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Review

An exploratory study of total mercury levels in archaeological caribou hair from northwest alaska

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Abstract

Over the past ten years, total mercury (THg) levels have been surveyed in Alaskan wildlife and fish as part of the Arctic Monitoring and Assessment (AMAP). Beyond these studies there is little historical data on THg levels in important subsistence species for people in Alaska. A survey of THg in caribou hair from archaeological deposits would provide data to develop temporal trends for this region of the Arctic. Caribou hair from a Western Thule settlement beneath the Alaska native village of Deering (ca. AD 1150) show variability in hair THg values, with a mean level (86 ng/g) which is in the range that is observed in modern *Rangifer* sp. (caribou and reindeer). Hair from House 1 had a THg mean level of 99.6 ng/g and hair from House 2 had a THg mean of 64.2 ng/g. This is the earliest reported record of mercury in caribou associated with human subsistence activities in the western North American Arctic, and is a first step toward compilation of a needed database through which to measure and evaluate exposure to mercury by people who rely heavily on caribou as a food source. We hypothesize that similarity in mercury values in archaeological samples of caribou and in contemporary samples would give an additional perspective on human exposure to mercury through caribou harvest and consumption today. Since this hypothesis will be more useful if evaluated at a regional rather than global scale, further studies will be needed at different archaeological sites across Alaska to determine the generality of this observation in relation to geographic scale.

Keywords: Alaska; Caribou; Rangifer; Hair; Mercury; Deering; Archaeofauna; Beringia

Contents

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1. Introduction

Among a host of potential individual and systemic variables, both ecosystem and community health are linked to small and large-scale industrial developments, commercial enterprises, and anthropogenic pollutant outputs (AMAP, 2003; Van Oostdam et al., 2005). The bioaccumulation of metals as contaminants, especially mercury (Hg), continues to be a global concern, but one with regional ramifications. Hg exposure risk over time and space is a significant environmental health issue in Alaska today (Rothschild and Duffy, 2002; Jewett et al., 2003; Dehn et al., 2006). Mercury poisoning may cause paresthesia and tunnel vision, and have other adverse effects on health as well as a negative influence on fetal growth, development and survival (Grandjean et al., 1997; Grandjean et al., 2004).

Data on total Hg (THg) in ancient biological samples is useful for identifying temporal patterns in concentrations and variations in THg input sources, and for modeling the possible effects of anthropogenic sources (Outridge et al., 2005; Braune et al., 2005). Past studies of Hg accumulation in arctic food chains and temporal trends in heavy metal accumulation are focused mostly on aquatic and marine biota (Outridge et al., 2000; Beckmen et al., 2002; Outridge et al., 2002; Braune et al., 2005; Campbell et al., 2005), while information on contaminants levels in terrestrial wildlife species in circumpolar regions is less abundant (Elkin and Bethke, 1995; Aastrup et al., 2000; Larter and Nagy, 2000; Duffy et al., 2001; Robillard et al., 2002; Duffy et al., 2005). Some data on temporal trends of Hg in wildlife of the north exist (Outridge et al., 2002; Gamberg et al., 2005) but more studies are needed to understand long term patterns of accumulation.

The transport of Hg from plant and seed biomass to larger terrestrial herbivores is low when compared with conversions in marine systems (Froslie et al., 1984; Gamberg et al., 2005), although high consumption rates of grasses and lichens among arctic herbivores may intensify Hg uptake (Larter and Nagy, 2000). Among the many mammal and bird species of potential concern for human health issues, *Rangifer* sp. (caribou and reindeer) are particularly important because they served and continue to serve as a food staple in circumpolar regions. Caribou and reindeer are associated with the taiga and tundra biomes where they are known to favor low-growing species such as sedges and cotton grasses which are a major component in the summer diet, and lichens which are more important in the winter diet of caribou (Aastrup et al., 2000; Robillard et al., 2001).

Hg reaches caribou and reindeer via the food chain (Gamberg and Braune, 1999). Their food sources, especially lichens, are hypothesized to have become increasingly contaminated as new Hg is input to the Arctic from global industrialization. Hg that is absorbed by plants and ingested by caribou accumulates in tissue and organs (Gamberg et al., 2005), resulting in biomagnification, a trophic process in which retained substances become more concentrated with each increase in food chain trophic levels (AMAP, 2003). It is not known if Hg levels in Alaskan caribou are increasing compared to levels in the past as there are few temporal studies of Hg levels in Alaska. For Canada, Outridge et al., 2002; Outridge et al., 2005 reported that in both *Odobenus rosmarus* (walrus) and *Delphinapterus leucas* (beluga whales), concentrations of mercury and some other metals in teeth are now similar to or higher than concentrations in historical specimens, suggesting that the current levels in marine mammals in some arctic regions result from increased output from industrial sources.

In terrestrial settings, the concentration of mercury in caribou hair offers a means of measuring variation in Hg bioaccumulation (Duffy et al., 2001; Duffy et al., 2005), and in selected samples the MeHg levels in reindeer hair is approximately 79% of THg (range 58%–97%), (Duffy et al., 2005). In the present study, we report the levels of THg in almost a thousand year old caribou hair samples from northwestern Alaska.

2. Materials and methods

2.1. Sample descriptions and context

The 37 samples of prehistoric caribou hair used in this study were recovered from two discrete archaeological house deposits located in Deering, Alaska (Fig. 1). Deering is located on the northern Seward Peninsula, within an area of discontinuous permafrost, with mean annual temperatures between −4°C and −8 °C, and mean annual precipitation of 130–150 mm. Vegetation is described as shrub tundra, with the spruce tree line about 75 km to the east (Hulten, 1968; Matthews, 1974). The modern village of Deering is built upon a gravel and sand spit that has been aggrading for over two thousand years. The 2 km long spit has a maximum height of 4.3 m ASL and has formed via a combination of eastward longshore sediment flow derived from bluff erosion, replenished periodically by storm surges. It forms a barrier that tends to impound sediments from the northward flowing Inmachuk River and it's tributary, Smith Creek. Surficial sediments comprise a series of gravel and sand beds, capped in places by sand dunes (Bowers et al., 1999; Bowers, 2006).

Bedrock in the region consists of Paleozoic metalimestone and schistose pelitic rocks. Thick deposits of Quater-