The Uptake and Interorgan Distribution of Mercury in a Carnivorous Crab

Samuel N. Luoma[1]

Department of Zoology and
Water Resources Research Center
University of Hawaii
Honolulu, Hawaii
[1]*Present address: U.S. Geological Survey, 345 Middlefield Road, Menlo Park, Calif.*

Laboratory experiments indicate that trace metal flux rates from solute sources into the muscle tissue of fish (PENTREATH, 1973), molluscs (HARRISON, 1969; RITSCHARD, 1975) and crabs (HUTCHESON, 1974) are quite slow. It has been suggested that metals originating from food may accumulate more rapidly in muscle than do solute metal forms (PENTREATH, 1973; YOUNG, 1975). However, in nature, metal concentrations in muscle tissue are often higher than would be expected on the basis of flux rates from either source (LUOMA, in press). A more thorough understanding of the factors governing trace metal (and radionuclide) distributions among the tissues of commercially important aquatic species is essential.

In this study carnivorous portunid crabs (Thalamita crenata) were fed 203-Hg labelled polychaetes (Neanthes succinea) for 13 days. Interorgan distribution of the 203-Hg label in experimental crabs was compared to total Hg uptake and interorgan distributions observed in crabs from nature.

METHODS

Adult, intermoult crabs, ranging in weight from 12 g to 35 g, were maintained in the laboratory individually in one-gallon jugs of seawater (wrapped in tin-foil to minimize disturbance). The seawater was changed every other day to prevent solute 203-Hg build-up. Each crab was fed a similar mass of labelled worms daily (200-400 mg). The concentration of the labelled Hg in the worms was held as constant as possible (70$\pm$ 20 ng/g) over the 13 day course of the experiment. At the completion of the experiment the crabs were frozen, then dissected. Chela muscle, body muscle, viscera and gills were digested then analyzed for 203-Hg using liquid scintillation procedures.

Crabs were also periodically collected from an Hawaiian estuary (Ala Wai Canal) for total Hg analysis. These animals were frozen immediately after collection, and dissected prior to analysis. Thawing and refreezing (which may allow interorgan metal diffusion - MARTIN AND FLEGAL, 1975) was avoided. Total Hg analyses were conducted

Bulletin of Environmental Contamination & Toxicology,
Vol. 16, No. 6 © 1976 by Springer-Verlag New York Inc.

by cold vapor flameless atomic absorption (MANNING, 1970) after tissue digestion with concentrated sulfuric:nitric acid (2:1), potassium permanganate and potassium persulfate (KNAUER AND MARTIN,1972).

Organic Hg analyses were conducted according to a modified Westoö procedure (RIVERS, ET AL, 1972). Homogenized tissue samples (2-4 g) were extracted with benzene. The benzene phase was extracted with a 1% cysteine solution. Concentrated HCl and 6% $KMnO_4$ were added to the cysteine extract, and, after oxidation for 30 min, the samples were analyzed for Hg^{+2} using flameless atomic absorption.

RESULTS

The concentration of 203-Hg in each type of crab tissue analyzed at the end of the 13 day laboratory experiment was a function of the weight-specific feeding rate (percent whole body weight ingested per day) of the individual crabs (Fig. 1). Feeding rates ranged, among the crabs, from 0.24% to 1.44% body weight per day (0.17 ng - 1.02 ng 203-Hg ingested /g crab d^{-1}) due to variations in the weight of the different animals. The slopes of the regressions comparing feeding rate with 203-Hg uptake (Table 1) indicate Hg

Table 1

The uptake of ^{203}Hg into tissues of crabs (Thalamita crenata) fed polychaetes for 13 days, relative to ^{203}Hg concentrations (70 ppb) in the polychaetes. Minimum concentrations represent an ingestion rate of 0.24% of body weight per day or 0.17 ng ^{203}Hg per gram crab per day. Maximum concentrations represent an ingestion rate of 1.44% body weight per day or 1.2 ng ^{203}Hg per gram crab per day. Equations represent regression of uptake (Y) against weight specific ingestion rate (X) for 7 individual crabs (r = correlation coefficient). All regressions are significant ($p<0.01$).

Organ	Range of $C_{tissue}/C_{polychaete}$ [a]	Regression equations
Viscera	0.211 - 1.112	Y = 2.5 + 46.4X r = 0.84
Gills	0.006 - 0.310	Y =-2.7 + 14.2X r = 0.83
Body muscle	0.027 - 0.124	Y =-0.007 + 6.1X r = 0.94
Chela muscle	0.009 - 0.053	Y =-0.05 + 2.3X r = 0.88

[a] The concentration of ^{203}Hg in the organ of the crab relative to the concentration of the nuclide in the food of the crab.

accumulation into viscera exceeded accumulation into body muscle by 7.5 times. Uptake by viscera exceeded uptake by chela muscle by 20.9 times. Uptake by body muscle was 2.7 times that of chela muscle.

Total Hg concentrations in the tissues of crabs from Ala Wai Canal generally increased between August 15, 1973 and February 6, 1974 (Table 2). Organic Hg concentrations in pooled samples of chela and body muscle in December (13 ng/g) were similar to levels observed in February (15 ng/g). In

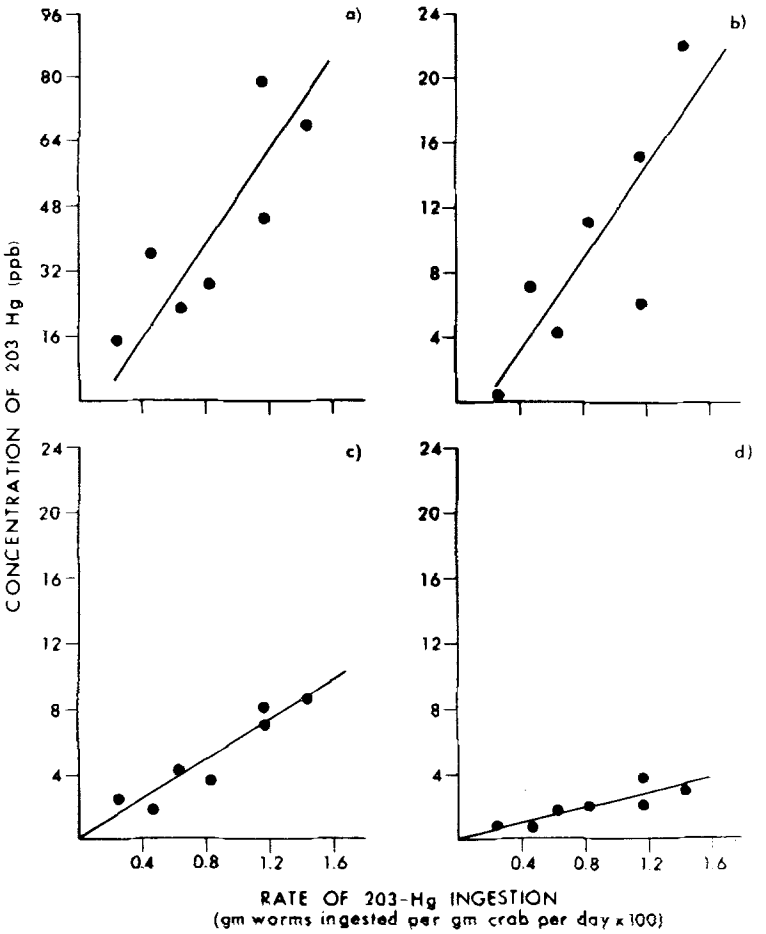

Figure 1. The concentration of 203-Hg in tissues of Thalamita crenata fed labelled polychaetes for 13 days, as a function of the weight specific feeding rate of the crabs. The concentration of 203Hg in polychaetes was held constant at 70 ppb. Each point represents a single crab. Lines were fit by linear regression. a) viscera; b)gills; c) body muscle; d) chela muscle.

contrast to laboratory studies total Hg concentrations in the body muscle of crabs from the estuary were always higher than concentrations in viscera. The rate of increase in body muscle Hg between August and February was also 1.5 times that of viscera. Total Hg partitioning between body muscle and chela muscle in December was similar to that observed in laboratory experiments. However, in both August and February chela muscle Hg concentrations were equal to those of body muscle.

DISCUSSION

During the rainy season (November - March) biologically available solute Hg enters Ala Wai Canal with storm runoff (LUOMA, 1974a). Total Hg concentrations in detritus feeders from the estuary (some of which are prey of the crab - LUOMA, 1974b) increase in response to the influx of the runoff. Increasing Hg levels in the food of T. crenata between November and February may contribute to increased tissue concentraitons of the metal in the predator. However, the more

Table 2

Total mercury concentrations in tissues of crabs collected between August 15, 1973, and February 6, 1974, from Ala Wai Canal. Numbers in parentheses indicate the number of samples from which each mean was calculated.

Date of Collection	Mean total mercury concentration ± one std. dev. (ppb)			
	Chela Muscle	Body Muscle	Viscera	Gills
Aug. 15	26 ± 8 (8)	27 ± 13 (5)	21 ± 16 (6)	
Nov. 14	32 ± 18 (3)	46 ± 32 (3)	25 ± 5 (4)	33[a]
Nov. 30		28[b] (1)	25 (1)	119 (1)
Dec. 5	20 ± 7 (2)	57 ± 37 (2)	30 ± 8 (3)	35 ± 5 (2)
Feb. 6	58 ± 22 (3)	61 ± 20 (3)	44 ± 6 (3)	88 ± 30 (3)

[a]Pooled sample of gills from three animals.

[b]Pooled sample of body muscle and chela muscle from one animal.

rapid rate of increase in crab body muscle than in viscera, which is opposite to that observed when Hg uptake is from food alone, suggests solute Hg may be the more important source of the metal over this period. High Hg levels in crab gills observed immediately after rain storms on November 30 and February 6 are also consistent with exposure to solute forms of Hg (VERNBERG AND VERNBERG, 1972).

The body muscle - chela muscle partitioning of Hg observed in December is as expected during a period of Hg uptake. However, the partitioning between these two tissues in August (near the end of the dry season) and February (after 2 1/2 months of the rainy season) indicates that, after a sufficient period of exposure to Hg, levels in chela muscle will reach those of body muscle. However, there appears to be a lag in translocation of Hg from the environmental interface of the animal to the chela muscle. If a similar lag occurs in metal translocation to slowly exchanging tissues in other animals, short term laboratory experiments may underestimate the potential for contamination of such tissues.

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