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Mercury Residues in South Florida Apple Snails (*Pomacea paludosa*)

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Mercury concentrations in the sediments of south Florida wetlands have increased three fold in the last century (Rood et al. 1993). Because south Florida is home to many endemic and endangered species, it is important to understand the potential impacts of mercury in this ecosystem's food web. Recent research by Malley et al. (1996) has shown mollusks to be sensitive indicators of methyl mercury which can reflect small differences in background methyl mercury concentrations. In this study, we attempted to determine if the apple snail (*Pomacea paludosa*) or its eggs are good indicators of bioavailable mercury. Then, using the apple snail as an indicator, we attempted to determine geographic differences in the concentrations of mercury in south Florida.

The apple snail, an important component of freshwater food webs, is distributed throughout the extreme southeastern United States. Being aquatic, it leaves the water only to lay eggs on emergent vegetation. The apple snail, a primary consumer which feeds on periphyton, is the primary food source to the Snail kite (*Rostrhamus sociabilis*) (Stieglitz and Thompson 1967; Sykes 1987), is a major food item for the Limpkin (*Aramun guarauna*) (Harper 1936, 1941; Cottam 1941), and is found in the diet of a variety of other species (Kushlan 1975).

MATERIALS AND METHODS

Sixty-two apple snails and 66 egg masses were collected in August of 1992 from six distinct geographical locations in various water management areas of south Florida (Fig. 1). Within each location three snails and three egg masses from up to seven sites were collected. The snails were dipnetted from water 0.5 to 1.5 m deep. Egg masses were collected from the stalks of emergent vegetation from the same location as the

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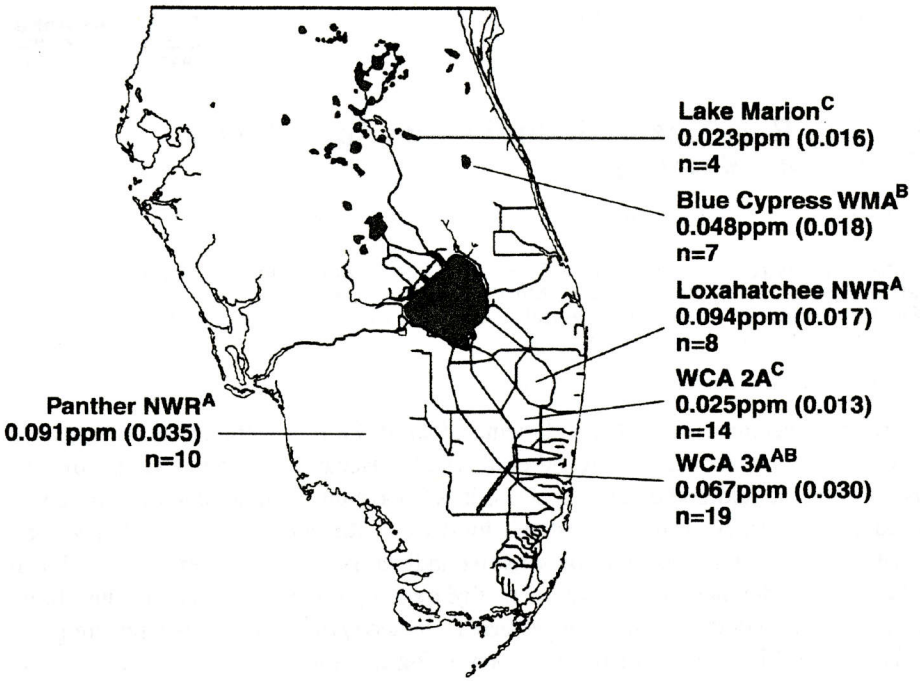

Figure 1. Mean (and standard deviation) mercury concentrations in apple snails from major water management locations in south Florida. Locations with different superscripts are significantly different at the 0.05 alpha level as tested by Tukey's means separations test.

snails. Wherever possible, snail collections were made in locations where Snail kites were observed feeding.

Collected snails and eggs were placed in labeled plastic storage bags and stored on wet ice until returning to the Patuxent Environmental Science Center, where they were stored at -20°C. Once thawed, snails were weighed and measured from the apex to the distal flare of the aperture lip following methods by Sykes (1987). The soft body was removed from the shell and weighed. Egg masses were removed from the vegetation and weighed. Soft tissues and egg masses were homogenized separately using a Brinkman 'Tissue Tearor' homogenizer and homogenized samples were stored at -20°C until they were analyzed.

Mercury concentrations were determined by a method modified from Monk (1961). Between 1 and 1.5 g of tissue were refluxed for two hours at 100°C in 7 ml 3:1 95% sulfuric:70% nitric acid. To prevent scorching, five ml of nitric acid were slowly added during the digestion. The resulting solution was transferred to a 50-ml polypropylene screw-capped centrifuge tube and diluted to 50 ml with reverse osmosis deionized water. Five ml digested tissue were added to 100 ml reverse osmosis deionized water in a Biochemical Oxygen Demand bottle. The sample was

reacted with 5 ml hydroxylamine hydrochloride and 5 ml stannous chloride to reduce bound mercury to metallic mercury. Volatilized metallic mercury concentrations were determined by cold-vapor atomic absorption using a Coleman Mercury Analyzer Model MAS 50B. Readings were taken in duplicate and averaged. Concentrations were expressed as wet weight. Reference material (Dogfish muscle, "DORM-1", Chemistry Division of the National Research Council of Canada), duplicates, spiked samples and blanks were analyzed to verify the method accuracy and consistency.

QA/QC sample results indicated our analyses were consistent and within acceptable recovery limits. Our average recovery for spikes and reference material was 101% and 92%, respectively. Blanks were below the method detection limit (U.S. EPA 1988) of 0.025 ppm. Duplicate samples had a coefficient of variation of 6%.

For statistical purposes, samples with mercury concentrations below the method of detection limit were assigned a value of 0.0125 ppm, one-half the limit of detection. The Shapiro-Wilks test was used to test the normality of the residuals of the data and the F-max test to test for heterogeneity of variance prior to further analysis. Where required to correct problems of normality and to stabilize the variance, data were log transformed before conducting one-way Analysis of Variance (ANOVA). Where significant differences were noted, Tukey's mean separation test was used to compare means. Pearson's correlation was used to relate snail size to mercury concentration.

RESULTS AND DISCUSSION

The average length of the apple snails was 36.0 mm (19.2 to 49.7 mm) and the average weight was 8.6 g (1.24 to 20.57 g). Approximately 45% of the total weight was soft body tissue.

The average mercury concentration of the 62 snails analyzed was 0.063 ppm wet weight. Mercury concentrations were below the method detection limit in nine snails, six from Water Conservation Area 2A and 3A from Lake Marion (Fig. 1). Ten samples contained 0.1 ppm or greater. The greatest individual concentration, 0.14 ppm, was found in two snails from Panther National Wildlife Refuge and one from Water Conservation Area 3A.

Mercury concentrations in snails were comparable to those reported by Rumbold (1992) in the West Palm Beach Water Catchment Area; between 1989 and 1991, mercury concentrations in five composite samples averaged 0.0318 ppm wet weight (0.014 ppm to 0.056 ppm).

Mercury concentrations varied with geographical area. The greatest average concentrations were at the Loxahatchee National Wildlife Refuge, the Panther

Table 1. Mean (and standard deviation) of length, width, and mercury concentrations (wet weight) in apple snails collected from south Florida.

Site	n	Avg. Wt. (g)	Avg. Length (mm)	Avg. Hg Conc. (ppm)	No. Below Detection
Everglades Region	41	10.27 (2.47)	39.0 (3.86)	0.056[A] (0.034)	6
Panther NWR	10	9.04 (4.84)	36.8 (6.83)	0.091[B] (0.035)	0
North of Lake Okeechobee	11	6.46 (3.83)	32.2 (7.72)	0.039[A] (0.021)	3

Note: Mercury concentrations with different superscripts are different at the 0.05 confidence level as tested by Tukey's means separation test.

National Wildlife Refuge and Water Conservation Area 3A. The lowest concentrations were in Water Conservation Area 2A and in areas north of Lake Okeechobee. Table 1 illustrates differences over broader geographical regions - the Bald Cypress Swamp, as represented by the Panther National Wildlife Refuge, the Everglades and areas north of Lake Okeechobee. Statistical comparison of mean mercury concentrations over these regions indicate concentrations significantly higher at Panther National Wildlife Refuge than other regions.

Mercury concentrations detected in snails were below concentrations in largemouth bass (*Micropterus salmoides*) collected in south Florida. Ware et al. (1990) reported concentrations ranging from 0.13 to 3.64 ppm in largemouth bass collected between 1985 and 1988. This is not unexpected given the difference in trophic position of the two species. The high concentrations reported by Ware et al. (1990) for Water Conservation Area 3A and Loxahatchee National Wildlife Refuge and low concentrations detected in areas north of Lake Okeechobee agree with our data. However, over 50% of the snails collected at the Panther National Wildlife Refuge contained mercury concentrations higher than the average concentration in snails detected in the Everglades. Ware et al. (1990) reported one of the lowest concentrations in bass from a lake near the headwaters of Panther National Wildlife Refuge, Lake Trafford. Low mercury concentrations were detected in snails from Water Conservation Area 2A. Ware et al. (1990) also reported concentrations in this location to be the third highest in Florida.

Morphological comparisons were made to explain the low mercury concentrations observed in Water Conservation Area 2A. ANOVA was used to test whether snails collected in Water Conservation Area 2A were significantly smaller than other areas; no significant difference was observed. In addition, no relationship was found between mercury concentration and snail length, total weight or soft tissue weights. This relationship was tested for snails collected within the same location, and by combining all 62 samples. No significant correlations were observed. The low

concentrations detected in Water Conservation Area 2A were most likely due to the local variation in sediment or water column mercury concentrations.

While traces of mercury were present in the egg samples (as detected by the response of the instrument), all concentrations were below the method detection limit. Snail eggs appear to be unsuitable as a biomonitor of environmental mercury concentrations.

Apple snails can serve as indicators of bioavailable mercury. They form an important component of the food webs of south Florida as sedentary primary consumers, feeding on periphyton and as prey to a variety of species. Our analysis indicated mercury concentrations in snails are highest in watersheds south of Lake Okeechobee. In addition, mercury concentrations in the southwestern region of the state may be higher than previously thought. Since mercury concentrations in snails are significantly lower than those reported in fish, wildlife feeding on apple snails are at lower risk of mercury intoxication than piscivorous wildlife.

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