THE USE OF MERCURY AND STABLE ISOTOPES

TO INVESTIGATE FOOD CHAIN STRUCTURE

IN AQUATIC ECOSYSTEMS IN THE AMAZONIA

Mario J. F. Thomé-Souza
Instituto Nacional de Pesquisas da Amazônia
Alameda Cosme Ferreira, 1756, Manaus, AM
thome@inpa.gov.br

Bruce Rider Forsberg
Instituto Nacional de Pesquisas da Amazônia
forsberg@horizon.com.br

Richard Carl Vogt
Instituto Nacional de Pesquisas da Amazônia

Maria das Graças Pires Sabbayrolles
Universidade Federal do Pará; Campus-Santarém.

José Reinaldo Pacheco Peleja
Instituto Nacional de Pesquisas da Amazônia

Introduction

$\delta^{15}N$ has been used as an indicator of trophic level in many food chain studies because of the large isotopic fractionation which occurs as nitrogen passes between trophic levels (Leite, et al., 2002; Hamilton et al., 1992). The natural variation in stable carbon isotope ratios, $\delta^{13}C$, has also been used as a tracer of autotrophic carbon sources in these studies (Araujo-Lima et al., 1986; Forsberg et al., 1993). $\delta^{15}N$ has been shown to be a poor indicator of trophic level in Amazonian ecosystems due to the large isotopic variation encountered between plants at the base of the aquatic food webs (Victoria et al., 1992). Total mercury concentrations also accumulate consistently through the aquatic food chain and have been shown to vary little among aquatic plants in the Amazon. Here we demonstrate the potential of using mercury as a trophic level indicator and the

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value of using mercury together with $\delta^{13}C$ to investigate the structure of aquatic food chains in the Amazon River basin.

Methodology

To test this methodology, we collected aquatic plants and animals along the main channel of the Rio Negro and analyzed them for δ^{13} C, $\delta^{15}N$ and total mercury concentration. In total, 180 samples were collected, including 33 flooded forest tree leaf, 33 periphyton, 68 benthic fish, 25 large catfish and 21 turtle samples. Most of these samples were collected during the high water periods of 1997, 1999 and 2000. Periphytic algae were collected on the margins of rivers and streams where they grew attached to submerged tree branches. Benthic fish and large catfish were collected with a deep trawl deployed at depths varying from 5 - 15 m. Twenty eight species of benthic fish were collected, predominantly Gymnotiformes and Siluriformes, but with numerically significant contributions from the Clupeiformes and Perciformes as well. Four species of large catfish were collected, *Pseudoplatystoma trigrinum*, *Pseudoplatystoma fasciatum*, *Brachyplatystoma filamentosum* and *Phractocephalus hemiliopterus*. Two species of turtles were collected, *Podocmenis erythrocephala* and *Peltocephalus dumeriliana*. Fish and turtle flesh, tree leaves, and algae were dried at 60°C and then ground with mortar and pestle to a fine powder. Subsamples were analyzed for total Hg, following acid digestion, by cold vapor atomic fluorescence Spectroscopy (CVAFS) at the Universidade Federal do Para in Santarém, Para. Additional sub samples were analyzed for stable isotopes of carbon and nitrogen by mass spectrometry at the Centro de Energia Nuclear na Agricultura in Piracicaba, São Paulo, following methodology described by Forsberg et al., (1993). Results for different groups of plants and animals were compared using the SNK test ($P<0.05$).

Results

Mercury concentrations in the tissues of the organisms demonstrated bioaccumulation along the food chain with average values ($\pm$ standard error) of 0.03±0.01, 0.04±0.01, 0.11±0.01, 0.16±0.02 and 0.53±0.05 ppm for forest leaves, periphytic algae, turtles, benthic-fish and big-catfish, respectively. The SNK test indicated that the mercury levels of periphyton, tree leaves and turtles were not significantly different but were all significantly lower than those of

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large catfish. The mercury concentrations of benthic fish were significantly higher than those of both plant groups, significantly lower than those of the large predatory catfish and similar to those of turtles. A rough positive correlation was found between the levels of mercury and $\delta^{15}N$ for all samples (Figure 1).

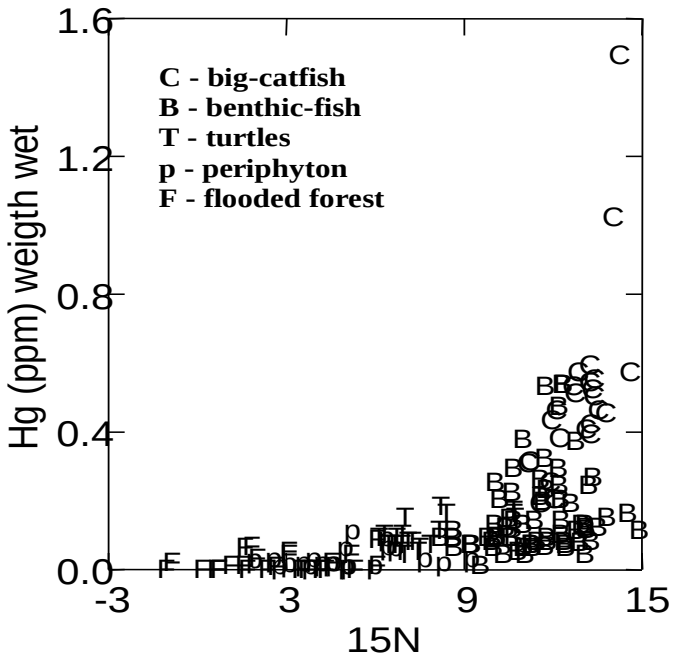

Figure 1. Relationships between total mercury (Hg) and $\delta^{15}N$ levels for plants and consumers of the Rio Negro.

The small variation in mercury relative to $\delta^{15}N$ values for plants together with the consistent increase in mercury levels with known trophic level apparent in this figure indicates the superiority of mercury as an indicator of trophic level in this system. The two turtle species included in the study were predominantly herbivorous. Assuming that the average increase in mercury in these species

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relative to aquatic plants (0.075 ppm) represents a constant bioaccumulation rate per trophic level in the food chain, we classified turtles, benthic fish, and large catfish as herbivores, omnivore/predator 1 and predator 5, respectively, based on the average mercury level of each group (Figure 2). The average $\delta^{13}C$ values (± SE) determined for leaves, periphyton, benthic-fish, big-catfish and turtles were -30.24±0.25, -38.40±0.7, -33.65±0.38, -32.26±0.37 and -31.36±0.39‰, respectively. The $\delta^{13}C$ values of all consumers all between the average values for plants indicating that their carbon was derived from a mixture of these two autotrophic sources. Turtles and large catfish derived their carbon predominantly from igapo forest trees while benthic fish showed a much larger contribution from periphytic algae. When the results for both $\delta^{13}C$ and mercury were plotted on the same graph (Figure 2) the trophic level and autotrophic carbon sources of aquatic consumers were clearly evident.

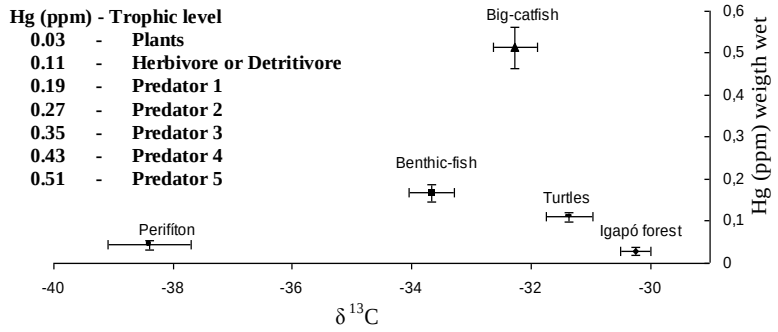

Figure 2. Average levels of total Hg and $\delta^{13}C$ (± Standard Error) for aquatic plants and consumers of the Rio Negro food web, indicating the trophic level and autotrophic carbon sources of consumers.

Conclusion

These preliminary results demonstrated the superiority of total mercury as an indicator of trophic level in aquatic food webs in the Amazon when compared to the traditional $\delta^{15}N$ index. When total mercury and $\delta^{13}C$ were used together, they provided a clear picture of both the trophic level and autotrophic carbon

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sources of aquatic consumers. Results from the rio Negro indicated that turtles were herbivores and derived their carbon predominantly from flooded forest trees. The majority of the fish analyzed were predators and derived their carbon either predominantly from flooded forest trees (large catfish) or from a mixture of this source and periphytic algae.

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