of the respective compounds in woodcock tissues were 0.2532 ppm heptachlor epoxide in fat, 21.2103 ppm dieldrin in fat (the magnitude and inconsistency of this value suggest possible contamination), 0.7661 ppm DDE in liver, and 12.4878 ppm PCB's in fat.

All 8 mourning doves contained insecticides (Table 2). As with the woodcock, none of the doves contained either heptachlor or aldrin. Of the 8 doves, all showed heptachlor epoxide and measurable dieldrin; DDE was found in 3 and PCB's in 1. Highest levels detected in the doves were 0.1319 ppm heptachlor epoxide in fat, 0.1785 ppm dieldrin in brain, 4.7526 ppm DDE in fat, and 0.3718 ppm PCB's in fat.

All 6 robins contained insecticides (Table 3). Of the 6 robins, heptachlor was found in 2, heptachlor epoxide in 4, aldrin in 1, dieldrin in 5, and PCB's in 2. Highest levels in robins were 0.3354 ppm heptachlor in brain, 0.9677 ppm heptachlor epoxide in brain, 0.0052 ppm aldrin in brain, 0.0162 ppm dieldrin in muscle, 0.3158 ppm DDE in heart, and 6.7438 ppm PCB's in fat.

In general, levels of organochlorine insecticides were less than 1 ppm. In only one tissue did PCB's exceed 10 ppm. Levels of heptachlor epoxide were higher in robins than in mourning doves

Table 1. Incidence of insecticides and PCB's in ppm[1] in tissues of woodcock from east-central Illinois, August 1978 and 1979.

| Tissue | Heptachlor | Heptachlor Epoxide | Aldrin | Dieldrin | p,p'-DDE | PCB's |
|---|---|---|---|---|---|---|
| Muscle | | | | | | |
| Rate | 0/15 | 5/15 | 0/15 | 13/15 | 3/15 | 2/15 |
| Mean | <0.0001 | 0.0086 | <0.0001 | 0.0343 | 0.0074 | 0.299 |
| Range | <0.0001 | <0.0001-0.0337 | <0.0001 | <0.0001-0.297 | <0.0001-0.0620 | <0.0001-4.48 |
| Liver | | | | | | |
| Rate | 0/11 | 3/11 | 0/11 | 8/11 | 2/11 | 1/11 |
| Mean | <0.0001 | 0.0071 | <0.0001 | 0.0450 | 0.0806 | 0.0225 |
| Range | <0.0001 | <0.0001-0.0539 | <0.0001 | <0.0001-0.209 | <0.0001-0.766 | <0.0001-0.247 |
| Heart | | | | | | |
| Rate | 0/15 | 8/15 | 0/15 | 14/15 | 3/15 | 1/15 |
| Mean | <0.0001 | 0.0120 | <0.0001 | 0.0567 | 0.0173 | 0.0053 |
| Range | <0.0001 | <0.0001-0.0895 | <0.0001 | <0.0001-0.455 | <0.0001-0.126 | <0.0001-0.0791 |
| Brain | | | | | | |
| Rate | 0/15 | 4/15 | 0/15 | 12/15 | 1/15 | 0/15 |
| Mean | <0.0001 | 0.0094 | <0.0001 | 0.0206 | 0.0039 | <0.0001 |
| Range | <0.0001 | <0.0001-0.0948 | <0.0001 | <0.0001-0.234 | <0.0001-0.0580 | <0.0001 |
| Fat | | | | | | |
| Rate | 0/6 | 4/6 | 0/6 | 6/6 | 0/6 | 1/6 |
| Mean | <0.0001 | 0.0634 | <0.0001 | 3.7174[2] (0.2187) | <0.0001 | 2.08 |
| Range | <0.0001 | <0.0001-0.253 | <0.0001 | <0.0001-21.2[2] | <0.0001 | <0.0001-12.5 |
| Sum | | | | | | |
| Rate | 0/62 | 24/62 | 0/62 | 53/62 | 9/62 | 5/62 |
| % | 0 | 39 | 0 | 85 | 15 | 8 |

[1]Means computed using an assumed level of 0.00005 for values less than 0.0001.

[2]Possibly contaminated sample.

Table 2. Incidence of insecticides and PCB's in ppm[1] in tissues of mourning doves from east-central Illinois, August 1978 and 1979.

| Tissue | Heptachlor | Heptachlor Epoxide | Aldrin | Dieldrin | p,p'-DDE | PCB's |
|---|---|---|---|---|---|---|
| Muscle | | | | | | |
| Rate | 0/8 | 5/8 | 0/8 | 6/8 | 2/8 | 0/8 |
| Mean | <0.0001 | 0.0203 | <0.0001 | 0.0103 | 0.0138 | <0.0001 |
| Range | <0.0001 | <0.0001-0.121 | <0.0001 | <0.0001-0.0260 | <0.0001-0.1061 | <0.0001 |
| Liver | | | | | | |
| Rate | 0/7 | 5/7 | 0/7 | 6/7 | 1/7 | 0/7 |
| Mean | <0.0001 | 0.0079 | <0.0001 | 0.0107 | 0.0031 | <0.0001 |
| Range | <0.0001 | <0.0001-0.0245 | <0.0001 | <0.0001-0.0317 | <0.0001-0.0211 | <0.0001 |
| Heart | | | | | | |
| Rate | 0/6 | 2/6 | 0/6 | 5/6 | 1/6 | 0/6 |
| Mean | <0.0001 | 0.0032 | <0.0001 | 0.0198 | 0.0179 | <0.0001 |
| Range | <0.0001 | <0.0001-0.0174 | <0.0001 | <0.0001-0.0878 | <0.0001-0.107 | <0.0001 |
| Brain | | | | | | |
| Rate | 0/4 | 2/4 | 0/4 | 3/4 | 0/4 | 0/4 |
| Mean | <0.0001 | 0.0247 | <0.0001 | 0.0503 | <0.0001 | <0.0001 |
| Range | <0.0001 | <0.0001-0.0816 | <0.0001 | <0.0001-0.179 | <0.0001 | <0.0001 |
| Fat | | | | | | |
| Rate | 0/4 | 2/4 | 0/4 | 4/4 | 3/4 | 1/4 |
| Mean | <0.0001 | 0.0497 | <0.0001 | 0.0555 | 1.2676 | 0.0930 |
| Range | <0.0001 | <0.0001-0.132 | <0.0001 | <0.0230-0.122 | <0.0001-4.75 | <0.0001-0.372 |
| Sum | | | | | | |
| Rate | 0/29 | 16/29 | 0/29 | 24/29 | 7/29 | 1/29 |
| % | 0 | 55 | 0 | 83 | 24 | 3 |

[1]Means computed using an assumed level of 0.00005 for values less than 0.0001.

Table 3. Incidence of insecticides and PCB's in ppm[1] in tissues of robins from east-central Illinois, August 1978 and 1979.

| Tissue | Heptachlor | Heptachlor Epoxide | Aldrin | Dieldrin | p,p'-DDE | PCB's |
|---|---|---|---|---|---|---|
| Muscle | | | | | | |
| Rate | 1/6 | 4/6 | 0/6 | 3/6 | 1/6 | 0/6 |
| Mean | 0.0089 | 0.0303 | <0.0001 | 0.0032 | 0.0017 | <0.0001 |
| Range | <0.0001-0.0533 | <0.0001-0.0881 | <0.0001 | <0.0001-0.0162 | <0.0001-0.0102 | <0.0001 |
| Liver | | | | | | |
| Rate | 0/5 | 4/5 | 0/5 | 3/5 | 1/5 | 0/5 |
| Mean | <0.0001 | 0.0107 | <0.0001 | 0.0026 | 0.0046 | <0.0001 |
| Range | <0.0001 | <0.0001-0.0167 | <0.0001 | <0.0001-0.0098 | <0.0001-0.0230 | <0.0001 |
| Heart | | | | | | |
| Rate | 0/4 | 3/4 | 0/4 | 1/4 | 3/4 | 1/4 |
| Mean | <0.0001 | 0.0632 | <0.0001 | 0.0017 | 0.0833 | 0.288 |
| Range | <0.0001 | <0.0001-0.118 | <0.0001 | <0.0001-0.0066 | <0.0001-0.316 | <0.0001-1.15 |
| Brain | | | | | | |
| Rate | 2/6 | 3/6 | 1/6 | 2/6 | 1/6 | 2/6 |
| Mean | 0.0576 | 0.283 | 0.0009 | 0.0013 | 0.0043 | 1.48 |
| Range | <0.0001-0.335 | <0.0001-0.968 | <0.0001-0.0052 | <0.0001-0.0061 | <0.0001-0.0258 | <0.0001-6.74 |
| Sum | | | | | | |
| Rate | 3/21 | 14/21 | 1/21 | 9/21 | 6/21 | 3/21 |
| % | 14 | 67 | 5 | 43 | 29 | 14 |

[1]Means computed using assumed value of 0.00005 for values less than 0.0001.

Table 4. Mean levels of heptachlor epoxide and dieldrin in tissues of woodcock, mourning doves, and robins from east-central Illinois, August 1978 and 1979.

| | Heptachlor Epoxide | | | Dieldrin | | |
|---|---|---|---|---|---|---|
| Tissue | Woodcock | Mourning Dove | Robin | Woodcock | Mourning Dove | Robin |
| Muscle | 0.0086 | 0.0203 | 0.0303 | 0.0343 | 0.0103 | 0.0032 |
| Liver | 0.0071 | 0.0079 | 0.0107 | 0.0450 | 0.0107 | 0.0026 |
| Heart | 0.0120 | 0.0032 | 0.0632 | 0.0567 | 0.0198 | 0.0017 |
| Brain | 0.0094 | 0.0247 | 0.283 | 0.0206 | 0.0503 | 0.0013 |
| Fat | 0.0634 | 0.0497 | -- | 0.219 | 0.0555 | -- |

Table 5. Percent of tissue samples of woodcock, mourning doves, and robins from east-central Illinois with detectable levels of heptachlor, heptachlor epoxide, aldrin, dieldrin, p,p'-DDE and PCB's, August 1978 and 1979.

| | Heptachlor | Heptachlor Epoxide | Aldrin | Dieldrin | p,p'-DDE | PCB's |
|---|---|---|---|---|---|---|
| Woodcock | 0 | 39 | 0 | 85 | 15 | 8 |
| Mourning Doves | 0 | 55 | 0 | 83 | 24 | 3 |
| Robins | 14 | 67 | 5 | 43 | 29 | 14 |

and lowest in woodcock (Tables 4 and 5). The reverse was generally true for dieldrin; levels were higher in woodcock than in doves and lowest in robins. There was no consistent pattern for either DDE or PCB's. Environmental levels of DDE, dieldrin, and heptachlor epoxide in Illinois were probably lower in 1978-1979 than in earlier years, as those compounds gradually degrade (BEYER and GISH 1980, CAREY 1979, KLAAS and BELISLE 1977, LICHTENSTEIN et al. 1971, PIMENTEL 1971).

The apparent differences in levels of heptachlor epoxide and dieldrin among species of birds are probably due to differences in

food habits. Earthworms (Lumbricidae), a principal food of numerous avians, including woodcock and robins, are resistant to DDT and its residues (BOYKINS 1970). Such residues have been found five times as high in earthworms as in the associated soils (BEYER and GISH 1980) and an order of magnitude higher in robins than in earthworms (DIMOND et al. 1970). One might expect woodcock and robins to have relatively similar levels of pesticide residues because both feed extensively on earthworms. Why doves rank between woodcock and robins in heptachlor epoxide and dieldrin content in the data reported here cannot be explained by the authors, except to point out that robins forage extensively in open urban lawns and gardens, taking a variety of invertebrates, whereas woodcock feed almost exclusively on earthworms in dense mesic forests.

Migratory birds undoubtedly reflect the chemical status of both winter and summer ranges. WRIGHT (1965) concluded that woodcock breeding in New Brunswick received high dosages of DDT on their breeding range where the insecticide had been applied to control spruce budworm (Choristoneura fumiferana) and heptachlor on their winter range where the latter insecticide had been used to control fire ants (Solenopsis saevissima). STICKEL et al. (1965) found that woodcock lose residues of heptachlor at a rate of 2.8% per day. MCLANE et al. (1978) found generally higher levels of pesticides in wings of adult woodcock east of the Appalachian Mountains, with particularly high levels in woodcock wings from New Jersey, the Carolinas, Georgia, and Louisiana; heptachlor epoxide was found only in wings of Louisiana woodcock.

Woodcock occur in Illinois from late February or early March through mid-November (William R. Edwards, unpublished data), but where these woodcock winter has not been determined with certainty. However, the incidence of heptachlor epoxide in Illinois and Louisiana woodcock and its absence in other collections reported by MCLANE et al. (1978) supports the concept of OWEN (1977) that woodcock breeding west of the Appalachians winter west of the Appalachians. The lack of heptachlor epoxide in wings of woodcock taken north of Illinois in Michigan, Wisconsin, and Minnesota (MCLANE et al. 1978) suggest that those populations are discrete from east-central Illinois woodcock.

MCLANE et al. (1971) reported mean values of 1.26 ppm (0.18-2.49) DDE, 0.149 ppm (0.022-0.62) heptachlor epoxide, and 0.090 ppm (0.023-1.09) dieldrin for woodcock wings; those values are generally higher than we report here for Illinois woodcock. The differences could relate to differences in environmental loads of pesticides in time, space, or tissues analyzed; however, MCLANE et al. (1971) concluded that Louisiana woodcock contained less heptachlor epoxide in 1965 than in 1961-1962. CLARK and MCLANE (1978) concluded that Louisiana woodcock in 1970-1971 had less DDE and less heptachlor epoxide than in 1965.

Although the number of samples assayed was small and their distribution restricted, it appears that residues of the organo-

chlorine insecticides in woodcock, mourning doves, and robins probably remained widespread but at relatively low and probably decreasing levels in east-central Illinois in 1978-1979.

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Accepted May 18, 1983