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Parental Transfer of Organic Contaminants to Young-of-the-Year Spottail Shiners, *Notropis hudsonius*

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Young-of-the-year (YOY) spottail shiners (Notropis hudsonius) have been recommended for measuring trends of contaminants at specific nearshore areas in the Great Lakes (International Joint Commission 1986). They were chosen as biological indicators because of their common availability in tributaries and nearshore areas of the lakes and because it is assumed that the residues in these relatively sedentary fish represent localized conditions of contamination (Suns et al. 1985). However, a portion of the contaminant burden in YOY could be acquired from the parent by deposition in the egg. Consequently, residues measured in YOY may not represent local exposure conditions; rather, their concentrations may be influenced significantly by the exposure history of the adult fish which have a much greater range than the YOY (Becker 1983). We conducted this study to determine what percentage of the contaminant burden in YOY spottail shiners could be attributable to parental transfer.

MATERIALS AND METHODS

Two nearshore areas in the Great Lakes were selected for sampling because of their past history of contamination and abundance of spottail shiners. One site was on the southeastern shore of Lake Michigan near Port Sheldon, Michigan (42°55'N, 85°51'W), and the other was in the Saginaw Bay region of Lake Huron near the mouth of the Saginaw River (43°40'N, 83°50'W). Adult spottail shiners were collected in May and June 1985 by trawling and seining. YOY were collected from late August to early October of the same year by seining. A total of 36 gravid adult female spottail shiners (28 from Lake Michigan and 8 from Saginaw Bay) and 144 YOY (105 and 39 from the respective sites) were collected. All samples were frozen immediately after collection.

Adult spottail shiners were dissected to determine their sex and to remove gonads from gravid females. Gonads from 29 females were microscopically examined to determine egg diameter. Due to their small size and weight (0.5 to 2.8 g), gonads from four females were combined to form each composite sample for analysis. The

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corresponding bodies were similarly composited. The YOY spottail shiners from each site were weighed, measured, and composited into size groups by length. All composite samples were thoroughly homogenized before contaminant analysis.

We extracted organic contaminants (PCB, Σ DDT (*p,p'*DDE + *p,p'*DDD + *p,p'*DDT) and dieldrin) from homogenized samples of spottail shiner gonad and body and samples of YOY, using a Goldfisch fat/oil extractor. A 5-g portion of wet tissue was mixed with 20 g Na_2SO_4 until dry, then poured into a glass tube (10 cm x 2.8 cm i.d.) with a glass-wool plug in the bottom and extracted with 45 ml petroleum ether for 24 hr. A subsample of the extract was air-dried and weighed to determine lipid content. Gel permeation chromatography was used to remove lipid from the extracted contaminants (Hesselberg et al. 1990). We fractionated PCB and *p,p'*DDE from the other contaminants by silica gel column chromatography (Seelye et al. 1982). Both fractions were analyzed on a Varian[1] 3700 gas-liquid chromatograph (GC) equipped with an electron capture detector and a 2-mm i.d. glass column packed with 2% SE-30 and 3% OV-210 on Chromsorb W 80/100. The operating conditions were as follows: detector (320°C), injector (220°C), column (190°C), and carrier gas (30 ml nitrogen/min). Chromatographic output was collected and processed on an IBM PC-AT using Nelson Analytical chromatography software.

We quantified PCBs on the basis of total peak area, using four concentrations of a 1:1:1 mixture of Aroclors 1248, 1254, and 1260. Four concentrations of a mixed pesticide standard containing the above-mentioned compounds were used to identify and quantify pesticides in samples. Analytical precision and accuracy were maintained by routinely analyzing samples with well-established contaminant concentrations (check samples) and blanks. The average recovery of contaminants from check samples containing 239 ng/g PCB, 139 ng/g Σ DDT and 32 ng/g dieldrin, ranged from 85 to 88%.

The parental contribution of contaminants to YOY spottail shiners was estimated by using equation 1:

$$\text{Parental contribution (\%)} = \frac{\text{Contaminant burden of the egg (ng)}}{\text{Contaminant burden of the YOY (ng)}} \qquad (1)$$

where

$$\text{Contaminant burden of the egg (ng)} = \text{Contaminant concentration in the gonad (ng/g)} * \text{Egg weight (g)}$$

[1] Use of trade names does not imply U.S. Government endorsement of commercial products.

Microscopic examination of the gonads revealed that most of the eggs (>90%) ranged from 0.7 to 1 mm with a small percentage of less developed eggs (0.4 mm). To estimate egg weight, we used the egg diameter of the largest and presumably most mature eggs (1 mm) and a specific gravity (SG) of 1:

$$\text{Egg weight} = 4/3\pi r^3 * SG = 0.523 \text{ mg}$$

where: r = Egg radius (0.5 mm)

Because adult and YOY spottail shiners were collected from the same location, we assumed that contaminant concentrations measured in the gonads were representative of the concentrations in the eggs from which the YOY hatched.

RESULTS AND DISCUSSION

We detected PCBs, Σ DDT and dieldrin in adult and YOY spottail shiners from both collection sites (Table 1). The PCB concentrations in YOY were considerably higher in Saginaw Bay than in Lake Michigan, even though concentrations in the adults were similar. The mean PCB concentration in Saginaw Bay YOY (777 ng/g) was comparable to levels reported for other Great Lakes areas that are considered to be heavily contaminated with PCBs (Suns et al. 1985). Concentrations of Σ DDT and dieldrin in spottail shiners were higher in Lake Michigan than in Saginaw Bay.

Table 1. Mean concentrations (ng/g wet weight; SE in parentheses) of PCB, Σ DDT (*p,p'*DDE + *p,p'*DDD + *p,p'*DDT) and dieldrin in composite samples of adult female spottail shiner bodies and gonads and YOY collected in 1985 from Lake Michigan and Saginaw Bay.

Sample	N	Lipid (%)	PCB	Σ DDT	Dieldrin
			Lake Michigan		
Body	5	3.2 (0.3)	1222 (83)	384 (29)	43 (5)
Gonad	5	2.0 (0.3)	915 (56)	273 (20)	36 (1)
YOY	6	3.1 (0.9)	163 (55)	53 (9)	21 (4)
			Saginaw Bay		
Body	2	2.4 (0.03)	1197 (83)	133 (4)	18 (2)
Gonad	2	2.9 (1.0)	1054 (183)	118 (11)	24 (1)
YOY	7	1.2 (0.2)	777 (156)	41 (6)	1 (1)

Parental transfer accounted for only a small percentage of the contaminant burden in YOY spottail shiners (Table 2). Evidently, YOY obtained most of their contaminant burden from the environment by accumulation from either the water or food. Contaminants transferred to YOY from the parents (by way of the egg) are greatly diluted because of the small size of the eggs and rapid growth after hatching of larvae and YOY. Spottail shiners spawn in the Great Lakes during spring and early summer (Scott and Crossman 1979); by September, YOY have grown to a weight 2000 to 5000 times that of a spottail shiner egg. In contrast, lake trout (Salvelinus namaycush) produce large eggs (about 0.1 g) and by fall, larval lake trout weigh only 16 to 32 times the weight of the eggs (Eschmeyer 1956). As a result, a high percentage of the contaminant burden (PCB) in larval lake trout is derived from the egg (Mac and Seelye 1981), whereas, parental contribution accounted for <1% of the residues in all but the smallest spottail shiner YOY (2-10%).

Table 2. Parental contribution of PCB, Σ DDT (*p,p'*DDE + *p,p'*DDD + *p,p'*DDT) and dieldrin in YOY spottail shiners. Values for each contaminant are body burden of the YOY (ng contaminant per YOY), body burden of the eggs (ng contaminant per egg), and the parental contribution (PC) measured as the percentage of the YOY burden represented by the egg burden.

Mean length of YOY (mm)	N[a]	PCB Body burden (ng)	PCB PC (%)	Σ DDT Body burden (ng)	Σ DDT PC (%)	Dieldrin Body burden (ng)	Dieldrin PC[b] (%)
Lake Michigan							
29	32	5	9.6	3	4.7	2	0.9
31	27	12	4.0	4	3.5	3	0.6
34	22	23	2.1	9	1.5	6	0.3
36	17	43	1.1	13	1.1	9	0.2
56	4	460	0.1	107	0.1	22	0.1
70	3	1024	<0.05	230	0.1	96	<0.05
EGGS		0.48		0.14		0.018	
Saginaw Bay							
45	9	999	0.1	42	0.1	<1	ND
51	8	1435	<0.05	72	0.1	6	0.2
54	6	675	0.1	47	0.1	3	0.4
59	6	835	0.1	63	0.1	3	0.4
61	4	1211	<0.05	41	0.1	<1	ND
65	4	983	0.1	53	0.1	<1	ND
74	2	1961	<0.05	117	0.1	<1	ND
EGGS		0.55		0.061		0.012	

[a]Number of YOY spottail shiners in each composite sample.
[b]ND - not determined because the concentration in YOY was below detection limit (0.1 ng/g).

The contribution of parentally derived contaminants is inversely related to YOY size and contaminant concentration and positively related to the contaminant concentration in the gonads (egg). For conditions where small YOY have low contaminant levels, but adult spottail shiners from the same area are highly contaminated, the parental contribution of contaminants to YOY could be relatively large. In areas such as Saginaw Bay where large YOY were highly contaminated relative to the adults, parental contribution would be negligible.

Our method of calculating parental contribution was based on assumptions which may have biased these estimates. By using the contaminant concentration of whole gonads to approximate concentrations within individual eggs we may have nominally underestimated parental contribution because the gonads contained eggs of different sizes and possibly different contaminant burdens. However, we also assumed that the entire contaminant burden of the egg was retained by the YOY and did not account for any elimination of contaminants during that period. Therefore, our results represent maximum estimates of parental contribution.

This study shows that YOY spottail shiners are suitable biomonitors. Selecting large YOY (>50 mm) for monitoring contaminant trends in Great Lakes nearshore areas would insure minimal contribution of parentally derived contaminants to YOY.

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