Bull. Environ. Contam. Toxicol. (1999) 63:598-603

Bulletin of Environmental Contamination and Toxicology

Mercury Levels in Alligator Meat in South Louisiana

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Received: 5 May 1999/Accepted: 30 July I999

In recent years, environmental contaminants have been recognized as an area of concern for some crocodilian species (Brisbin et al. 1998). Publications in the scientific and popular literature have focused on organic chemicals as potential endocrine disruptors in reptiles, including the American alligator (Guillette and Crain 1996). A recent review suggested environmental contaminants affecting crocodilians may be grouped into three categories; organic chemicals, heavy metals, and radionuclides (Brisbin et al. 1998).

The heavy metal considered to be of greatest concern to crocodilians is mercury (Brisbin et al. 1998), as it is potentially hazardous to numerous species including humans (Eisler 1987). Alligator meat is used for human consumption in several southeastern states. Mercury has been measured in alligator tissues collected from several sites in southeastern states, as reviewed by Brisbin et al. (1998). The US Food and Drug Administration has set an advisory limit of 1 ppm for the consumption of fish flesh and some regulatory agencies issue health advisories at levels of 0.5 ppm [Jagoe et al. 1998, Louisiana Department of Environmental Quality (LDEQ) 1981].

Similar standards have not been set for the consumption of alligator meat (Yanochko et al. 1997, Jagoe et al. 1998), perhaps because it is generally not consumed in large quantities by individuals, but rather is served as a novelty item. However, large quantities of alligator meat are processed in Louisiana for human consumption in domestic and overseas markets. When hide prices are low, the meat value becomes a significant portion of the market value of harvested alligators. Approximately 350,000 kg of deboned meat is processed annually from wild alligators in Louisiana.

Several studies in Florida have documented mercury levels in alligator muscle which exceeded state and federal allowances for safe human consumption (Hord et al. 1990, Heaton-Jones et al. 1997) in certain areas. Concern over elevated mercury levels in tail meat from alligators in some southern Florida Water Conservation Areas led to cancellation of alligator harvests on those areas in 1989 and 1990, at an estimated loss of over $270,000 in revenue to the trappers for the 1989 season (Hord et al. 1990). Alligator harvests have remained closed on those areas since (A. Woodward, pers. comm.).

A recent report in South Carolina noted very high mercury levels in a large (3.92 m) adult male alligator found dead in the Par Pond Reservoir, which formerly served as a nuclear reactor cooling area of the US Department of Energy's Savannah River site (Brisbin et al. 1998). Wet-mass mercury levels in this animal were 158 ppm liver, 35.5 ppm kidney, and 3.48 ppm muscle.

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Louisiana has the most intensive alligator harvest program in the United States, with some 25,000-29,000 sub-adult and adult alligators harvested from the wild each September, yielding some 350,000 kg of meat annually at a value of 3-4 million dollars per year. The purpose of this study was to determine if mercury levels in alligator meat in southern Louisiana pose any health hazards from the consumption of this meat.

MATERIALS AND METHODS

Samples of tail muscle were collected in September 1998 from alligators taken in the closely regulated legal harvest program. Specimens were taken from alligators from southwest Louisiana which were processed at a skinning facility in Abbeville, Louisiana and from alligators harvested in southeast Louisiana which were processed in Venice, Louisiana. Alligators freshly trapped in the morning were brought by trappers to the skinning facilities, where they were skinned soon after arrival, or held in a walk-in cooler for processing as soon as possible.

During the skinning process, we collected a composite sample of several pieces of muscle (each approximately a 3-5 cm cube) from each side of the tail, such that each sample was approximately 40-50 g. A fresh disposable scalpel was used between samples to avoid contamination, and each composite sample was placed in a labeled zip-lock bag, and kept on ice, until frozen for later analysis.

We attempted to select alligators of over a range of sizes, and included males and females. Fourteen samples were from southwest Louisiana (10 males, 4 females), 27 were from southeast Louisiana (14 males, 6 females, 7 sex unknown) and one sample (a 124 cm male) from central Louisiana was collected after delivery to the Abbeville processing facility. Males ranged in size from 124 cm - 368 cm total body length, females ranged from 142 cm - 264 cm, the samples of unknown sex fell within these upper and lower limits.

Mercury analysis was performed courtesy of the Louisiana Department of Environmental Quality. Samples were analyzed at the Soil-Plant Analysis Laboratory at Northeast Louisiana University in Monroe, Louisiana. Mercury in the tissue samples was analyzed by atomic absorption spectrometry with a Perkin Elmer FIMS system (LDEQ 1998) with a detection level of 0.0001 ppm. Quality assurance/quantity control were as previously described (LDEQ 1998).

The Student's t-test was used to test for differences between mercury levels in males and females, and between southeast and southwest collection sites. A simple linear regression was used to determine if mercury levels were correlated to total body length.

RESULTS AND DISCUSSION

Mercury levels in alligator tail muscle ranged from 0.047 ppm to 0.386 ppm, all well below the FDA action level for human consumption of fish flesh. All samples combined ($n = 42$) averaged 0.131 ppm mercury. Samples of both sexes from southwest Louisiana were significantly higher (0.176 ± 0.022 ppm, $n = 14$) than those from southeast Louisiana (0.098 ± 0.008 ppm; $n = 27$; $p < 0.0002$). Samples of males from southwest Louisiana (0.190 ± 0.028 ppm, $n = 10$) were significantly higher ($p<0.0006$) than males from southeast Louisiana (0.091 ± 0.008 ppm, $n = 14$), but no significant difference was seen between females between sites, possibly due to small samples size (0.139 ppm SW, $n = 4$; 0.101 ppm SE, $n = 6$).

No difference ($p = 0.3971$) was seen between males and females pooled from all sites. Mercury levels for all males were 0.143 ± 0.018 ppm ($n = 25$) and for all females 0.117 ± 0.014 ppm ($n = 10$). There was no correlation between tissue mercury level and total body length ($y = -0.0008x + 0.1919$, $r^2 = 0.051$).

Results in our study document that meat samples from wild harvested sub-adult and adult alligators in south Louisiana have generally low mercury levels, averaging 0.131 ppm. The highest level detected (0.386 ppm) is much lower than the FDA action level for safe human consumption of fish flesh (LDEQ 1998). This is also below the level (0.5 ppm in fish and shellfish) at which the Louisiana Department of Health and Hospitals considers issuing a health advisory limiting fish consumption for pregnant or breast feeding women, or children under seven years of age (LDEQ 1998).

The average alligator meat mercury level in Louisiana (0.131 ppm) was lower than those reported in other southeastern states (Table 1). In Georgia, Ruckel (1993) noted mercury levels from 22 alligators averaged 0.48 ppm (range 0.1 - 1.4 ppm). He also detected no difference between sexes, and no correlation between mercury levels and total length. Jagoe et al. (1998) also documented low mercury levels in alligator muscle samples from Georgia (0.8 mg/kg dry weight).

Studies in Florida noted dramatically differing levels of mercury depending on the collection site. Delany et al. (1988) reported an average level of 0.61 ppm from large alligators in central Florida, whereas Hord et al. (1990) found widely variable mercury levels ranging up to 3.88 ppm at several sites (Table 1). Fifty-eight samples collected from alligator meat processors in north, central, and south Florida averaged 0.39 ppm, and 19 samples from the Ft. Lauderdale area averaged 0.74 ppm. Of particular concern, results from alligator meat from water conservation areas sampled in south Florida had mercury levels of 1.66 ppm in February 1989 ($n = 8$) and levels of 2.92 ppm in June 1989 ($n = 10$, Hord et al. 1990). These high levels caused the Florida Game and Freshwater Fish Commission to cancel alligator harvests in the WCA, and sale of meat from nuisance alligators caught in the Everglades is prohibited (Hord et al. 1990, A. Woodward, pers. comm.).

Recent studies in Florida and South Carolina (Heaton-Jones et al. 1997, Yanochko et al. 1997, Jagoe et al. 1998) have documented mercury levels in alligators from organs and tissues other than muscle. In contrast to our study and that of Ruckel(1993), Heaton-Jones et al. (1997) found muscle mercury was correlated with alligator total length, as did Yanochko et al. (1997) in their Everglades samples, but length correlated only with scute mercury levels in their samples from South Carolina. Muscle mercury did not correlate with total length at three of four locations evaluated by Jagoe et al. (1998). As in our study and that of Ruckel (1993), Yanochko et al. (1997) noted no difference in mercury levels between sexes. Heaton-Jones et al. (1997) noted that all Everglades alligators contained muscle mercury concentrations in excess of the FDA, U. S. Environmental Protection Agency, and Florida Department of Health and Rehabilitative Services allowances for safe human consumption.

A preliminary study in South Carolina of fifteen samples of alligator meat had an average mercury level of 0.694 ppm (range 0.049 - 3.44 ppm, Rhodes 1998). Several samples exceeded the FDA's action level for human consumption of fish. This is an ongoing project and additional samples have been collected for analysis (W. Rhodes, pers. comm.). Using the more conservative level of 0.5 mg Hg/kg wet weight for

Table 1. Mercury levels in alligator meat from several southeastern states.

State/Location	Mercury (ppm)	(n)	Citation
Florida/central	0.61	32	Delany et al. 1988
Florida/north, central, south	0.39	58	Hord et al. 1990
Florida/Ft. Lauderdale area	0.74	19	Hord et al. 1990
Florida/south, WCA's (2/89)	1.66	8	Hord et al. 1990
Florida/south, WCA's (6/89)	2.92	10	Hord et al. 1990
Florida/Everglades	2.61	12	Heaton-Jones et al. 1997
Florida/non-Everglades	0.33	12	Heaton-Jones et al. 1997
Georgia	0.48	22	Ruckel 1993
Louisiana	0.13	42	present study
South Carolina/coastal	0.69	15	Rhodes 1998
South Carolina/Par Pond	3.48	1	Brisbin et al. 1998

consumption advisories, Jagoe et al. (1998) noted 94% of their samples from South Carolina (and all their samples from the Everglades) would be considered contaminated and unsafe for consumption.

In Louisiana, levels of mercury in fish exceeding the FDA action level of 1 ppm have been found in many areas; and the first fish advisory due to mercury was issued in August 1992 for part of the Ouachita River in north Louisiana (LDEQ 1998). In addition to the LDEQ and Louisiana Department of Health and Hospital's advisory, the USFWS strongly recommends that no fish or racoons taken on either the Upper Ouachita or D'Arbonne National Wildlife Refuges be consumed (LDEQ web page last updated 12/3l/97). By late September 1998, 15 advisories have been issued on 14 water bodies in Louisiana due to mercury contamination in fish (LDEQ 1998). Alligators are known to consume fish in their diet (McNease and Joanen 1977), and being long lived could accumulate the element over time. We expected to see higher levels of mercury in the larger (older) alligators, due to accumulation with time and longer exposure to mercury if available. Mercury levels were low overall in our study, and no such relationship was seen. We also postulated that our samples from southeast Louisiana might have higher mercury levels than those in southwest Louisiana, as the southeast site is near the mouth of the Mississippi River which in known to carry industrial/municipal pollutants. Unexpectedly, our samples from southwest Louisiana had higher mercury levels than those collected near the mouth of the Mississippi River.

Many of the fish advisories in Louisiana are for water bodies in north/central Louisiana. The majority of the alligators in Louisiana occur in coastal parishes, and only approximately 20% of alligators harvested are from central/north Louisiana. It would be of interest to determine if alligators from areas where fish advisories have been required

have elevated mercury levels. However, as noted many of the north/central areas of Louisiana have a relatively low harvest of alligators, limiting the potential for excessive human consumption of alligator meat from those areas.

A considerable amount of alligator meat is produced from commercial alligator farms in Louisiana. In 1996 and 1997, farm production reached 160,000 - 170,000 juvenile alligators harvested at the 1.0 - 1.5 m size class. Approximately 230,000 - 245,000 kg deboned meat valued at over $2 million was produced in each of those years. Heaton-Jones et al. (1997) measured mercury from 6 farm-raised alligators in Florida fed a commercially prepared diet and found very low mercury levels in all tissues analyzed, including tail and leg muscle. Some commercially prepared diets fed in Louisiana alligator farms are fish based, but as the alligators reach harvest size within l-2 years of hatching we would expect they would not accumulate high levels of mercury in that limited time, even if it was present in the commercially prepared diet.

Our results thus far suggest alligator meat in south Louisiana has low levels of mercury, and presents no public health concern. The highest level we noted in one sample (0.386 ppm) was substantially below the FDA action level for consumption of fish flesh. Because alligator meat in consumed infrequently as a novelty item, the chance of illness from mercury contamination seems remote.

Acknowledgments. We thank Will Tucker and Dugan Sabins of the Louisiana Department of Environmental Quality for coordinating analyses of mercury samples. We thank Wayne Sagrera and Don Delesdernier for cooperation in collection of alligator meat samples at their processing facilities. We thank Karen McCall for assistance in preparation of the manuscript and Dr. Grahame Webb for helpful suggestions to initiate the study.

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