Mercury Concentrations in Alligator Meat in Georgia

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Abstract: Tail meat samples from 22 American alligators (*Alligator mississippiensis*) collected from 10 collection areas in Georgia during 1990 were analyzed for mercury (Hg) concentrations (wet weight basis). Mercury was detected in all samples and ranged from 0.1 ppm to 1.4 ppm ($\bar{x}$ = 0.48 ppm). No differences in mercury concentration were found between sexes (P = 0.638) or among all collection areas (P = 0.178). Pooled samples from collection sites on the headwaters of the Suwannee River system had higher mercury concentrations ($P < 0.005$) than those from all other collection sites combined. There was no correlation ($P > 0.20$) between alligator total length and mercury concentration in the meat samples. Because the mean mercury concentration in alligator meat in this study was below the U.S. Food and Drug Administration (FDA) "action level" for fish flesh and because alligator meat is consumed infrequently, no public health problem was indicated.

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Mercury is a naturally-occurring element often associated with oligotrophic waters of low pH. It appears to concentrate in swampy environments containing abundant organic materials, sometimes as much as 14 times higher than the average concentration in soils and rocks from the United States in general (W. McLemore, Ga. Dep. Nat. Resour. geologist, pers. commun.). Mercury is widely used in a variety of manufacturing processes, and certain industrial activities may release it into the environment.

While mercury has no known biological function, it has been found in a variety of organisms. Sublethal levels may affect metabolism, blood chemistry, reproduction, growth and development, behavior, motor coordination, and vision in humans, fish, and wildlife (Eisler 1987). The fat-soluble compound, methylmercury, is formed as organisms attempt to metabolize mercury and is the basis for its biomagnificiation through food chains (Ogden et al. 1974).

Fish contaminated by mercury were discovered in northwest Florida in 1983, and elevated mercury concentrations were noted statewide in fish samples collected

in 1988 and 1989 (Hord et al. 1990). Fourteen out of 15 samples of largemouth bass (*Micropterus salmoides*) collected by the Georgia Department of Natural Resources (DNR) Environmental Protection Division (EPD) from the headwaters of the Suwannee River in Georgia in 1989 exceeded the FDA action level of 1 ppm of mercury in fish flesh for human consumption (M. Gaddis, DNR EPD, pers. commun.).

Peters (1983) found that American alligators are capable of accumulating mercury in muscle tissue in captive situations. Delany et al. (1988) and Hord et al. (1990) reported mercury concentrations as high as 3.88 ppm in meat from wild alligators in Florida.

While FDA action levels have not been established for contaminants in alligator meat for human consumption, the presence of concentrations of mercury in alligators above the action level for fish is reason for concern. Alligator meat is being marketed in Georgia, but no data exist regarding mercury contamination of alligators in Georgia. This paper reports on the presence and concentration of mercury in alligator meat from various locations in southern Georgia.

The author thanks Georgia nuisance alligator trappers involved in collecting samples for the project and DNR employees who coordinated the project on a regional basis. Special appreciation is extended to M. Gaddis who provided initial guidance on sample collection and whose EPD laboratory analyzed the samples. T. Holbrook contributed advice on statistical analysis and provided helpful comments on earlier drafts of this manuscript.

Methods

To determine the presence and concentration of mercury in alligators from a variety of geographic locations and habitat types, meat samples were taken from nuisance alligators harvested from Clay County ($N = 1$), Seminole County ($N = 2$), Crisp County ($N = 1$), Dooly County ($N = 1$), Sumter County ($N = 1$), Pierce County ($N = 1$), Camden County ($N = 1$), Glynn County ($N = 2$), McIntosh County ($N = 2$), and Chatham County ($N = 4$). Because a 1989 DNR collection found elevated mercury concentrations in largemouth bass from the headwaters of the Suwanee River system (M. Gaddis, DNR EPD, pers. commun.), it was suspected that alligators collected from those same areas might likewise exhibit higher concentrations of mercury in their meat. Therefore, meat samples were obtained in Lowndes County ($N = 4$) and Clinch County ($N = 2$) from 2 alligators collected from each section of the Alapaha, Suwanee, and Withlacoochee rivers where largemouth bass were previously collected for mercury analysis.

One sample weighing approximately 113 g was taken from the lateral tail muscle immediately posterior to the back legs of each alligator (Hord et al. 1990) designated by DNR personnel for harvest and sampling by nuisance alligator trappers. Each sample was labeled, double-wrapped with aluminum foil, and frozen until analyzed.

Samples were analyzed for mercury presence and concentration by the DNR EPD laboratory in Atlanta. A weighed portion of each sample was digested with sulfuric and nitric acid at 58° C followed by overnight oxidation with potassium

permanganate at room temperature. Mercury was subsequently measured by the conventional cold vapor technique using an atomic absorption spectrophotometer (U.S. Environ. Protect. Agency, unpubl. rep., Environ. Monitoring and Support Lab., Cincinnati, Oh.). Concentrations were expressed as μg of Hg per g wet weight of muscle tissue (ppm). The procedure involved analysis of a reference sample, 1 duplicate per 10 samples, and 1 spike per 20 samples. Recovery of spikes was 80% and agreement of duplicates was 93.8%. Detection limit was 0.1 μg per g.

The Kolmogorov-Smirnov test determined that mercury concentrations from all collection areas did not have a normal-like distribution ($P < 0.05$). Mean mercury concentrations among collection areas were compared with a Kruskal-Wallis Test. The Mann-Whitney Test was used to compare mean mercury concentrations between males and females. The mean mercury concentration from the Alapaha, Suwannee, and Withlacoochee rivers collection areas was likewise compared by the Mann-Whitney Test to the mean mercury concentration of all other collection areas. To determine the relationship between mercury concentrations and alligator length, the Spearman's rho correlation coefficient was computed. Differences were considered significant at $P = 0.05$.

Results

Meat samples were collected from 22 alligators harvested between 14 March and 25 July 1990. Alligators from which samples were taken ranged in length from

Table 1. Mean alligator lengths and mercury (Hg) concentrations (wet weight basis) in alligator meat samples collected by nuisance alligator trappers from 10 collection areas in Georgia during 1990.

Collection area		$\bar{x}$		
		Alligator length		Hg
No.	Location	*N*	(m)	(ppm)
1	Lowndes Co. (Withlacoochee R.)	2	1.9	1.00
2	Lowndes Co. (Alapaha R.)	2	2.6	0.80
3	Clinch Co. (Suwanne R.)	2	2.0	0.95
4	Clay Co. (Pond)	1	2.0	0.20
5	Seminole Co. (L. Seminole)	2	3.2	0.20
6	Crisp Co. (Pond)	1	2.9[a]	0.27[a]
	Dooly Co. (L. Blackshear)	1		
	Sumter Co. (L. Blackshear)	1		
7	Camden Co. (Pond)	1	2.4[a]	0.55[a]
	Pierce Co. (Pond)	1		
8	Glynn Co. (Pond)	2	2.2	0.25
9	McIntosh Co. (Pond)	2	2.2	0.20
10	Chatham Co. (Ogeechee R.)	1	3.0[a]	0.44[a]
	Chatham Co. (Savannah R.)	2		
	Chatham Co. (Pond)	1		

[a] Mean of the locations sampled in a collection area representing a common geographic location and habitat type.

1.6 m to 3.8 m; 17 males ($\bar{x}$ total length = 2.7 m) and 5 females ($\bar{x}$ total length = 1.9 m) were sampled. Of the alligators collected, 9 were from rivers and 13 were from lake or pond habitats. Detectable concentrations of mercury ranging from 0.1 ppm to 1.4 ppm ($\bar{x}$ = 0.48 ± 0.364(SD) ppm) were found in meat from all alligators sampled. Since mean mercury concentrations of meat from females ($\bar{x}$ = 0.56 ± 0.493(SD) ppm) and males ($\bar{x}$ = 0.46 ± 0.322 (SD) ppm) were not significantly different (P = 0.638), data were pooled for comparison among collection areas. Apparent differences in mercury concentrations among collection areas (Table 1) were not significant (P = 0.178). When samples from the Alapaha, Suwannee, and Withlacoochee rivers were pooled ($\bar{x}$ = 0.92 ± 0.312 (SD) ppm) and compared to pooled samples from all other collection areas ($\bar{x}$ = 0.32 ± 0.223 (SD) ppm), the difference in mercury concentrations was highly significant ($P < 0.005$). There was no significant correlation between alligator total lengths and mercury concentration in the meat samples ($P > 0.20$).

Discussion

Delany et al. (1988) found mercury concentrations (wet weight basis) in alligator meat collected between 26 August and 29 October 1985 from 8 Florida lakes ranging from 0.04 ppm to 0.61 ppm. Mean mercury concentrations (wet weight basis) in alligator meat ranged from 2.92 ppm (N = 10) in certain south Florida Water Conservation areas to 0.74 ppm (N = 19) in samples from a nuisance alligator trapper in the Ft. Lauderdale area, to 0.39 ppm (N = 58) in samples obtained from alligator meat processors in north, central, and south Florida (Hord et al. 1990).

The mean mercury concentration in alligator meat from all collection areas in Georgia was 0.48 (SD = 0.364, N = 22) ppm. Two samples from this study exceeded the FDA action level of 1 ppm for fish; 1 (1.4 ppm) came from the Withlacoochee River, and 1 (1.2 ppm) was collected from the Suwannee River. These 2 collection sites, along with 1 on the Alapaha River, are the same sites where 93% of the largemouth bass sampled in 1989 exceeded the FDA action level.

FDA action levels have not been established for alligator meat for human consumption. Action levels are based on quantity and frequency of meat consumption, meat preparation, and various consumer characteristics such as age and sex. Because the mean mercury concentration in alligator meat analyzed in this study was below the action level for fish flesh, and because alligator meat generally is a novelty food that is consumed infrequently, no public health problem is indicated at this time. However, periodic monitoring of mercury concentrations in alligator meat was recommended (M. Gaddis, DNR EPD, pers. commun.).

Delany et al. (1988) speculated that adult female alligators might exhibit lower levels of contaminants than males because in reptiles some contaminants are removed when eggs are laid. In this study, the difference in mercury concentrations between male and female alligators was not significant.

Since alligators represent a high level of the food chain and are relatively long-lived, their potential for biomagnification of contaminants is high (Delany and Abercrombie 1986). Chabreck and Joanen (1979) reported a strong positive relationship between total length and age in alligators; therefore, in general, larger alligators are likely to be older. Delany et al. (1988) postulated that smaller (younger) alligators would be expected to exhibit lower concentrations of contaminants. However, with the relatively small sample size, this study revealed no significant correlation between total alligator length and mercury concentration in meat samples.

Although there appeared to be differences in mercury concentrations in alligator meat from the 10 collection areas, these differences were not significant, possibly due to the small sample size. Statistical analysis revealed that mercury concentrations from the 3 collection areas on the headwaters of the Suwannee River where elevated mercury concentrations were discovered in fish were higher than other collection areas. Since there are no known industrial sources of mercury in the area drained by these 3 streams, contamination of alligator meat there may be due to naturally occurring sources. Mercury concentration in alligator meat from other collection sites may be from natural sources as well, but further study will be necessary to delineate sources.

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