Site-specific dietary exposure assessment of several passerine bird species to PCDFs and PCDDs

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ABSTRACT

Dietary exposures of passerine birds nesting in the Tittabawassee and Chippewa River floodplains near Midland, Michigan, were examined due to the presence of polychlorinated dibenzofurans (PCDFs) and dibenzo-*p*-dioxins (PCDDs) in both the terrestrial and aquatic food webs. Historical chemical production around the turn of the century is a possible source of the PCDF/PCDD compounds currently occurring downstream of Midland. Mean concentrations of PCDF/PCDDs in soil and sediment were 10- to 20-fold greater downstream (target sites) of Midland compared to upstream (reference sites). Based on life history, site presence and availability of on and off site historical data, tree swallow, eastern bluebird, and house wren were chosen as passerine receptor species of interest. Dietary exposures were estimated from site-specific concentrations of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin equivalents (TEQs) in representative food web samples of species available in the floodplain, combined with both a literature-based and site-specific dietary assessment for each receptor. Bolus samples collected from nestlings and adults were used to estimate site-specific dietary composition for each receptor species over the course of the breeding season. Seventeen 2,3,7,8 (PCDF/PCDD) congeners were measured and converted to TEQs using avian WHO TEF values. Concentrations of TEQs in soil and sediment ranged from 3.95-24.8 (*n*=11) and 0.208-5.50 (*n*=16) ng/kg dry weight (dw) upstream of Midland while downstream concentrations of TEQs ranged from 425-18800 (*n*=23) and 15.2-6060 (*n*=38) ng/kg dw, respectively. Concentrations of TEQs in aquatic (benthic and aquatic emergent) and terrestrial insects ranged from 0.296-32.3 (*n*=31) and 0.42-4.15 (*n*=11) ng/kg wet weight (ww) upstream of Midland while downstream TEQs ranged from 3.09-1570 (*n*=41) and 5.26-1900 (*n*=20) ng/kg ww, respectively. Estimated dietary exposure and average potential daily doses were calculated and compared to literature values for receptor species. Since no species-specific dose response data exist for the majority of the PCDF congeners present, the estimation of risk from dietary sources was dependent on the selection of literature based effects thresholds.

INTRODUCTION

- Site located in **Midland Co, Michigan, USA** on the **Tittabawassee River** (Fig. 1.)
- Elevated concentrations of PCDFs and PCDDs downstream of Midland, MI [1]
- Upstream ("reference") and downstream ("target") sites identified
- Receptors of interest: **tree swallow** (*Tachycineta bicolor*), **house wren** (*Troglodytes aedon*), and **Eastern bluebird** (*Sialia sialis*)

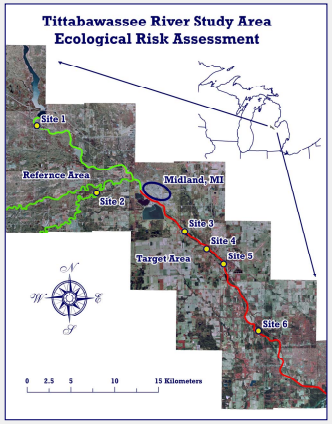
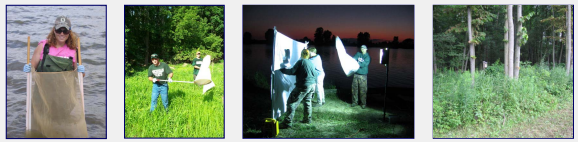


Fig. 1. Tittabawassee River study area in Midland Co, Michigan USA. Upstream references sites (1 & 2) and downstream target sites (3-6) are indicated, all study sites were located within the Tittabawassee, Chippewa, and Pine River 100-yr floodplains.

METHODS AND MATERIALS



- Extensive food web sampling effort in 2004, including: aquatic emergent, benthic, and terrestrial invertebrates

- Receptor based studies began in 2005
- 202 nest boxes placed at 2 reference sites (*n*=69) and 4 target sites (*n*=133)

- Ligature method used to obtain food samples from nestlings [3]
- Insects sorted to taxonomic order
- Chemical extraction followed EPA method 3540C & 3541
- Chemical analyses followed EPA method 8290
- Food ingestion (FI) rate and average potential daily dose (APDD) were estimated [4] based on avian-specific World Health Organization (WHO_{Avian}) TCDD equivalency factors [5]

RESULTS AND DISCUSSION

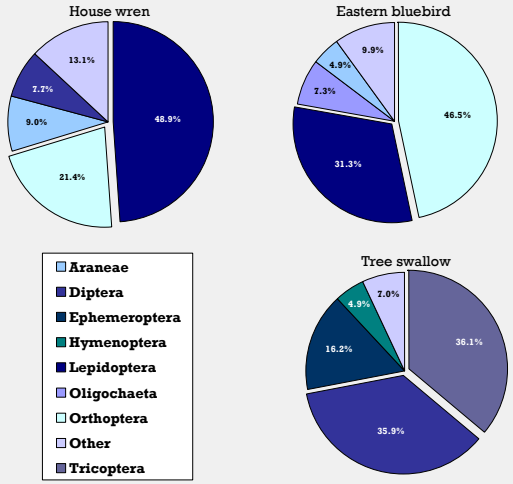


Fig. 2. Site specific dietary composition of Eastern bluebird (*n*=226 items), house wren (*n*=438 items), and tree swallow (*n*=1709 items) diets in the Tittabawassee River study area. Dietary composition is based on mass of dietary items recovered from bolus samples taken during the 2005 sampling season. The "Other" category is composed primarily of coleoptera, gastropoda, hemiptera, plant material, odonata, and opiliones.

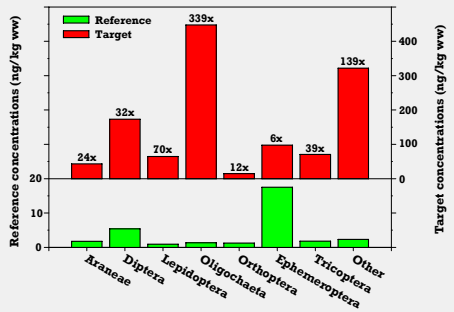


Fig. 3. Average concentrations of TEQs in invertebrate orders represented in the primary diets of the study species from site-specific dietary analyses. Number above target area plots represent fold-differences over reference area concentrations per order.

Table 1. Estimated dietary dose (ng/kg/day) based on WHO_{Avian} TEQs for total PCDF/Ds.

	Species					
	Tree swallow		House wren		Eastern bluebird	
Site	Mean	95% CI	Mean	95% CI	Mean	95% CI
Reference sites	1.42	1.27-1.65	0.43	0.38-0.52	0.41	0.37-0.47
Target sites	30.91	27.64-36.01	23.66	21.13-28.59	20.87	18.89-23.76

- Overall site-specific diets comparable to literature based diets (Fig. 2.) [6-8]
- WHO_{Avian} TEQs are made up of ~90% PCDF congeners (2,3,4,7,8-PeCDF/2,3,7,8-TCDF)(Fig. 3.)
  - Dietary concentrations at target sites were 6-339x higher than at reference sites
  - Congener profile downstream is similar across sites (data not presented)
- Estimated APDDs downstream were 3-4x higher than upstream estimations (Table 1.)
  - Custer et al. [8] implicated dioxin concentrations (primarily 2,3,7,8-TCDD) in reduced hatching success in a field study of tree swallows in Rhode Island, USA

CONCLUSIONS

- Receptors of interest are being exposed to dietary TEQ concentrations similar to 2,3,7,8-TCDD concentrations that have been implicated to cause reduced hatching success [8]
- All data presented are from one year of data collection and should be considered preliminary
- Future research will include analysis of egg, nestling, and individual bolus samples for concentrations of PCDF/Ds from the study area

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