

EXPOSURE AND CONDITION OF AMERICAN ROBINS ALONG THE TITTABAWASSEE RIVER UTILIZING A MULTIPLE LINES OF EVIDENCE APPROACH

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Abstract

Previous studies have indicated that the Tittabawassee River, located in central Michigan, USA, has elevated concentrations of polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-*p*-dioxins (PCDDs) in the sediments, floodplain soils, and biota downstream of the city of Midland. A multiple lines of evidence approach was utilized in order to evaluate the ecological risk of PCDD/DFs to American robins (*Turdus migratorius*) nesting in the floodplain. American robin tissues including eggs, nestlings and adults were collected from upstream reference and downstream study locations in order to assess receptor tissue PCDD/DF concentrations during the 2005-2008 breeding seasons. Concentrations of the seventeen 2,3,7,8 substituted PCDD/DFs were quantified in American robin and dietary item tissues and normalized to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin using WHO 1998 avian toxic equivalency factors (TEFs). Concentrations of TEQs in American robin eggs ranged from 1.0 ng/kg wet weight (ww) in the reference area to 1.7 x 10³ ng/kg ww in the study area. Terrestrial invertebrates were collected during the spring and summer of 2004- 2006 in order to evaluate site-specific PCDD/DF exposure via dietary intake utilizing literature-based dietary compositions. Resulting potential average daily dose estimates for adult robins in reference locations for the summer dietary composition were more than 100-fold less than upper-end estimates for study area locations for the spring dietary composition. In addition to dietary- and tissue-based assessments, a total of 215 nests were monitored for reproductive endpoints including hatch success, fledge success and nest success. Adjusted mean (±SD) hatch success ranged from 74±26% in study areas (n=51) to 93±14% in reference areas (n=25). Findings from each line of evidence will be compared to determine the overall risk to American robins nesting within the Tittabawassee River floodplain

Introduction

- o In the early to mid-1900s, dibenzofurans, dioxins and other environmental contaminant were input into the Tittabawassee River near Midland, MI, USA.
- o Mean soil PCDD/DF concentrations in soils and sediments downstream of Midland, MI were 10- to 20-fold greater than those collected at an upstream reference location [1].
- o The American robin is a useful receptor for the ecological risk assessment of study areas contaminated with bioaccumulative contaminants of concern [2].
- o American robins are an ideal representative of the soil, plant and invertebrate food web as they have an intimate relationship with soil as a nest building material and soil ingesting invertebrates as dietary components.
- o American robins are common and have a widespread nesting distribution making data collection and sampling realistic.

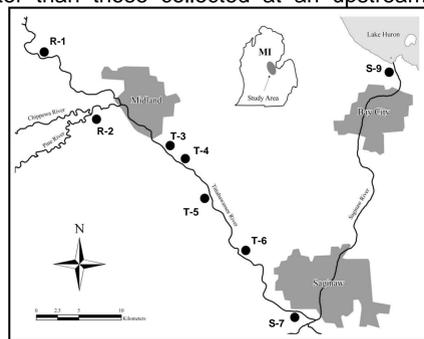


Figure 1. Map of sampling locations in the Tittabawassee River floodplain in Michigan, USA.

Methods

- o American robin productivity endpoints were measured from 2005-08 from nests located within the floodplains of target and reference areas.
- o Nests were visited approximately every third day to record productivity variables.
- o Predicted average daily dietary dose was estimated using a re-sampling approach in R with literature based dietary compositions and site-specific dietary item TEQs [3], [4] and [5].
- o American robin tissues were collected during 2005-08 from nests and breeding territories located within the floodplains of target and reference areas.
- o Fresh egg samples were collected randomly prior to or during incubation while addled egg samples were collected opportunistically following hatch date or nest failure.
- o Nestling samples were collected approximately 12 d following hatch date and were homogenized following removal of feathers, bill and legs below the tibiotarsus.
- o Soil samples and dietary samples were collected from the Tittabawassee River floodplain during 2003-06.
- o Concentrations of TEQs in soil are expressed as ng/kg on a dry weight basis and ng/kg wet weight for tissues.
- o Analyses of the seventeen 2,3,7,8 substituted PCDD/DF congener concentrations in samples were conducted at AssureQuality Limited (Lower Hutt, New Zealand) using EPA method 8290.
- o All TEQ values are based on avian World Health Organization toxicity equivalency factors [6].
- o TEQ concentrations are calculated by assigning a proxy value of ½ the detection limit (DL) for congeners below the DL.
- o Chemical extraction EPA methods 3540C and 3541 were utilized.

Results

Dietary Exposure

- o Diet is assumed to comprise 7% plant material, 18% earthworms, 25% Coleoptera, 25% Lepidoptera, 25% miscellaneous insects and spiders (Orthoptera, Hemiptera, Homoptera, and Araneae), based on proportion of mass in the diet.
- o Dietary items (n=153) were collected and analyzed for ΣPCDD/DFs.

Table 1. Potential average daily dose TEQ_{WHO-Avian}^a daily dose (ADD_{pot}; ng/kg body weight/d) calculated from site-specific food web-based dietary exposure for adult American robins breeding during 2004-2006 within the river floodplains near Midland, Michigan, USA.

	R-1 and R-2 ^b	T-3 to T-6	S-7 and S-9
50th Centile	1.9 ^{c,d}	270	89
95th Centile	5.1	590	200
Max	6.3	880	290

^a TEQ_{WHO-Avian} were calculated based on the 1998 avian WHO TEF values

^b R-1 to R-2 = Tittabawassee and Chippewa rivers reference area; T-3 to T-6 = Tittabawassee River study area; S-7 to S-9 = Saginaw River study area

^c Values were rounded and represent only two significant figures

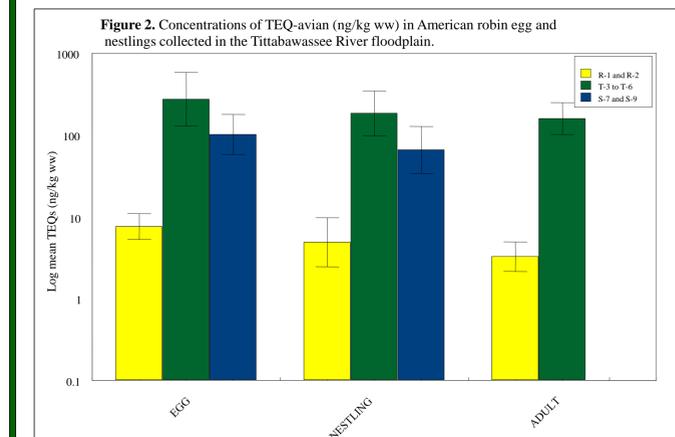
^d Food ingestion rate calculated from equations from US EPA, 1993 [7]

Results

- o Potential average daily dose exposures were compared to toxicity reference values (TRVs) derived from Nosek [8].
 - o Diet NOAEC: 14 ng TEQ/kg bw/day
 - o Diet LOAEC: 140 ng TEQ/kg bw/day
- o T-3 to T-6 study area potential average daily dose based on the 50th centile was 140-fold greater than that of the reference area.

Tissue Exposure

- o A total of 84 fresh and addled eggs, 53 14-day old nestlings and 12 adult American robins were collected and analyzed for ΣPCDD/DFs.



- o PCDD/DF TEQ concentrations in eggs were compared to TRVs derived from eastern bluebirds from Thiel [9].
 - o Egg NOAEC: 1,000 ng TEQ/kg
 - o Egg LOAEC: 10,000 ng TEQ/kg
- o Study area PCDD/DF TEQ concentrations were greater than those of the reference area .



Population Health

- o A total of 239 nests were monitored for productivity endpoints during 2005-2008.

Results

Table 2. Productivity measurements for all nesting attempts for American robins breeding in the river floodplains near Midland, Michigan during 2005-2008.

	R-1 and R-2		T-3 to T-6		S-7 and S-9	
	n	Mean (SD) ^a	n	Mean (SD)	n	Mean (SD)
Clutch Size	29	3.3 (0.8)	42	3.2 (0.81)	12	3.5 (0.67)
Hatching Success ^b	23	87% ^A (17%)	42	75% ^B (23%)	10	68% ^B (23%)
Adjusted Hatching Success ^c	23	93% ^A (14%)	42	81% ^B (23%)	12	74% ^B (26%)
Fledging Success ^c	23	74% (30%)	59	80% (27%)	10	79% (19%)
Adjusted Fledging Success ^c	23	93% (18%)	59	97% (11%)	10	100% (0%)
Number Fledged Per Nest	62	0.92 (1.3)	119	1.2 (1.4)	28	0.68 (1.0)
Adjusted Number Fledged Per Nest ^d	61	1.1 (1.5)	116	1.4 (1.5)	27	0.93 (1.4)
Productivity ^d	17	68% (29%)	33	61% (30%)	6	50% (16%)
Adjusted Productivity ^e	17	83% (20%)	33	72% (24%)	6	63% (26%)

^a Means with different uppercase letters were significantly different (P<0.05).

^b Hatch success is the number hatched divided by the number of eggs .

^c Fledge success is the number fledged divided by the number hatched.

^d Productivity is defined as the number fledged divided by the number of eggs laid.

^e Adjusted variables correct for sampled items from the numerator.

- o Productivity endpoints were similar between reference and study areas with the exception of hatch and adjusted hatch success which was 12 to 19% greater in reference areas.

Conclusions

- o Dietary and tissue based assessments were spatially consistent, noting the greatest sum TEQ-avian exposure in the Tittabawassee River study areas, lesser exposures further downstream in the Saginaw river floodplain and least exposures in the reference areas.
- o Study area dietary exposure exceeded TRVs, however, tissue exposure for eggs did not exceed TRVs.
- o Potential average daily dose was greater for American robins than eastern bluebirds, however, tissue concentrations were similar to those of eastern bluebirds from the reference and study areas (see platform 249).
- o Hatch and adjusted hatch success were greater in reference areas, however, all other productivity variables including number fledged and adjusted number fledged per nest were similar.

Literature Cited

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