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Heavy Metal Burdens in American Crocodile Eggs From Florida Bay, Florida, USA

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The neotropical range of the American crocodile (*Crocodylus acutus*) extends from the north and west coasts of South America to the coasts of Mexico, the Greater Antilles and south Florida. Potentially viable populations exist in Jamaica, Hispanola, Cuba and on the southern tip of the Florida peninsula. The status of these populations, each of which are in some way threatened with extinction, has long been of concern (Moore, 1953; Ogden, 1968; Klukas et al., 1979).

The possibility that pesticides and heavy metals in waste products could represent a substantial threat to the continued existence of the south Florida population was raised in the early 1970s. In response to this potential threat a preliminary survey of the pesticide and heavy metal burdens in the upper food chain organisms of Everglades National Park was conducted (Ogden et al., 1974). This survey included the determination of various pesticide and heavy metal residues in 5 American crocodile eggs collected in May 1972. Pesticide residue levels in crocodile eggs were examined again by Hall et al. (1979); however, there have been no additional investigations regarding heavy metal burdens. The purpose of this study is to present more recent data, based on collections made in 1980, regarding the heavy metal levels in American crocodile eggs.

Nine, unhatched American crocodile eggs were collected from the south Florida population in Florida Bay, Everglades National Park, at the end of the 1980 nesting season. The eggs were shipped, intact, under ice, to the Institute of Ecology, University of Georgia, Athens, Georgia, for heavy metals analyses.

The egg samples were partitioned into two components, the shell and the albumin-yolk mass. These components were then lyophilized. All heavy metal determinations, with the exception of mercury, were made from the lyophilized material digested by a modification of the method outlined by Giesey and Wiener (1978). The preweighed samples were heated in 5 ml of concentrated nitric acid at 100°C for 4 h. An additional 5 ml of concentrated nitric acid were added, and the samples were heated overnight. Then 10 ml of 30 percent hydrogen peroxide were added to the digestate and heated for 30 min. The samples, digested in this manner, were analyzed for heavy metal concentrations using an inductively coupled plasma spectrometer, Jarrel-Ash, Model 750 Autocomp, following the addition of 5 ml of deionized water to attain a final sample volume of 50 ml. In addition to the standard background corrections used to compensate for nonspecific emission, corrections were also made for the acid and peroxide contributions to the recovered metal concentrations. The percent recovery of heavy metals from the shell and albumin-yolk mass materials using this method ranged from 91 to 96% as indicated by concurrent analyses of NBS SRM 1577 bovine liver preparations.

Mercury analyses were conducted on lyophilized shell and albumin-yolk mass samples prepared with a low-temperature digestion (Knechtel and Fraser, 1979). The percent recovery was of the same order as reported for sea turtle eggs (Stoneburner et al., 1980). The data from all of the shell analyses were pooled, and the mean and standard error of the mean were calculated. The albumin-yolk mass data were treated in the same manner. The pooled means of the shell and albumin-yolk mass samples were compared for significant differences using a *t*-test at the 0.5 level with 8 degrees of freedom. The mean concentrations of 10 heavy metals found in the shell and albumin-yolk mass samples and the results of the statistical analyses are presented in Table 1. No significant differences in heavy metal concentra-

TABLE 1. Mean heavy metal concentrations in nine American crocodile egg shells and albumin-yolk mass (μg/g dry wt.).

	Shell		Albumin-yolk mass	
	Mean	± SE	Mean	± SE
Aluminum	52.36[1]	3.57	10.86	1.61
Cadmium	1.36[1]	0.56	0.13	0.08
Cobalt	1.70	0.76	1.12	1.01
Chromium	20.46[1]	6.39	2.64	1.40
Copper	17.17[1]	3.64	6.21	1.83
Lead	16.42[1]	4.08	3.35	1.39
Mercury	0.21[1]	0.06	0.66	0.11
Molybdenum	25.43[1]	12.16	2.37	1.65
Nickel	22.04[1]	7.46	2.35	0.96
Strontium	529.50[1]	66.73	45.65	10.29

[1] Indicates significance at 0.05 level with 8 degrees of freedom.

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TABLE 2. Mean concentrations of cadmium, copper, lead, and mercury in American crocodile collections made in 1972 and 1980 ($\mu g/g$ wet weight).

	1972 collections Egg contents		1980 collections Albumin-yolk mass[1]	
	Mean	± SD	Mean	± SE
Cadmium	0.05	0.00	0.01	0.00
Copper	3.74	5.63	5.59	1.50
Lead	0.34	0.10	0.64	0.14
Mercury	0.09	0.03	0.13	0.01

[1] Data originally presented as $\mu g/g$ dry weight, Table 1.

tions were found among eggs removed from a single clutch or among the 3 clutches sampled. The metal concentrations among all eggs sampled (N = 9) appeared to be random, as indicated by the standard error statistic.

The distribution of metals in eggs has been found to be of importance regarding the reproductive success of several oviparous organisms. The concentrations of 8 of the heavy metals were significantly higher in the shell samples. In contrast, mercury concentrations were significantly higher in the albumin-yolk mass samples. Cobalt was of interest for two reasons. First, the presence of concentrations in excess of 1 $\mu g/g$ in an apparently viable population and second, the distribution of cobalt appeared to be ubiquitous with respect to the albumin-yolk mass and shell. It is interesting to note that a similar observation regarding cobalt was made on sea turtle eggs collected from Florida (Stoneburner et al., 1980). The importance of these differences, with respect to the various interrelated physiological and biochemical functions of the shell and embryo of the American crocodile, are unknown.

The data, presented in Table 1 on a $\mu g/g$ dry weight basis, were coverted to mg/g wet weight to facilitate a comparison with the 1972 data reported by Ogden et al. (1974). The transformed 1980 data (N = 9 eggs) and the 1972 data (N = 5 eggs) for cadmium, copper, lead, and mercury are presented in Table 2. Statistical treatment of the two data sets was not considered appropriate because of small sample size, differences in analytical procedures, and the inherent variability of data reported on a wet weight basis. Inspection of these data leads to the tentative conclusion that the mean concentrations of lead and mercury in the eggs of the South Florida American crocodile have increased since 1972. The data indicate that the mean concentration of cadmium decreased, while the mean concentration of copper did not change during the same 8-year period.

We found no literature on the sensitivity of crocodiles to any of the heavy metals examined. Hence, we have elected to report these data for future comparisons and not to speculate about the potential of heavy metal toxicosis or what the apparent increases of lead and mercury levels in the eggs of the American crocodile may mean regarding the future viability of the Florida Bay population.

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