THE AMERICAN DIPPER AS A BIOINDICATOR OF SELENIUM CONTAMINATION IN A COAL MINE-AFFECTED STREAM IN WEST-CENTRAL ALBERTA, CANADA

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Abstract. Elevated levels of selenium have been found in water and aquatic biota downstream from two open-pit coal mines in the Rocky Mountain foothills of Alberta. Birds are particularly sensitive to excessive dietary selenium. However, there is relatively little information on selenium accumulation in birds’ eggs on fast-flowing mountain streams. We determined levels of selenium in water samples, caddisfly larvae and eggs of American dippers (Cinclus mexicanus) nesting on the Gregg River, downstream from the mines, and on reference streams in the same general vicinity. Selenium levels (mean, 95% confidence limits) in water samples and caddisflies collected from sites near dipper nests on the Gregg River (water: 4.26, 1.90–9.56 μg L⁻¹; caddisflies: 8.43, 7.51–9.46 μg g dry wt⁻¹) were greater than those collected from sites near nests on reference rivers (water: 0.38, 0.21–0.71 μg L⁻¹; caddisflies: 4.65, 4.35–4.97 μg g dry wt⁻¹). The mean (±1SE) selenium level in dipper eggs from the Gregg River (6.3 ± 0.2 μg g⁻¹ dry wt) was significantly higher than it was in eggs from reference streams (4.9 ± 0.2 μg g⁻¹ dry wt). Concentrations of selenium in eggs were significantly correlated with those in water samples (r = 0.45). The maximum selenium level in eggs from the Gregg River (9.0 μg g⁻¹) may have been high enough to warrant concern from an ecotoxicological perspective. The American dipper can serve as a useful bioindicator of selenium contamination in mountainous, lotic ecosystems.

Keywords: selenium, coal mining, Alberta, birds, American dippers

1. Introduction

Coal is mined in the Rocky Mountains of Alberta and British Columbia, mainly at a small number of large open-pit mines (Ryan and Dittrick, 2000; Alberta Energy, 2005). At open-pit mines, large quantities of soil and rock are disturbed by various mining activities that can expose the overburden to air and surface waters. Waste materials are generally deposited on the surface in tailings piles, ponds, landfills, dumps and rock drains. Surface waters may drain from these deposits into nearby aquatic ecosystems and eventually into streams that drain the local watershed (Hamilton and Buhl, 2004).

There is concern that open-pit coal mines in the Rocky Mountains of Canada can mobilize selenium into fast-flowing streams in greater quantities than would normally occur in a natural setting (Casey and Siwik, 2000; McDonald and Strosher, 2000).
Lemly (1999) proposed that selenium should not bioaccumulate to as significant a degree in fast-flowing streams as in lentic ecosystems. In support of his proposal, Adams et al. (2000) found that selenium bioaccumulation factors in fish from lotic environments were about ten-fold lower than those in fish from lentic environments and that fish tissue selenium concentrations remained relatively low and constant across a range of water concentrations up to 13 μg L⁻¹. In addition, Orr et al. (2005) have recently shown that biota in coal mine-affected lentic systems accumulated more selenium than those in coal mine-affected lotic systems. However, contrasting with these results and fueling concern about potential effects of coal mining on selenium mobilization and bioaccumulation, are studies that reported increased levels of selenium in fish at sites downstream from coal mines in the Rocky Mountains of Canada (Kennedy et al., 2000; Palace et al., 2004; Holm et al., 2005). One of those studies reported a significant, selenium-dependent increase in deformities in trout fry hatched from fertilized eggs of fish from coal mine-affected streams (Holm et al., 2005), heightening to an even greater extent the level of concern about possible coal mining effects.

Bird eggs are exposed to selenium by maternal transfer of organoselenium accumulated by the female through her diet (Ohlendorf, 1996). Bird eggs are sensitive to selenium toxicity (Ohlendorf et al., 1986; Heinz et al., 1989; Skorupa and Ohendorf, 1991; Adams et al., 1998). Therefore, elevated levels of selenium in streams draining coal mines could impair the reproductive success of species of aquatic birds attempting to breed there. Such species include the American dipper (Cinclus mexicanus), the spotted sandpiper (Actitis macularia) and the harlequin duck (Histrionicus histrionicus), a species designated as ‘sensitive’ in the province of Alberta because of concern about possible long-term population declines (MacCallum, 2001).

The American dipper is an aquatic bird that occurs on fast-flowing, clear streams (Kingery, 1996). It feeds mainly on immature aquatic insects, which serve as a dietary source of selenium. During the breeding season, dippers establish territories along streams in close proximity to their nests (Kingery, 1996). Its animal diet and territoriality make the American dipper a potentially useful avian bioindicator species for contaminants that are transferred through stream food chains. The closely-related Eurasian dipper (C. cinclus) has been used as an indicator of stream quality in Europe for many years (Ormerod and Tyler, 1987, 1990; O’Halloran et al., 2003). In North America, the use of dippers as indicators of stream quality is a more recent phenomenon (Strom et al., 2002; Feck and Hall, 2004; Morrissey et al., 2004, 2005). Harding et al. (2005) examined dipper reproductive performance and selenium levels in dipper eggs on streams located downstream from coal mines in south-eastern British Columbia. They reported that selenium levels were not higher in dipper eggs from nests on coal mine-affected streams than in eggs from nests on reference streams, a phenomenon they attributed, in part, to the low bioaccumulation rates inherent in lotic ecosystems.