

TISSUE-BASED ASSESSMENT OF PCDFs, PCDDs, AND PCBs IN GREAT BLUE HERON (*ARDEA HERODIAS*)



MICHIGAN STATE UNIVERSITY

National Food Safety and Toxicology Center

RESIDING IN THE TITTABAWASSEE RIVER FLOODPLAIN, MI, USA

Rita M. Seston[†], Matthew J. Zwiernik[†], Dustin L. Tazelaar[†], Timothy B. Fredricks[†], Sarah J. Coefield[†], Michael W. Nadeau[†], Patrick W. Bradley[†], Melissa S. Shotwell[§], Denise P. Kay[§], John P. Giesy^{††}

[†]Department of Zoology, Food Safety & Toxicology Center, Center for Integrative Toxicology, Michigan State University, East Lansing, MI 48824

[§]ENTRIX, Inc. East Lansing, MI

^{††}Department of Biomedical Veterinary Sciences & Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan



ENTRIX ENVIRONMENTAL CONSULTANTS

ABSTRACT

The great blue heron (GBH) was selected as a species of interest in an ecological risk assessment being performed on the Tittabawassee River, Michigan, USA. The trophic status of the GBH, along with its strong site fidelity and territoriality, make it an ideal species to investigate bioaccumulative contaminants, such as polychlorinated dibenzofurans (PCDFs), polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated biphenyls (PCBs). The study area, which includes 38 km of the river from the upstream boundary at the city of Midland, MI to the confluence of the Tittabawassee and Shiawassee Rivers, has previously been shown to contain elevated concentrations of PCDFs, PCDDs, and PCBs in soils, sediments, and biota. GBH tissues, including eggs and nestling tissues (liver, adipose, and muscle), were collected from three separate breeding colonies located in the study area. Concentrations of the seventeen 2,3,7,8-substituted PCDF/Ds, as well as the AHR-active PCB congeners (105, 114, 118, 123, 126, 156, 157, 167, 169, 189, 77, 81) were quantified in each tissue type and normalized to 2,3,7,8 dibenzo-p-dioxin using WHO_{AVIAN} TEFs. Total lipid normalized TEQs in GBH eggs collected from within the study area ranged from 8.4x10²-7.4x10³ ng/kg, lipid weight (lw) (n=13), with PCBs accounting for a mean of 78% of the total TEQs. In GBH nestling liver, adipose, and muscle (n=9), total TEQs ranged from 5.4x10²-1.6x10³ ng/kg, lw, 6.1x10²-1.8x10³ ng/kg, lw, 4.6x10²-1.6x10³ ng/kg, lw, respectively, with a majority of the total TEQs being attributable to PCBs, accounting for a mean of 87%, 85%, and 72% of the total TEQs, respectively. GBH eggs collected from breeding colonies located in British Columbia were found to contain greater concentrations of both total PCBs and PCDF/Ds, yet no adverse population level effects were observed.

INTRODUCTION

- Around the turn of the century, dibenzofurans, dioxins and other contaminants were discharged into the Tittabawassee River near Midland, MI.
- Mean PCDF/D concentrations in soils and sediments downstream of Midland, MI were 10- to 20-fold greater than those collected from an upstream reference area [1].
- Great blue heron (*Ardea herodias*) selected as a receptor species due to its presence on site, high trophic status, territoriality, and site fidelity.

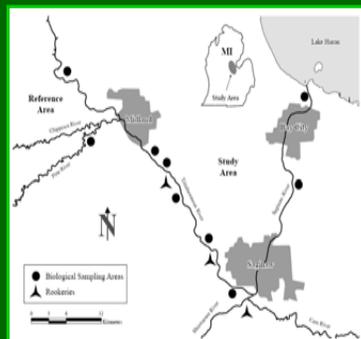


Figure 1. Map of research areas including reference and study areas in the Tittabawassee and Saginaw River floodplains. Dietary items were collected from biological sampling areas in the reference and study areas. GBH tissues were collected from rookeries located in the study area.

METHODS AND MATERIALS



- Forage fish, crayfish, and frogs were collected from nine predetermined biological sampling areas (BSAs), two in reference areas, five along the Tittabawassee River (TR) and two along the Saginaw River (SR) (Figure 1).
- Dietary items were collected between 2003 – 2006.
- GBH eggs and nestling tissues were collected from GBH rookeries in the study area during 2006 – 2007 (Figure 1).
- Liver, adipose, and muscle were harvested from nestlings which were opportunistically collected after nestlings fell from nests as a result of weather events or siblicide.
- Nestling plasma was collected by accessing nests when nestlings were approximately four to five weeks old.
- Analyses of the seventeen 2,3,7,8 substituted PCDF/D congener concentrations were conducted atASUREQuality Limited (Lower Hutt, New Zealand) using EPA method 8290.
- All TEQ values are based on avian World Health Organization TCDD equivalent factors [2]

RESULTS

- Dioxins and furans (DFs) account for 82%, 97%, and 98% of the total TEQs in fish, crayfish, and frogs, respectively, collected from TR (Table 1).
- Median DF-TEQs in dietary items collected from TR range from approximately 30 – 165 fold greater than those collected from the reference area (Table 1).
- Median DF-TEQs in dietary items collected from SR range from approximately 2 – 50 fold greater than those collected from the reference area and 3 – 14 fold less than those collected from TR (Table 1).
- Median PCB-TEQs in fish collected from TR and SR are approximately 20 fold and 60 fold greater respectively, than those collected from the reference area (Table 1).
- In GBH tissues, median DF-TEQs range from 140 to 560 ng/kg, lw (Table 2).
- Using a literature-derived dietary composition for GBH of 96% fish, 2% crayfish and 2% frog [3,4], DFs account for approximately 83% of the total TEQs in a diet from TR compared to 33% in a diet from SR (Figure 2).
- In the study area, PCBs account for 82%, 84%, 85%, 81%, and 56% of the total TEQs in GBH eggs, nestling liver, nestling adipose, nestling muscle, and nestling plasma, respectively (Figure 2).

Table 1. Dioxin (D), furan (F) and polychlorinated biphenyl (PCB) concentrations expressed as lipid-normalized TEQs_{WHO-avian} (ng/kg) in dietary items collected from the Tittabawassee River (TR) and Saginaw River (SR) study areas.

	Reference Area			TR			SR		
	n	Median	Range	n	Median	Range	n	Median	Range
Fish									
DF	2	20	18 - 21	7	3300	1700 - 10000	4	1000	840 – 2600
PCB	2	33	31 - 35	7	710	340 – 2500	4	2000	780 – 7500
Crayfish									
DF	5	77	27 - 290	15	8300	780 – 18000	8	1600	840 – 4200
PCB	0			3	270	250 – 330	0		
Frog									
DF	29	94	19 - 330	106	3000	79 - 97000	12	210	160 – 600
PCB	0			4	67	39 – 96	0		

Table 2. Dioxin (D), furan (F) and polychlorinated biphenyl (PCB) concentrations expressed as lipid-normalized TEQs_{WHO-avian} (ng/kg) in great blue heron (GBH) tissues collected from breeding colonies within the study area.

	n ^a	Median	Range
GBH Egg			
DF	18	560	350 – 2500
PCB	18	2600	410 – 5900
GBH Nestling Liver^b			
DF	4	140	57 – 220
PCB	4	720	550 – 1300
GBH Nestling Adipose^b			
DF	4	190	96 – 370
PCB	4	1100	560 – 1600
GBH Nestling Muscle^b			
DF	4	180	100 – 280
PCB	4	790	400 – 1400
GBH Nestling Plasma^b			
DF	8	490	83 – 1100
PCB	8	630	350 – 4700

^aSample size represents the number of sampled nests.

^bNest mean was used for nests from which more than one individual was sampled.

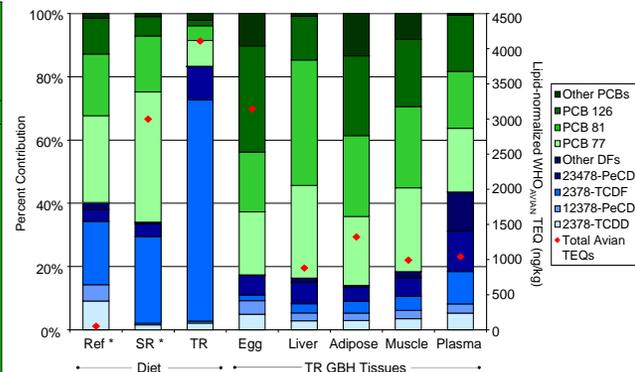


Figure 2. Percent contribution of the seventeen 2,3,7,8-substituted PCDF/D and twelve dioxin-like PCBs to total TEQs in the diet and great blue heron (GBH) tissues. Dietary items collected from reference areas (Ref), Tittabawassee River (TR), and Saginaw River (SR). GBH tissues collected from rookeries located within the study area. Each diet profile represents a composite of 96% fish, 2% crayfish, and 2% frog sampled from designated sampling area. Each GBH tissue profile represents the median of all individuals analyzed. Based on lipid-normalized WHO_{AVIAN} TEQ (ng/kg)(1/2 DL). *Contribution of PCBs based only on fish.

DISCUSSION

- It was initially thought that GBH would be receiving a majority of their diet from the Tittabawassee River and its floodplain. Although the same six congeners are dominant in the Tittabawassee River based diet and GBH tissues, their relative proportions shift significantly (Figure 2). This shift could be due to:
 - GBH foraging in a combination of the reference or off-site areas, Tittabawassee River, and Saginaw River.
 - GBH foraging in the Tittabawassee River are consuming fish species that originated upstream or downstream of the study site.
- GBH nesting along the Tittabawassee River have total TEQs similar to those in GBH nesting in reference colonies in British Columbia [5].

CONCLUSIONS

- PCBs constitute a majority of the total TEQs for GBH nesting along the Tittabawassee River while the congener profiles of dietary items collected on-site would suggest furans are of greatest concern.
- Both the nature and extent of PCBs in GBH tissues suggests that GBH breeding within the study area are consuming fish that originate in a combination of the reference area and the Tittabawassee and Saginaw Rivers.
- Although GBH nesting along the Tittabawassee River are being exposed to dioxin-like compounds, their concentrations appear to be near background levels.
- Future work will investigate biomagnification factors of individual congeners to try to determine the proportion of the diet coming from each river system.

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