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TOXICANTS IN SNAPPING TURTLES[1]

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ABSTRACT

Selected tissues from 32 snapping turtles from New York waters were analyzed for organochlorine contaminants. High levels of organochlorines, especially PCB's, were found in the fat (e.g., a mean of 2,990.60 ppm for the specimens from the Hudson River). Snapping turtles from the Hudson River and some other localities in the State seem unsuitable for human consumption because of contamination of their tissues with persistent pollutants. It is suggested that the snapping turtle would make a useful addition to the species used for monitoring, and finding, cumulative toxicants.

The snapping turtle (*Chelydra serpentina*) is a common, large, omnivorous, aggressive, freshwater chelonian that has a wide distribution in the eastern United States (Carr, 1952; Ernst and Barbour, 1972). Since snapping turtles are relatively sedentary (Hammer, 1969) and long-lived, it was hypothesized that they would be an excellent species for monitoring pollutants in aquatic ecosystems. In addition, since their skeletal muscle, liver and eggs are used for human food (Rombauer and Becker, 1931; Seagears, 1949; Angier, 1970; Herity, 1978), it appeared important to examine selected tissues (especially from specimens from the heavily PCB-polluted Hudson River) for levels of organochlorine contaminants.

MATERIALS AND METHODS

Thirty-two snapping turtles were captured from various waters in New York (23 from the Hudson River and nine from other localities) and submitted to the Wildlife Pathology Unit of the State Department of Environmental Conservation. The turtles were weighed and then killed by freezing or decapitation, after which the plastron was removed. Notes were made on the general condition of the carcass and the distribution of body fat. Samples of selected tissues (fat, liver, skeletal muscle and eggs) were placed in chemically clean containers, frozen and sent in that condition to Raltech Scientific Services, Inc. at Madison (Wis.) or to the Department's Pollution Laboratory at Rome (N.Y.) where the levels of several organochlorine compounds were determined by gas chromatography (U.S. Food and Drug Administration, 1968; Heath and Hill, 1974), and cad

[1]The authors acknowledge the assistance of Dr. James Powers in statistical analyses, and David Seymour in obtaining turtles from the Hudson River.

mium and mercury concentrations by atomic absorption spectrophotometry. The analyses of fat samples were made on a fat basis; all other data represent wet weight.

In addition to the tissues themselves, turtle soup was made from two specimens. One was a turtle taken July 20, 1978 from the Hudson River 8 miles below Ford Edward, and the other was one taken July 31, 1978 from White Creek in Washington County. Both had high concentrations of PCB's in their fat. Liver and skeletal muscle were used primarily for the turtle from White Creek a special effort was made to discount as much of the fat as possible from the muscle tissue. The soups were prepared according to the recipe of Seagears (1949).

Because of the relatively small samples and apparent differences in variability for the several tissues examined, *F* tests were first performed for appropriate comparisons, and then the *t* test (Steele and Torrie 1960, p. 81) was used to compare differences between the resultant mean values.

RESULTS

The tissues examined comprised fat samples from 20 turtles, liver samples from 31 specimens, skeletal muscle samples from 29 specimens and eggs from six specimens. The levels of polychlorinated biphenyls (PCB's), the DDT metabolite DDE, and the insecticide Dieldrin in these tissues are summarized in Tables 1 to 4. All samples[2] had detectable levels of PCB's, the highest being in the fat of turtles from the Hudson River (mean 2,990.60 ppm), while concentrations in the fat of nine specimens from other localities averaged 464.16 ppm. Ten (58.8 per cent) of the 17 fat samples that were tested for Dieldrin had high concentrations (> 0.3 ppm), and five (31.2 per cent) of the 16 tested for DDE had concentrations greater than 5 ppm. A male turtle from Irondequoit Bay on Lake Ontario that weighed 16.4 kilograms had residue levels (ppm) in its fat as follows: PCB's, 666.0; DDE, 81.3; Dieldrin, 34.1; hexachlorobenzene, 0.1; heptachlor epoxide, 19.7; and Mirex, 19.7.

Concentrations of PCB's in 22 liver samples from turtles from the Hudson River averaged 66.05 ppm, and eight livers from turtles from other waters had a mean of 7.77 ppm. Concentrations of DDE and Dieldrin were generally low in the livers, but there were occasional exceptions (Table 2). The liver of the male turtle from Irondequoit Bay already mentioned had residue levels (ppm) as follows: PCB's, 27.8; DDE, 3.58; Dieldrin, 0.99; hexachlorobenzene, 0.24; heptachlor epoxide, 0.85; Mirex, 0.1; and mercury, 2.72.

In contrast, skeletal muscle from 22 samples from turtles from the Hudson River averaged 4.24 ppm for PCB's with five of them (22.7 per cent)

[2] The samples examined totalled 83 because the tissues (except eggs) for two turtles from the Hudson River were pooled.

TABLE 1. TOXICANTS IN SAMPLES OF FAT TISSUE FROM SNAPPING TURTLES FROM VARIOUS LOCALITIES IN NEW YORK

Locality	Date	Sex	Gross weight (kilograms)	Toxicant*		
				PCB's	DDE	Dieldrin
	Hudson River					
North Bay (near Tivoli)	June 14, 1976	Female	4.2	306	< 5.00	< 0.20
North Bay (near Tivoli)	June 14, 1976	Male	2.0	§	§	§
Constitution Island Marsh	May 19, 1977	Male	4.6	4,319	57.50	8.80
Piermont Marsh	May 26, 1977	Male	1.5	628	n.d.	1.50
North Bay (near Tivoli)	June 13, 1977	Male	10.2	1,698	n.d.	0.50
Vanderburgh Cove (near Staatsburg)	June 13, 1977	Male	15.4	7,990	n.d.	26.50
Vanderburgh Cove (near Staatsburg)	June 15, 1977	Male	15.6	5,412	n.d.	12.80
Suckley Cove (near Staatsburg)	June 21, 1977	Female	5.5	1,123	.	17.00
North Bay (near Hudson)	June 22, 1977	Male	4.5	339	15.30	0.33
6 miles below Fort Edward	July 20, 1978	Male	9.1	7,456	..	..
6 miles below Fort Edward	July 20, 1978	Male	2.7	842	..	..
Mean			6.51	2,990.60	<11.11	< 8.45
	Other waters					
Otselic River (near Cincinnatus)	May 2, 1977	Female	2.3	99.9	0.14	n.d.
Spring Lakes (Dutchess Co.)	June 23, 1977	Female	2.9	44.4	1.4	n.d.
Black Pond (near Ellisburg, Jefferson Co.)	June 12, 1978	Female	2.9	335	3.40	1.60
Black Pond (near Ellisburg, Jefferson Co.)	June 12, 1978	Female	2.7	410	8.40	2.40
St. Lawrence River (near Morristown)	June 12, 1978	Female	2.4	310	8.80	n.d.
White Creek (Washington Co.)	July 31, 1978	Male	3.4	2,281	n.d.	n.d.
Black Creek Marsh (near Guilderland, Albany Co.)	September 13, 1978	Male	9.1	30.8	0.06	0.06
Black Creek Marsh (near Guilderland, Albany Co.)	September 13, 1978	Male	8.2	0.36	0.02	n.d.
Ironsides Bay (Lake Ontario)	September 20, 1978	Male	16.4	666	81.30	34.10
Mean			5.50	404.16	15.50	4.21

*Data in parts per million fat basis; n.d. = substance tested for but not detectable.
§ Tissue samples from this specimen pooled with those from preceding specimen.

TABLE 2. TOXICANTS IN SAMPLES OF LIVER TISSUE FROM SNAPPING TURTLES FROM VARIOUS LOCALITIES IN NEW YORK

Locality	Date	Sex	Gross weight (kilograms)	Toxicant*		
				PCB's	DDE	Dieldrin
Hudson River						
North Bay (near Tivoli)	June 14, 1976	Female	4.2	10.60	[illegible]	[illegible]
North Bay (near Tivoli)	June 14, 1976	Male	2.0	§	§	§
Constitution Island Marsh	June 15, 1976	Female	3.8	6.95	0.91	n.d.
Constitution Island Marsh	June 15, 1976	Female	4.6	11.50	<0.05	0.026
Constitution Island Marsh	May 19, 1977	Male	8.6	45.80	0.63	0.16
Constitution Island Marsh	May 19, 1977	Male	1.0	9.42	..	..
Piermont Marsh	May 26, 1977	Male	1.5	1.79	0.09	..
Piermont Marsh	May 26, 1977	Female	3.8	3.13	0.05	0.017
North Bay (near Tivoli)	June 13, 1977	Male	10.2	0.54	n.d.	0.038
Vanderburgh Cove (near Staatsburg)	June 13, 1977	Male	15.4	103.00	..	..
North Bay (near Tivoli)	June 14, 1977	Female	3.9	21.32	0.35	..
Kingston Point	June 15, 1977	Female	9.1	107.00	..	..
Kingston Point	June 15, 1977	Female	5.4	73.90	..	..
Vanderburgh Cove (near Staatsburg)	June 15, 1977	Male	13.6	174.00	..	..
Iona Island Marsh	June 20, 1977	Male	5.3	91.71	2.11	..
Iona Island Marsh	June 20, 1977	Male	0.4	4.65	0.01	..
Iona Island Marsh	June 20, 1977	Male	2.2	1.79	0.04	..
Iona Island Marsh	June 20, 1977	Male	0.9	2.00	0.01	..
Suckley Cove (near Staatsburg)	June 21, 1977	Female	5.5	45.42	0.99	..
North Bay (near Hudson)	June 22, 1977	Male	4.8	2.50	0.17	..
8 miles below Fort Edward	July 20, 1978	Male	9.1	685.00	17.40	0.086
8 miles below Fort Edward	July 20, 1978	Male	2.7	9.21	n.d.	n.d.
8 miles below Fort Edward	July 31, 1978	Male	2.7	21.80	0.71	n.d.
Mean			5.16	66.05	<1.59	0.038
Other waters						
Spring Lakes (Dutchess Co.)	June 23, 1977	Female	2.9	0.48	..	..
Black Pond (near Ellisburg, Jefferson Co.)	June 12, 1978	Female	2.9	3.30	0.038	0.03
Black Pond (near Ellisburg, Jefferson Co.)	June 12, 1978	Female	2.7	7.40	0.049	0.07
St. Lawrence River (near Morristown)	June 12, 1978	Female	2.4	21.40	0.77	0.08
White Creek (Washington Co.)	July [illegible], 1978	Male	3.4	[illegible]	0.01	n.d.
Black Creek Marsh (near Guilderland, Albany Co.)	September 13, 1978	Male	9.1	0.29	n.d.	n.d.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Irondequoit Bay (Lake Ontario)	September 20, 1978	Male	16.1	27.80	4.58	0.99

Other waters						
Spring Lakes (Dutchess Co.)	June 23, 1977	Female	2.9	0.48	. .	. .
Black Pond (near Ellisburg, Jefferson Co.)	June 12, 1978	Female	2.9	3.30	0.038	0.03
Black Pond (near Ellisburg, Jefferson Co.)	June 12, 1978	Female	2.7	7.40	0.049	0.07
St. Lawrence River (near Morristown)	June 12, 1978	Female	2.4	21.40	0.77	0.08
White Creek (Washington [illegible]	July 31, 1978	Male	[illegible]	1.39	0.01	n.d
[illegible]	September 15, 1978	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Black Creek Marsh (near Guilderland, Albany Co.)	September 15, 1978	Male	8.2	0.10	n.d.	n.d.
Irondequoit Bay (Lake Ontario)	September 20, 1978	Male	16.4	27.80	3.58	0.99
Mean			6.0	7.77	0.64	0.17

*Data in ppm on wet weight basis: n.d. indicates substance was tested for but not detectable.
§Tissue samples from this specimen pooled with those from preceding specimen.

TABLE 3. TOXICANTS IN SAMPLES OF SKELETAL MUSCLE TISSUE FROM SNAPPING TURTLES FROM VARIOUS LOCALITIES IN NEW YORK

Locality	Date	Sex	Gross weight (kilograms)	Toxicant* PCBs	DDE	Dieldrin
Hudson River						
North Bay (near Tivoli)	June 14, 1976	Female	4.2	11.40	< 0.5	0.019
North Bay (near Tivoli)	June 14, 1976	Male	2.0	§	§	§
Constitution Island Marsh	June 15, 1976	Female	3.8	0.67	0.015	. .
Constitution Island Marsh	June 15, 1976	Female	4.6	1.63	< 0.05	n.d.
Constitution Island Marsh	May 19, 1977	Male	8.6	3.45	n.d.	0.01
Constitution Island Marsh	May 19, 1977	Male	1.0	0.31	n.d.	n.d.
Piermont Marsh	May 26, 1977	Male	1.5	0.20	0.01	. .
Piermont Marsh	May 26, 1977	Female	3.8	0.47	0.01	n.d.
North Bay (near Tivoli)	June 13, 1977	Male	10.2	1.67	n.d.	0.01
Vanderburgh Cove (near Staatsburg)	June 13, 1977	Male	15.4	15.70	. .	. .
North Bay (near Tivoli)	June 14, 1977	Female	3.9	0.69	0.01	. .
Kingston Point	June 15, 1977	Male	9.1	1.53	. .	. .
Kingston Point	June 15, 1977	Female	5.4	1.02	. .	. .
Vanderburgh Cove (near Staatsburg)	June 15, 1977	Male	13.6	5.27	. .	. .
Iona Island Marsh	June 20, 1977	Male	5.3	2.07	0.05	. .
Iona Island Marsh	June 20, 1977	Male	0.4	0.52	n.d.	. .
Iona Island Marsh	June 20, 1977	Male	2.2	0.19	n.d.	. .
Iona Island Marsh	June 20, 1977	Male	0.9	0.26	< 0.01	. .
Suckley Cove (near Staatsburg)	June 21, 1977	Female	3.5	27.62	0.74	. .
North Bay (near Hudson)	June 22, 1977	Male	4.8	0.26	< 0.01	. .
8 miles below Ford Edward	July 20, 1978	Male	9.1	11.40	0.26	n.d.
8 miles below Fort Edward	July 20, 1978	Male	2.7	3.03	n.d.	0.034
8 miles below Fort Edward	July 31, 1978	Male	2.7	2.50	n.d.	n.d.
Mean			5.16	4.24	0.093	0.008
Other waters						
Spring Lakes (Dutchess Co.)	June 23, 1977	Female	2.9	0.28	. .	. .
Black Pond (near Ellisburg, Jefferson Co.)	June [illegible], 1978	Female	2.9	0.39	< 0.010	0.01
[illegible]	June 12, 1978	Female	[illegible]	[illegible]	[illegible]	< 0.01
[illegible] Ellisburg, Jefferson Co.)	[illegible]	[illegible]	[illegible]	0.34	0.015	< 0.01
St. Lawrence River [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
White Creek (Washington Co.)	July [illegible]	Male	16.1	[illegible]	[illegible]	[illegible]

Other waters						
		Female	2.9	0.28	...	...
Spring Lakes (Dutchess Co.)	June 23, 1977	Female	2.9	0.39	< 0.010	0.01
Black Pond (near Ellisburg, Jefferson Co.)	June 12, 1978	Female	2.7	0.81	0.025	< 0.01
Black Pond (near Ellisburg, Jefferson Co.)	June 12, 1978	Female	[illegible]	0.34	0.018	< 0.01
St. Lawrence River [illegible]		Male	[illegible]			
White Creek (Washington Co.)	July 31, 1976	Male	16.4	0.36	0.023	0.16
Irondequoit Bay (Lake Ontario)	September 20, 1978					
Mean			5.12	0.44	<0.023	< 0.038

*Data in ppm on wet weight basis; n.d. indicates substance was tested for but not detectable.

§Tissue samples from this specimen pooled with those from preceding specimen.

[illegible]	July 20, 1978	Male	9.1	11.10	0.29	n.d.
[illegible]	[illegible]	[illegible]	[illegible]	3.03	n.d.	n.d.
6 miles below Lor[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mean			5.16	4.24	0.093	0.008

Spring Lakes (Dutchess Co.)	June 23, 1977	Female	[illegible]	[illegible]	[illegible]	[illegible]
Black Pond (near Ellisburg, Jefferson Co.)	June 12, 1978	Female	2.9	0.39	< 0.010	0.01
Black Pond (near Ellisburg, Jefferson Co.)	June 12, 1978	Female	2.7	0.81	0.025	< 0.01
St. Lawrence River (near Morristown)	June 12, 1978	Female	2.4	0.34	0.013	< 0.01
White Creek (Washington Co.)	July 31, 1978	Male	3.4	0.48	0.042	n.d.
Irondequoit Bay (Lake Ontario)	September 20, 1978	Male	16.4	0.36	0.023	0.16
Mean			5.12	0.44	<0.025	< 0.038

*Data in ppm on wet weight basis; n.d. indicates substance was tested for but not detectable.
§Tissue samples from this specimen pooled with those from preceding specimen.

TABLE 4. TOXICANTS IN EGGS OF SNAPPING TURTLES FROM THE HUDSON RIVER

Locality	Date	Gross weight* (kilograms)	Toxicants§		
			PCB's	DDE	Dieldrin
North Bay (near Tivoli)	June 14, 1976	4.2	17.9	< 0.05	0.022
Constitution Island Marsh	June 15, 1976	3.8	42.9	< 0.05	0.049
Constitution Island Marsh	June 15, 1976	4.6	15.7	0.36	< 0.050
Piermont Marsh	May 26, 1977	3.9	10.4	0.055	0.018
North Bay (near Tivoli)	June 14, 1977	3.9	20.9	..	0.015
Suckley Cove (near Staatsburg)	June 21, 1977	3.5	32.7	..	0.055
Mean		3.97	28.9	< 0.18	< 0.035

*Of parent female.
§Data in ppm.

exceeding 5 ppm. Such tissues from six turtles from other localities averaged 0.14 ppm. The levels of DDE and Dieldrin in skeletal muscle were all quite low.

All six egg samples were from turtles from the Hudson River and had considerable concentrations (> 5.0 ppm) of PCB's (mean = 28.9 ppm). Levels of DDE and Dieldrin were low.

Tests for statistical differences between turtles from the Hudson River and those from other localities, with respect to mean concentrations of PCB's in the fat, liver and skeletal muscle, are summarized in Tables 5 and 6. Both the *F* and *t* tests indicated that there were significant differences, for the tissues analyzed, between the two areas.

The soup made from the turtle from the Hudson River yielded 230 ppm of PCB's, while that from the one from White Creek yielded 0.091 ppm. A single bowl of the former (250 milliliters = 270 grams) would contain a dose of 62.1 milligrams of PCB's. The tissues analyzed for the turtle from the Hudson River showed PCB levels of 7,258 in its fat, 683 ppm in its liver and 11.4 ppm in its skeletal muscle. The corresponding values for the other turtle were 2.281, 1.4 and 0.5 ppm, respectively. Despite the fact that the turtle from White Creek had lower amounts of PCB's in its tissues than the one from the Hudson River, removing the fat from the portions used in preparing the soup apparently was effective in reducing the relative amount of it to a much greater degree.

TABLE 5. RESULTS OF *F* TESTS OF THE VARIANCE OF PCB CONCENTRATIONS IN TISSUES OF SNAPPING TURTLES FROM THE HUDSON RIVER VS OTHER LOCALITIES IN NEW YORK

Tissue	Locality	Number	Sum of squares	Value of *F*
Fat	Hudson River	10	8,941,722.49	
	Other	9	512,102.88	17.46*
Liver	Hudson River	22	21,200.77	
	Other	8	116.52	161.95*
Skeletal muscle	Hudson River	22	45.58	
	Other	6	0.04	1,179.45*

*Significant at $P = < 0.001$.

TABLE 6. RESULTS OF *t* TESTS OF DIFFERENCES BETWEEN MEAN VALUES FOR PCB CONCENTRATIONS IN TISSUES OF SNAPPING TURTLES FROM THE HUDSON RIVER VS OTHER LOCALITIES IN NEW YORK

Tissue	Value of *t*	
	Critical	Calculated
Fat	2.26	2.59*
Liver	1.75	1.83*
Skeletal muscle	1.75	2.64*

*Significant at $P < 0.05$.

The two snapping turtles whose tissue samples were pooled were both taken on June 14, 1976 from North Bay at Tivoli on the Hudson River. The pooled sample of liver and that of skeletal muscle each had less than 0.06 ppm of cadmium. However, for four turtles from the Hudson River at Constitution Island Marsh, two taken on June 15, 1976 and two on May 19, 1977, the mean and range of cadmium concentrations were 16.9 (8.58-26.20) ppm in the liver and 0.77 (0.12 - 1.41) ppm in the skeletal muscle. Turtles seem to be able to tolerate large concentrations of cadmium (Robinson and Wells, 1975), but further research is needed.

DISCUSSION

These data demonstrate that the fat, liver and eggs (tissues that usually contain higher lipid levels than other tissues) of snapping turtles contain greater concentrations of organochlorine toxicants than does skeletal muscle. They also indicate that turtles from the Hudson River contain significantly higher levels of PCB's than turtles from the other localities from which specimens were obtained. In addition to toxicants received through diet, the snapping turtle may acquire hydrophobic compounds, such as PCB's, through its mucous membranes during aquatic pharyngeal and cloacal respiration (Hammer, 1969).

The U.S. Food and Drug Administration has recognized no specific tolerances or action levels for deleterious substances in snapping turtles. However, the agency's sanctioned levels for human consumption of the edible portion of fish are as follows: PCB's, 5.0; DDE, 5.0; Dieldrin, 0.3; heptachlor epoxide, 0.3; Mirex, 0.1; and mercury, 1.0 (U.S. Food and Drug Administration, 1978).

In light of the findings of the present study, snapping turtles from the Hudson River, below Hudson Falls-Fort Edward, appear unsafe for human consumption. Although the skeletal muscle was generally low in organochlorine residues, leaving a small amount of fat on the meat could result in elevated contaminant levels in soups and stews. In recipes that also use the liver and/or eggs, the risk of high levels of contaminants is even greater. More data are needed for snapping turtles from Lake Ontario and other areas (e.g., Lake Erie, Onondaga Lake and Lake Champlain), but the data for the specimens from Irondequoit Bay suggest that turtles from Lake Ontario may also be unfit for human consumption. Snapping turtles taken anywhere should be prepared carefully and even small amounts of fat as well as the liver rejected as human food.

Little research has been done on pesticides and industrial pollutants in reptiles. Snakes have been proposed as pollution-indicator species (Gauerke et al., 1975), and alarmingly high levels of some organochlorine toxicants were found in the body fat of a small sample of indigo snakes (*Drymarchon corais*) from Georgia (Lawler, 1977). However, the concentrations of

organochlorine reported in these snakes were lower than those found in snapping turtl during the present study in New York.

The adipose tissue may accumulate organochlorine toxicants throughout the life of a turtle. In order to monitor trends in the degree of pollutant contamination, the concentrations of specific toxic substances can be compared according to age for turtles from selected bodies of water. Age can be estimated from counts of scute annuli (small turtles), from carapace length and, perhaps, by microscopically counting the ring-like formations in sections of the long bones of larger turtles (Gibbons, 1968; Hammer 1960). Since snapping turtles hold high concentrations of lipid-soluble contaminants in their fat bodies, these organs should be ideal for GC/mass spectrophotometry analysis for a variety of compounds (e.g., dioxin, dibenzofuran and polynuclear aromatic hydrocarbons).

Snapping turtles appeared to be abundant, at least locally, in the Hudson River (e.g., North Bay at Tivoli, Vanderburgh Cove), so chemical pollutants have not noticeably reduced populations in those areas. However, research is needed concerning the impact of organochlorines and other pollutants on the health and behavior of snapping turtles and the hatchability of their eggs.

In addition, the snapping turtle should prove a useful laboratory animal for toxicology studies. Large fat bodies (Pond, 1978) are found on the ventral side of the turtles and extend from the vicinity of the medial aspect of the hind limbs to, in obese individuals, the area of the heart. Also, there are discrete fat deposits in the axial, pericardial, and lateral and ventral neck regions. These adipose tissues can be quickly and easily collected for laboratory chemical analyses.

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