

## Organochlorine Chemicals in Tree Swallows Nesting in Pool 15 of the Upper Mississippi River

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Navigation Pool 15 of the Upper Mississippi River (UMR) has been polluted with polychlorinated biphenyls (PCBs) (Woodward-Clyde 1996). These PCBs have been bioaccumulated by benthic aquatic insects (Steingraeber et al. 1994) and fish (Woodward-Clyde 1997). Although contamination levels have decreased over the past decade in fish (Woodward-Clyde 1997), it is unknown whether organochlorine chemical concentrations in avian species may still be of concern.

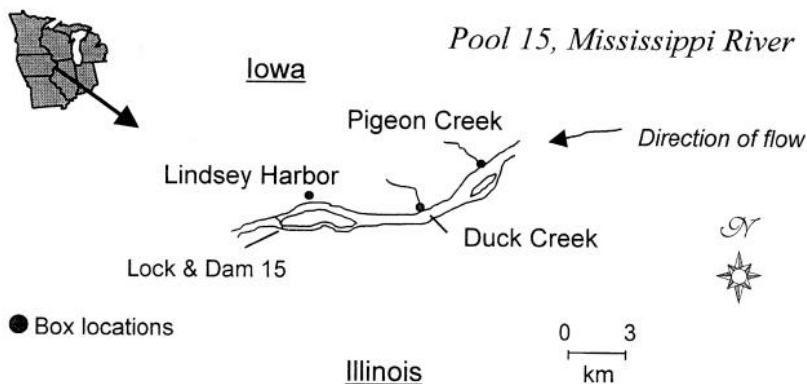
Swallows, especially tree swallows (*Tachycineta bicolor*) are now widely used as indicators of local aquatic contamination (Ankley et al. 1993, Bishop et al. 1995, 1999, Custer et al. 1998, DeWeese et al. 1985, Nichols et al. 1995, Secord et al. 1999, Shaw 1983). Tree swallows will readily use nest boxes, so study sites can be established at specific locations of interest. They also feed near their nest box ( $\pm$  400 m, Quinney and Ankney 1985) on emerging aquatic insects of several taxa (Blancher and McNicol 1991). Therefore, residues in tree swallow tissues reflect localized sediment contamination for bioavailable chemicals (Fairchild et al. 1992).

The objective of this study was to determine whether organochlorine compounds in tree swallow eggs and nestlings were higher near the historic source of PCB contamination in Pool 15 as compared to sites above and below that location.

### MATERIALS AND METHODS

Eighteen to twenty tree swallow boxes were placed at each of three sites (Fig. 1) along the Iowa shoreline of Pool 15 during spring 1998. The sites were (1) Pigeon Creek, river mile 491.0, which was an up-river reference site; (2) Duck Creek, river mile 490.4, which was located immediately adjacent to the historic PCB source, and (3) Lindsey Harbor, river mile 484.1 which was approximately six river miles downstream from the historic PCB source. Boxes were checked approximately weekly to monitor the progression of egg laying and hatching. Two to three eggs were collected from each of three boxes at Pigeon Creek, each of three boxes at Duck Creek, and each of seven boxes at Lindsey Harbor during mid- to late incubation under appropriate state and federal collecting permits.

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**Figure 1.** Location of tree swallow nesting boxes in the Quad Cities area, Davenport and Bettendorf, Iowa; Rock Island and Moline, Illinois, on Navigation Pool 15, Upper Mississippi River, 1998.

The egg contents were pooled by clutch and placed in chemically clean jars, then frozen until analyzed. Sibling 12- to 16-day old nestlings were collected from the same boxes from which egg samples were collected at Pigeon Creek and Lindsey Harbor. Vandalism of nest boxes at Pigeon Creek prevented our collecting nestlings at that site or having a larger sample of eggs there. Food samples were taken from the stomachs of all nestlings collected; these food samples were pooled by site and also analyzed. Samples were analyzed for 22 organochlorine chemicals, including total PCBs, at Mississippi State Chemical Laboratory using standard methodologies. All values are reported on a  $\mu\text{g/g}$  wet wt. basis with detection limits of  $0.01 \mu\text{g/g}$  for all chemicals except total PCBs, which had a detection limit of  $0.05 \mu\text{g/g}$ , and the dioxins and furans that are reported as  $\text{ng/g}$  (parts per billion) wet wt. with a detection limit of  $0.001 \text{ ng/g}$ . Spiked and duplicate samples were also analyzed (10% of total). The remaining portion of egg samples from Pigeon Creek and Lindsey Harbor were pooled by site and those pools analyzed for 2,3,7,8-tetrachlorodibenzodioxin (TCDD) and 2,3,7,8-tetrachlorodibenzofuran (TCDF) by Mississippi State Chemical Laboratory using EPA method 8290 (U.S. EPA 1994).

Mean concentrations were calculated and compared among the three locations using analysis of variance (ANOVA) when  $> 50\%$  of samples contained detectable concentrations. Half the detection limit was used in statistical analyses for samples with less than the detection limit. Because variances were homogeneous (Bartlett's test, Sokal and Rohlf 1981), values were not log transformed. Accumulation rates (mass of a chemical in the nestling minus the mass in the egg divided by the age of the nestling, Custer and Custer 1995) were calculated and compared between locations using ANOVA.

## RESULTS AND DISCUSSION

Eleven organochlorine chemicals were not detected in egg or nestling tree swallows. These were alpha benzene hexachloride (BHC), beta BHC, delta BHC, gamma BHC, gamma chlordane, endrin, hexachlorobenzene (HCB), o,p'-dichlorodiphenyldichloro-ethane (DDD), o,p'-dichlorodiphenyl-dichloroethylene (DDE), o,p'-dichlorodiphenyl-trichloroethane (DDT), and toxaphene. Chemicals found in fewer than 50% of samples were not statistically analyzed. These were alpha chlordane in one egg sample, cis-nonachlor in four eggs, mirex in one egg and one nestling, p,p'-DDD in four eggs, and p,p'-DDT in one egg. All concentrations were < 0.05 µg/g wet wt. except for one egg that contained 0.07 µg/g p,p'-DDD. Oxychlordane was detected in one nestling and in all eggs (Table 1). Trans-nonachlor was present in three nestlings and in 10 of 13 eggs (Table 1). Concentrations in the four nestlings were all < 0.03 µg/g wet wt. No organochlorine chemicals were found in either of the two diet samples.

Five of the 6 chemicals listed in Table 1 were found at detectable concentrations in all egg samples. Trans-nonachlor, however, was detected in only four of seven egg samples from Lindsey Harbor, but in all eggs from Pigeon and Duck Creeks. All organochlorine contaminants were at background concentrations and only p,p'-DDE varied among the locations. Total PCBs in tree swallow eggs in Pool 15 were similar to levels present in east-central Wisconsin reference sites, and 2 - 7 times lower than at PCB-contaminated locations in Green Bay, Lake Michigan (Custer et al. 1998). Total PCB egg concentrations in Pool 15 were either similar to or up to 8 times lower than that of tree swallow eggs in Canada at sites along the northern shore of Lakes Erie and Ontario (Bishop et al. 1995, 1999). Concentrations of p,p'-DDE in Pool 15 were similar to levels in Green Bay, Lake Michigan (Custer et al. 1998) but 5 - 12 times lower than at some locations in Canada (Bishop et al. 1995, 1999, Shaw 1984).

Both 2,3,7,8-TCDD and 2,3,7,8-TCDF were detected in pooled tree swallow egg samples. TCDD concentrations were 0.026 and 0.012 ng/g wet wt. at Pigeon Creek and Lindsey Harbor, respectively; TCDF concentrations were 0.14 and 0.22 ng/g wet wt. at the two sites. Concentrations of TCDD were 2 - 5 times higher in Pool 15 than in a pooled tree swallow egg sample from Green Bay, Lake Michigan (Ankley et al. 1993); TCDF was not detected in the tree swallow egg sample from Green Bay, WI.

Mean concentrations for organochlorine chemicals in nestlings were at or near background levels and did not vary between locations in Pool 15 (Table 2). Concentrations were above the detection limit for all nestlings listed in Table 2, except for heptachlor epoxide, which was present in three of four samples at Lindsey Harbor. Concentrations in nestlings were similar to reference areas used in other studies in east-central Wisconsin, were 10 - 30 times lower than in tree swallow nestlings in Green Bay, Lake Michigan (Custer et al. 1998) and similar to or 10 times lower than in tree swallows studied in Canada (Bishop et al. 1995).

**Table 1.** Concentrations (mean  $\pm$  1 SE,  $\mu\text{g/g}$  wet wt.) of organochlorine contaminants in tree swallow eggs from Pool 15 on the Upper Mississippi River, 1998.

Chemical	Pigeon Creek ( <i>n</i> = 3)	Duck Creek ( <i>n</i> = 3)	Lindsey Harbor ( <i>n</i> = 7)	<i>P</i> - values <sup>1</sup>
Total PCBs	0.28 $\pm$ 0.083	0.54 $\pm$ 0.052	0.40 $\pm$ 0.082	0.274
p,p'-DDE	0.11 $\pm$ 0.018	0.17 $\pm$ 0.004	0.11 $\pm$ 0.012	0.017 <sup>2</sup>
Dieldrin	0.03 $\pm$ 0.003	0.03 $\pm$ 0.002	0.03 $\pm$ 0.005	0.847
Oxychlorthane	0.02 $\pm$ 0.001	0.04 $\pm$ 0.003	0.03 $\pm$ 0.006	0.082
Heptachlor epoxide	0.05 $\pm$ 0.004	0.07 $\pm$ 0.004	0.05 $\pm$ 0.011	0.581
Trans-nonachlor	0.01 $\pm$ 0.002	0.02 $\pm$ 0.003	0.03 $\pm$ 0.014	0.581

<sup>1</sup> *P* -values for among location comparisons (1 -way ANOVA)

<sup>2</sup> Duck Creek was significantly higher than Lindsey Harbor. No other means differed from one another for p,p'-DDE

**Table 2.** Concentrations (mean  $\pm$  1 SE,  $\mu\text{g/g}$  wet wt.) of organochlorine contaminants in tree swallow nestlings from Pool 15 on the Upper Mississippi River, 1998.

Chemical	Pigeon Creek ( <i>n</i> = 3)	Lindsey Harbor ( <i>n</i> = 4)	<i>P</i> -values <sup>1</sup>
Total PCBs	0.13 $\pm$ 0.017	0.14 $\pm$ 0.022	0.788
p,p'-DDE	0.02 $\pm$ 0.001	0.04 $\pm$ 0.008	0.218
Dieldrin	0.04 $\pm$ 0.024	0.03 $\pm$ 0.005	0.552
Heptachlor epoxide	0.01 $\pm$ 0.001	0.07 $\pm$ 0.062	0.446

<sup>1</sup> *P*-values for between location comparisons (1 -way ANOVA)

Calculation of accumulation rate in nestlings effectively factors out the contaminant contribution from eggs, that might have been acquired elsewhere, and quantities only local exposure to contaminants. Although tree swallows in Pool 15 did accumulate some total PCBs and certain other organochlorine chemicals (Table 3), the accumulation rates for these compounds were similar to reference sites elsewhere in the U.S. (Custer et al. 1998) and did not differ above and below the historic PCB source in Pool 15.

**Table 3.** Accumulation rates ( $\mu\text{g/day}$ ) of three organochlorine chemicals in tree swallow nestlings from Pool 15 of the Upper Mississippi River, 1998.

Chemical	Pigeon Creek ( $n = 2$ )	Lindsey Harbor ( $n = 4$ )	$P$ -values <sup>1</sup>
Total PCBs	$0.18 + 0.047$	$0.21 + 0.034$	0.619
p,p'DDE	$0.02 + 0.004$	$0.05 + 0.016$	0.291
Dieldrin	$0.07 + 0.042$	$0.04 + 0.009$	0.406

<sup>1</sup>  $P$  values for between location comparisons (1 -way ANOVA)

Polychlorinated biphenyl concentrations were not different at, below, or above the historic source of PCBs in Pool 15. Likewise, other organochlorine chemical concentrations, except for p,p'DDE in tree swallow eggs, also did not vary among sites in Pool 15. All chemicals, including PCBs, were at background levels and below known, biological-effect levels for tree swallows. The mass of organochlorine chemicals accumulated by nestlings from the local environment was also at background rates.

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## REFERENCES

Ankley GT, Niemi G J, Lodge KB, Harris HJ, Beaver DL, Tillitt DE, Schwartz TR, Giesey JP, Jones PD, Hagley C (1993) Uptake of planar polychlorinated biphenyls and 2,3,7,8-substituted polychlorinated dibenzofurans and dibenzo-p-dioxins by birds nesting in the lower Fox River and Green Bay, Wisconsin,

- USA. Arch Environ Contam Toxicol 24:332-344
- Bishop CA, Koster MD, Chek AA, Hussell DJT, Jock K (1995) Chlorinated hydrocarbons and mercury in sediments, red-winged blackbirds (*Agelaius phoeniceus*) and tree swallows (*Tachycineta bicolor*) from wetlands in the Great Lakes-St. Lawrence River basin. Environ Toxicol Chem 14:491-501
- Bishop CA, Mahony NA, Trudeau S, Pettit KE (1999) Reproductive success and biochemical effects in tree swallows (*Tachycineta bicolor*) exposed to chlorinated hydrocarbon contaminants in wetlands of the Great Lakes and St. Lawrence River basin, USA and Canada. Environ Toxicol Chem 18:263-271
- Blancher PJ, McNicol DK (1991) Tree swallow diet in relation to wetland acidity. Canadian J Zool 69:2629-2637
- Custer CM, Custer TW, Allen PD, Stromborg KL, Melancon M (1998) Organochlorine contaminants and tree swallows nesting along the Fox River and in Green Bay, Wisconsin. Environ Toxicol Chem 17:1786-1798
- Custer TW, Custer CM (1995) Transfer and accumulation of organochlorines from black-crowned night-heron eggs to chicks. Environ Toxicol Chem 14:533-536
- DeWeese LR, Cohen RR, Stafford CJ (1985) Organochlorine residues and eggshell measurements for tree swallows *Tachycineta bicolor* in Colorado. Bull Environ Contam Toxicol 35:767-775
- Fairchild WL, Muir DCG, Currie RS, Yuarechewski AL (1992) Emerging insects as a biotic pathway for movement of 2,3,7,8-tetrachlorodibenzofuran from lake sediments. Environ Toxicol Chem 11:867-872
- Nichols JW, Larsen CP, McDonald ME, Niemi GJ, Ankley GT (1995) Bioenergetics-based model for accumulation of polychlorinated biphenyls by nestling tree swallows, *Tachycineta bicolor*. Environ Sci Technol 29:604-612
- Quinney TE, Ankney CD (1985) Prey size selection by tree swallows. Auk 102:245-250.
- Secord AL, McCarty JP, Echols KR, Meadows JC, Gale RW, Tillitt DE (1999) Polychlorinated biphenyls and 2,3,7,8-tetrachlorodibenzo-*p*-dioxin equivalents in tree swallows from the upper Hudson River, New York state, USA. Environ Toxicol Chem 18:2519-2525
- Shaw GC (1983) Organochlorine pesticide and PCB residues in eggs and nestlings of tree swallows, *Tachycineta bicolor*, in central Alberta. Canadian Field-Nat 98:258-260
- Sokal RR, Rohlf FJ (1981) Biometry. WH Freeman and Co., New York
- Steingraeber MT, Schwartz TR, Wiener JG, Lebo JA (1994) Polychlorinated biphenyl congeners in emergent mayflies from the Upper Mississippi River. Environ Sci Technol 28:707-714
- U.S. EPA (1994) Test methods for Evaluating Solid Waste. Polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) by high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS). SW-846, Method 8290, Revision 0
- Woodward-Clyde (1996) Sediment and water sampling results Mississippi River Pool 15, Phase III. Final Report, Vol. 1. Woodward-Clyde, 357 Riverside Dr., Franklin, TN
- Woodward-Clyde (1997) Evaluation of biennial fish investigations Mississippi River Pool 15. Final Rep. Woodward-Clyde, 357 Riverside Dr., Franklin, TN