

Accumulation of heavy metals in circumpolar willow ptarmigan (*Lagopus l. lagopus*) populations

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Received 10 May 2006; received in revised form 5 September 2006; accepted 6 September 2006

Available online 18 October 2006

Abstract

A circumpolar survey of heavy metals in willow ptarmigan liver and kidney revealed considerable variations in Cd content in Canada and Scandinavia. The Cd content in central Canada was comparable with that in Scandinavia and Russia, at least for kidney. However, in both liver and kidney the median for Canada as a whole was much higher than in the other countries. Some Canadian locations had exceptionally high levels, several birds having $>50 \text{ mg kg}^{-1}$ in liver and $>400 \text{ mg kg}^{-1}$ in kidney. In Norway, the Cd content was highest in central mountain areas in south Norway and inland locations in the two northernmost counties. Five locations in central and north Norway showed mean Cd levels in kidney above 100 mg kg^{-1} . It is difficult to evaluate regional differences in Sweden, but most locations had the same Cd level as moderately contaminated locations in Norway. Cd levels in Russia were comparable to moderately contaminated locations in the other countries. Due to a high intake of willow, naturally rich in Cd, direct comparison of the Cd level in willow ptarmigan from different locations cannot reveal the effects of long-range pollution.

The Pb concentration in willow ptarmigan kidney and liver varied significantly in Norway and Canada, but not in Sweden and Russia. Levels in Sweden and Russia were comparable to those in Canada and low levels in Norway. The highest median value from all locations within countries was found in Norway, both in liver and kidney. The highest Pb content was found in south Norway, indicating an effect of long-range pollution in willow ptarmigan. The level in western Canada was significantly higher than in central Canada.

The Hg content in liver varied significantly from one location to another in all the countries and in kidney everywhere except Sweden. In Scandinavia, there is no distinct regional pattern. Canada had a significantly higher Hg level in central than western regions in both tissues the opposite of that found for Cd and Pb.

Cu and Zn showed significant variations from one location to another in liver and kidney in Canada and Norway, but only in kidney in samples from Sweden. Comparison between western and central Canada revealed a significant difference for Cu in liver, samples from central Canada having more. There are no significant differences from one country to another, but some localities in Canada seem to have higher Cu concentrations in kidney than are found in Scandinavia and Russia.

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Keywords: Cadmium; Lead; Mercury; Copper; Zinc; Terrestrial environment; Circumpolar mapping; Willow ptarmigan; *Lagopus lagopus*; AMAP

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1. Introduction

Over much of the Arctic, long-range atmospheric transport of contaminants from industrial sources in Europe and North America accounts for a substantial part of the heavy metal deposition (AMAP, 1998). This is well documented for southern Scandinavia, which has been affected by long-range atmospheric transport of heavy metals from central Europe for several decades (Steinnes, 1987; Steinnes et al., 1989; Dunlap et al., 1999). Previous studies have shown elevated cadmium (Cd) and lead (Pb) levels in various game species in southern Norway (Frøslie et al., 1986; Fimreite et al., 1990; Kålås and Lierhagen, 1992). The highest levels have been found in rock ptarmigan (*Lagopus muta*) and willow ptarmigan (*Lagopus lagopus*). Similar elevated levels of heavy metals have been found in ptarmigan from arctic North America (Snyder-Conn and Lubinski, 1993; Gamberg, 1998). As the willow ptarmigan is a key species in the arctic–alpine ecosystem, having a profound effect on several other species and a wide distribution in addition to being one of the most important game species in Norway, it was selected for inclusion in the Norwegian Monitoring Programme for Terrestrial Ecosystems (Løbersli, 1989).

Several studies have shown that elevated levels of heavy metals may give lethal or sub-lethal effects in birds and mammals. Known effects include reduced growth, anaemia, kidney lesions, testicular damage and behavioural effects (Sarkar and Mondal, 1973; Richardson et al., 1974; Cain et al., 1983; Wren, 1983; Eisler, 1985, 1987, 1988; Scheuhammer, 1987, 1991; Pedersen and Sæther, 1999). A countrywide survey was carried out in Norway in 1990–1991 to map the incidence of various

heavy metals in small game species (mountain hare (*Lepus timidus*), black grouse (*Tetrao tetrix*) and willow ptarmigan) (Kålås and Lierhagen, 1992). No abnormal levels of copper (Cu), zinc (Zn) or mercury (Hg) were found in willow ptarmigan. Considerable variation between locations was found for both cadmium (Cd) and lead (Pb). However, whereas Pb, as expected, showed a clear regional pattern, with the highest concentrations in the most southern areas, Cd did not show such a pattern (Kålås and Lierhagen, 1992).

The willow ptarmigan, like the reindeer/caribou (*Rangifer* spp.), is one of very few species with a circumpolar distribution in the arctic–alpine environment throughout the year. Like the reindeer/caribou, the willow ptarmigan is very suitable for mapping the heavy metal load in a key herbivore in this system. To survey the “health” of this vulnerable environment, it is important not only to analyse snow samples and the chemistry of precipitation, but also the biotic components.

As part of the international “Arctic Monitoring and Assessment Programme (AMAP)”, circumpolar mapping of heavy metals in willow ptarmigan liver and kidney started in 1992. The results of mapping cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg) and zinc (Zn) at locations in Canada, Norway, Russia and Sweden are presented here.

2. Material and methods

2.1. Willow ptarmigan sample collection

In Canada, liver and kidney samples were collected from 29 willow ptarmigan from Chilkat Pass in north-

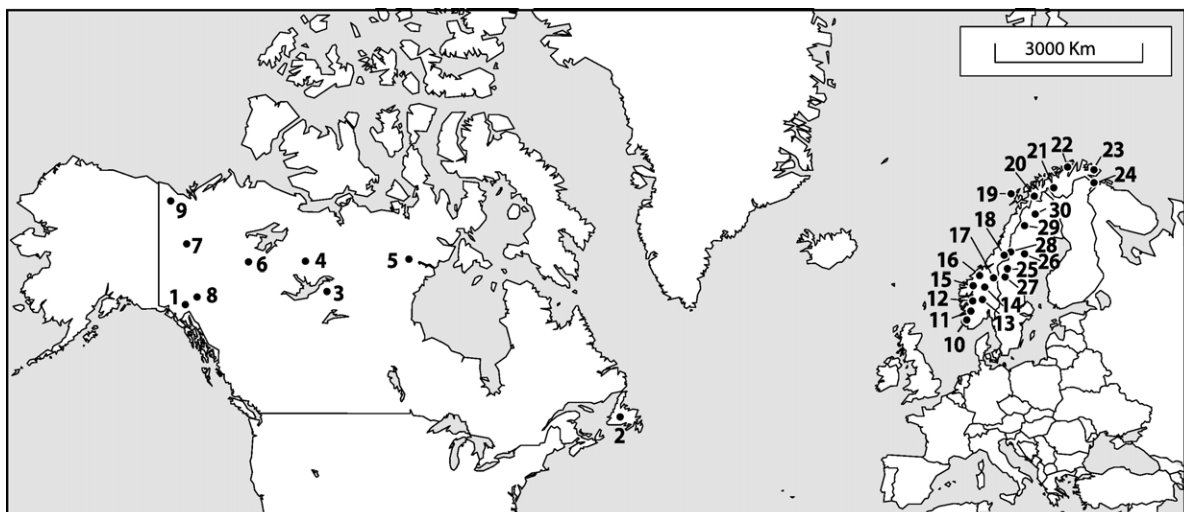


Fig. 1. Distribution of willow ptarmigan sampling localities. The numbers on the map correspond to the numbers in Table 1.

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