Contaminants in Yukon Moose and Caribou - 1997

Mary Gamberg
Gamberg Consulting
RR1, Site 20, Comp 460
Whitehorse, Yukon
Y1A 4Z6

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EXECUTIVE SUMMARY

This project is part of the ongoing monitoring of contaminants in Yukon wildlife that started in 1992 with a study of the Finlayson caribou herd, continued with a comprehensive look at contaminants in country foods, and is now monitoring temporal trends using moose and caribou as key species.

Yukon hunters were requested to submit kidney, liver and muscle samples, as well as an incisor, from moose and caribou killed during the 1997 hunting season. The incentive for the submissions was a chance at a free charter flight. Each hunter's name was put in the draw once for each tissue submitted, and one extra time if all samples requested were provided. The winner this year was Darren Shipman of Whitehorse, and the charter flight will be provided by Coyote Air Service Ltd.

Samples were submitted from 97 moose, 127 caribou and 1 Dall sheep. The incisor was used to age the animal, and kidney samples were analyzed for 26 elements by Elemental Research Laboratories Inc. in Vancouver, BC. Liver, muscle and some kidney samples were archived in freezers for possible future analysis. Although data for all 26 elements are presented in this report, only elements of interest are discussed (arsenic, cadmium, copper, lead, mercury, selenium and zinc).

Because of potential differences among caribou herds, and low numbers of aged caribou from each herd, only moose and Porcupine caribou were used to test the effect of age on element concentration. Renal cadmium increased with age in moose, while kidney copper decreased with age. These trends existed in the Porcupine caribou but were not significant, probably because of the low sample size of 10.

Data collected in 1996 were compared to data from the current year to determine if element concentrations are changing over time. Copper, lead and zinc concentrations in moose kidneys were higher in 1996 than in 1997, while arsenic levels were higher in 1997. In caribou, copper, selenium and zinc concentrations were all higher in 1996, while, as with moose, arsenic levels were higher in 1997. In all cases the differences between years are small and levels are well within normal ranges, so the biological significance of the differences is minimal at best.

Renal arsenic and lead levels found in this study were consistently low and should be considered background levels. Kidney copper, selenium and zinc concentrations were all found at normal levels.

Cadmium levels were highest in the Finlayson and Tay caribou herd and in moose, while concentrations in the Porcupine and Bonnet Plume caribou herds were lower and more similar to other arctic caribou. Levels in the Hart River herd spanned the difference between the two groups and the individual Dall sheep in this study had a notably low concentration of cadmium. Although there is no evidence from this study that cadmium levels are causing renal stress in these animals, the 1996 study indicated that there may be a small number of moose who may experience some renal dysfunction as a result of high cadmium concentrations in their kidneys. Health Canada has evaluated the previous work of this type in the Yukon and recommended limiting consumption of kidneys from moose and caribou among other species. The data from this year's study showed that the level of cadmium in moose and caribou has not changed over the last year, so the recommendations should still be relevant.

Kidney mercury concentrations in caribou and Dall sheep were somewhat higher than in moose. Previous work has shown that methylmercury concentrations in Porcupine caribou kidneys were below detection limits, indicating that the mercury present was in the less toxic form of inorganic mercury. It is likely that observed high levels of cadmium and mercury in the Canadian arctic reflect naturally occurring geological sources rather than industrial pollution, and concentrations found in this study should be considered background levels.

For the most part, element concentrations found in Yukon moose and caribou kidneys are at background levels and are not of concern to the animals themselves, or those who consume them. Those concerned about the consumption of cadmium or mercury from moose or caribou should follow the guidelines provided by Health Canada.

INTRODUCTION

This project is part of the ongoing monitoring of contaminants in Yukon wildlife that started in 1992 with a study of the Finlayson caribou herd (Gamberg, 1993), continued with a comprehensive look at contaminants in country foods (Gamberg, unpubl. data), and is now monitoring temporal trends using moose and caribou as key species (Gamberg, 1997).

METHODS

Collections

Yukon hunters were requested to submit kidney, liver and muscle samples, as well as an incisor, from moose and caribou killed during the 1997 hunting season. The request was advertised by posters and newspaper and radio ads and was done with the assistance of the Communications Coordinator at Renewable Resources in Whitehorse. The incentive for the submissions was a chance at a free charter flight. Each hunter's name was put in the draw once for each tissue submitted, and one extra time if all samples requested were provided. The draw was made by Watson Lake mayor Dave Kalles, and the winner was Darren Shipman of Whitehorse. The charter flight will be provided by Coyote Air Service Ltd. and will be to a maximum of $1000.00. Coyote Air generously donated half the cost of the flight to the project.

Hunters submitted their samples to their local Renewable Resources office where a sample form was filled out with details of date and location of the kill, sex of the animal, tissues submitted and name and address of the hunter. All samples were stored in freezers until processed.

Each hunter submitting samples was sent a letter thanking them, giving them the age of their animal if they submitted a tooth and telling them what the project was about. A brief background of cadmium in Yukon wildlife was included, as well as the consumption recommendations from Health Canada. Samples of the letter, the background and the recommendations may be found in appendices 1-3.

Tissue Processing and Analysis

If incisor bars or entire jaws were submitted, an incisor was extracted and cleaned of extraneous tissue. If possible, age was determined from tooth eruption patterns. Otherwise, caribou incisors were aged using the cementum technique by Matson's Laboratory in Milltown, Montana. Moose incisors were aged using the same technique by the author.

Kidneys were cleaned of extraneous tissue and the kidney capsule carefully removed. If the kidney was damaged (i.e. sliced or in pieces), or the capsule was torn or missing, the tissue was rinsed with distilled water. Only entire kidneys that were submitted with a tooth for aging were used for analysis. Samples from the Porcupine caribou herd from 1994 and 1995 were archived for possible future analysis if and when extra funds become available, while the 1997 kidney samples were analyzed. Outer portions of each liver and muscle sample were removed leaving 'clean' subsamples which were then archived in freezers for possible future analysis. Kidney samples were homogenized and analyzed for 26 elements by Elemental Research Laboratories Inc. in Vancouver, BC, using the inductively coupled plasma with mass spectroscopy technique. All tissue processing and analysis (with the exception of the teeth) were done under clean laboratory conditions to minimize external contamination of the tissue. All results are reported on a dry weight basis.

Statistical Analysis

Data was analyzed separately for moose and caribou. Dall sheep had a sample size of one, and so it was not included in the analyses. Because the data were not normally distributed, the Mann-Whitney Rank Sum Test was used to test differences in element concentrations between moose collected in 1997 and 1996 (1996 moose data [N=63] from Gamberg, 1997). When there was a difference between years, only 1997 data were used to determine the relationship between age and element concentration. If there was no difference between years, 1996 and 1997 data were combined to increase the power of the test. When the data were not normally distributed, the test used was a Spearman Rank Order Correlation, and if the data were normal, a linear regression was used (this was only in the case of zinc).

Because caribou herd has been shown to have a significant effect on some element concentrations (Gamberg, 1998), herd should be considered in this analysis as a potential significant effect on element concentrations. Unfortunately, only the Porcupine herd had a sample size greater than three, so the effect of herd was not tested. As with moose, the Mann-Whitney Rank Sum Test was used to test differences between data collected from 1996 and 1997 (1996 data [N=25] from Gamberg, 1997), to account for nonnormal data. Data for mercury was the exception, being normally distributed, and in this case, a t-test was used. The effect of age on element concentration was also tested using the 1997 Porcupine caribou data, although ages were only available for 10 animals, so negative results must be viewed with caution. All these data were normally distributed, so a linear regression was used to test the relationship.

In all analyses, half the detection limit was used in calculations to replace values below the detection limit. In all cases the criterion for significant effects was α=0.05, except in the case of tests of normality where α=0.10.

RESULTS

Hunter Response

Samples were submitted from 97 moose, 127 caribou and 1 Dall sheep. Of these, all the moose, 26 caribou and the sheep samples were contributed by hunters. One caribou sample was submitted by a YTG conservation officer from a hunter kill, and the remaining 100 caribou samples were provided by a YTG Renewable Resources biologist as part of an ongoing body condition study of the Porcupine caribou herd. Forty-three of the Porcupine herd samples were from the current year, and the remaining samples were stored tissues from 1994 and 1995. Teeth were submitted for 69 moose and 21 caribou. Hunters estimated ages for an additional three young moose. Ages should eventually be available for the 100 Porcupine caribou sampled by YTG, but are not at this time.

Of the 225 submissions, 68% included liver, 84% included kidney, 44% included muscle, 77% included a tooth, and 33% included all four tissues. 1% of submissions only included teeth and 6% of the kidneys submitted were unable to be analyzed.

Tissue Analysis - Quality Control

Samples were analyzed in 4 batches with 1 preparation blank, 1-2 standards and 2-3 duplicates included in each batch. All element concentrations were below detection limits in all preparation blanks. Recovery of standards ranged from 85-116% and averaged 94%., while differences between duplicate samples averaged 5% and ranged from 0-15% (with the exception of one pair of duplicates which had a difference of 40% for arsenic). When two kidneys were submitted from one animal, both kidneys were submitted for analysis under different sample numbers as ‘blind’ replicates. In total, 5 pairs of blinds were analyzed. Differences between pairs of blinds were greater than between pairs of duplicates (subsamples from the same homogenized kidney), which is to be expected. Differences between pairs of blinds ranged from 0-121% and averaged 23%. It should be noted that the pairs showing large differences usually had low concentrations of the element in question.

These results are within acceptable parameters for quality control of analysis. All quality control data may be found in Appendix 4.

Relationship between age and element concentration

Age was positively correlated with cadmium in moose (Fig. 1). This relationship has been extensively described in the literature (Brazil and Ferguson, 1989; Crete et al., 1987, 1989; Froslie et al., 1986; Gamberg and Scheuhammer, 1994; Glooschenko et al., 1988), but was not evident in the Porcupine caribou from this study. Since a positive relationship between age and cadmium was described by Gamberg and Scheuhammer (1994), for the Porcupine caribou herd, it is likely that the small sample size used in the analysis in this study (N=10) was too small to discern the relationship.

Renal copper decreased with age in moose from this study (Fig. 2), and although this trend was seen in moose from 1996, the relationship was not significant (Gamberg, 1997). Puls (1994) described the same relationship in deer, but since the range of renal copper levels found in moose in this study was quite small, the import of the relationship is largely academic.

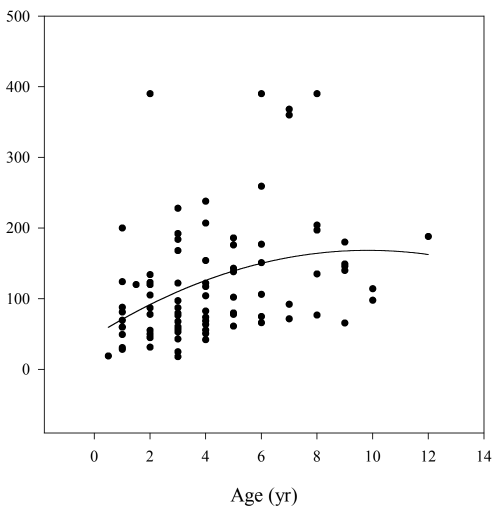

Figure 1. Cadmium concentrations in moose kidneys. (1996 and 1997 data used).

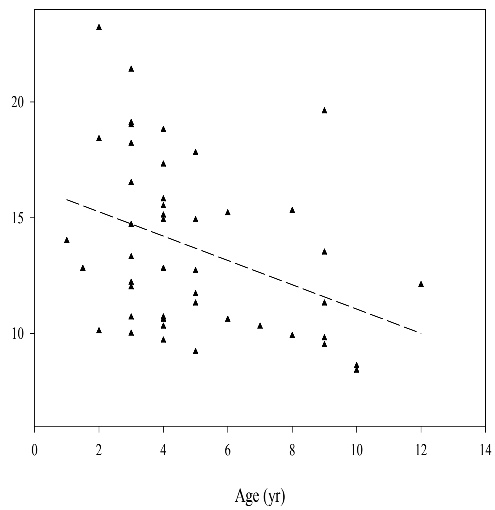

Figure 2. Copper concentrations in moose kidneys. (Only 1997 data used).

Relationship between year of collection and element concentration

Copper, lead and zinc concentrations in moose kidneys were higher in 1996 than in 1997, while arsenic levels were higher in 1997 (Figure 3). One outlier was removed from this data set. In caribou copper, selenium and zinc concentrations were all higher in 1996, while, as with moose, arsenic levels were higher in 1997. (Figure 3). In all cases the ranges from year to year are small and well within normal ranges, so the biological significance of the differences is minimal at best.

Individual Elements

All elements were discussed in detail as they related to moose and caribou in the 1996 report (Gamberg, 1997). Most of these elements were at background levels and posed no threat to the animals themselves, or to consumers of the animals. Although data for all 26 elements are presented in this report (Table 1), only elements of interest will be discussed (arsenic, cadmium, copper, lead, mercury, selenium and zinc).

Although arsenic is generally considered a non-essential element, it has recently been identified as an essential trace element for domestic goats (Puls, 1994). It can be absorbed by ingestion, inhalation and permeation of skin or mucous membranes and accumulates in the liver, kidney, spleen, muscle, skin and hair. Toxic effects include respiratory cancer, peripheral nervous system disorders and dermatitis (Jaworski, 1980). Toxicity depends on the concentration and form, trivalent arsenic (arsenite) being 5 to 10 times more toxic than pentavalent (arsenate). Elemental arsenic is non-toxic. Since the use of arsenic in herbicides, insecticides, fungicides and rodenticides has been largely discontinued, the main sources of arsenic to the environment are mine tailings, smelter waste and natural mineralizations (Jaworski, 1980).

Kidney arsenic concentrations in this study ranged from a mean of 0.05 ppm in the Pelly caribou to 0.69 in an individual Dall Sheep (Table 1). Although average levels for moose and caribou are slightly higher than found for the same species in 1996 (Fig. 3), they are still well below what was considered normal levels in white-tailed deer in Oklahoma (Kocan et al., 1980), and are within the normal range for domestic cattle (Puls, 1994). Arsenic levels found in this study should be considered background levels.

Table 1. Element concentrations (ppm dry wt) for Yukon wildlife.

Species	Moose		Dall Sheep	Caribou									
Herd				Clear Creek		Finlayson	Pelly		Porcupine		Redstone		Tay
	Mean	SD	Individual	Mean	SD	Individual	Mean	SD	Mean	SD	Mean	SD	Individual
Age (yr)	4.9	2.6	8	1.5	0.7	6	3.5	0.7	4.3	1.7	3.0	1.0	2
N (age)	47		1	2		1	2		10		3		
N (analysis)	47		1	2		1	2		50		3		
Moisture (%)	79.0	1.7	76.7	76.4	2.3	81.4	79.9	1.8	78.4	1.7	78.8	0.4	78.8
Aluminum	0.81	1.19	0.23	0.58	0.08	0.87	<0.05	0.00	0.76	0.43	0.22	0.99	<0.05
Antimony	<0.01	0.00	<0.01	<0.01	0.00	<0.01	<0.01	0.00	<0.01	0.00	<0.01	0.00	<0.01
Arsenic	0.37	0.31	0.69	0.41	0.49	0.60	0.05	0.07	0.51	0.44	0.27	0.30	<0.01
Barium	1.01	0.52	0.59	1.70	0.24	1.14	1.12	0.36	2.92	1.27	3.75	1.60	1.19
Beryllium	<0.01	0.00	<0.01	<0.01	0.00	<0.01	<0.01	0.00	<0.01	0.00	<0.01	0.00	<0.01
Boron	<0.1	0.02	<0.1	<0.1	0.00	<0.1	<0.1	0.00	<0.1	0.00	<0.1	0.00	<0.1
Cadmium	111.2	56.8	9.0	11.5	9.4	77.0	60.3	53.7	41.8	28.4	21.1	29.8	60.7
Calcium	269	80	221	192	24	297	290	34	290	67	228	11	214
Chromium	0.72	0.40	0.8	0.25	0.07	1.5	0.50	0.14	1.21	2.24	0.30	0.17	0.5
Cobalt	0.52	0.26	0.202	1.49	1.79	1.57	0.24	0.16	0.52	0.26	0.43	0.12	0.255
Copper	13.7	3.7	21.1	27.5	3.7	23.6	23.1	3.0	21.5	2.7	22.0	1.8	23.1
Iron	165	64	291	92	107	188	70	79	143	58	73	20	264
Lead	0.06	0.19	0.06	0.25	0.01	0.38	0.30	0.15	0.21	0.14	0.40	0.06	0.71
Magnesium	550	52	688	518	50	852	520	34	686	141	486	24	509
Manganese	7.38	3.18	6.80	8.41	0.95	9.50	5.13	2.40	9.67	2.34	6.84	0.42	5.68
Mercury	0.09	0.11	1.63	2.32	0.04	1.28	1.93	0.81	2.16	0.60	1.04	0.49	1.39
Molybdenum	1.24	0.58	0.98	0.67	0.23	0.38	1.26	0.36	1.02	0.33	1.34	0.44	0.92
Nickel	0.32	0.23	0.16	0.08	0.02	0.36	<0.05	0.00	0.54	2.15	0.10	0.03	<0.05
Selenium	5.42	2.22	2.22	3.43	0.41	3.39	1.97	0.75	3.67	0.77	4.34	0.73	2.08
Silver	<0.005	0.00	<0.005	<0.005	0.00	<0.005	<0.005	0.00	<0.005	0.01	<0.005	0.00	<0.005
Strontium	0.46	0.15	0.370	0.41	0.05	0.267	0.24	0.10	0.36	0.13	0.56	0.11	0.440
Thallium	0.02	0.03	<0.005	0.04	0.00	<0.005	0.04	0.01	0.01	0.02	0.08	0.03	0.063
Tin	<0.01	0.00	<0.01	<0.01	0.00	<0.01	<0.01	0.00	<0.01	0.02	<0.01	0.00	<0.01
Uranium	<0.01	0.00	<0.005	<0.005	0.00	<0.005	<0.005	0.00	<0.005	0.00	<0.005	0.00	<0.005
Vanadium	0.55	0.10	0.26	0.33	0.02	0.41	0.42	0.06	0.39	0.13	0.36	0.06	0.57
Zinc	115.8	28.3	98.7	96.0	3.8	111.0	95.4	0.0	93.9	13.2	90.6	14.4	114.0

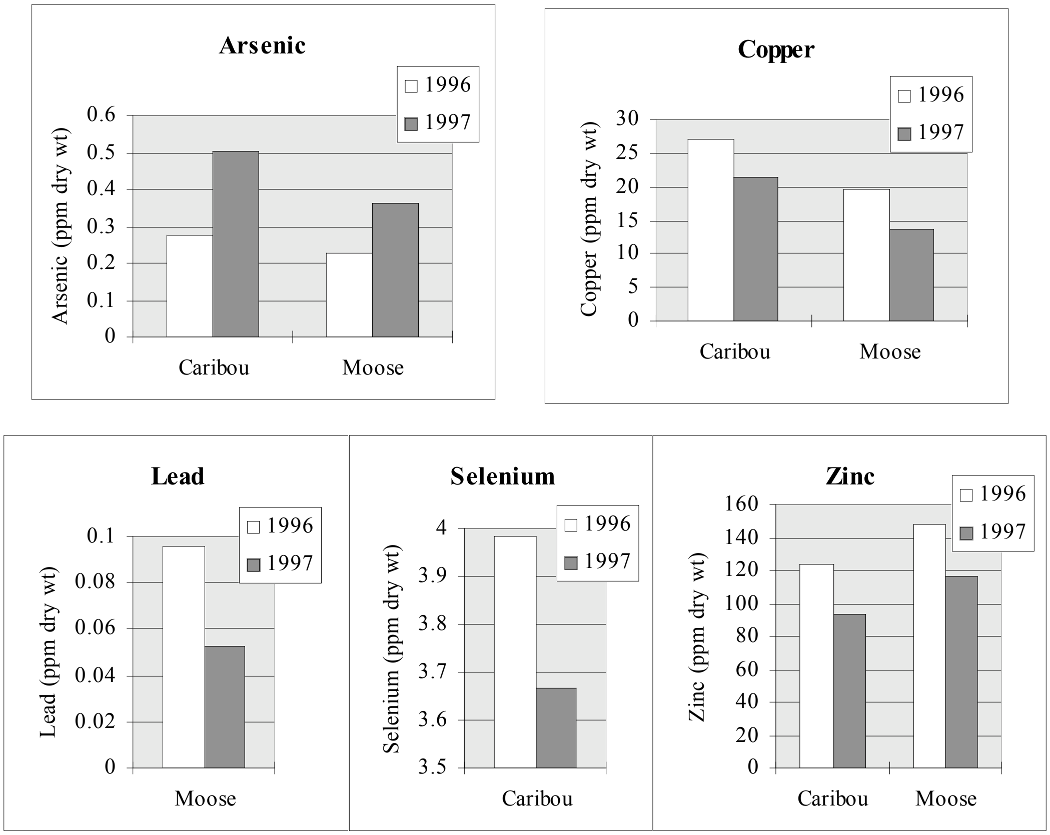

Figure 3. Element concentrations in Yukon moose and caribou for 1996 and 1997.

Cadmium is a toxic element that accumulates in animals over time (and therefore with age), primarily in the kidneys and liver. Chronic exposure may lead to anemia, enteropathy, renal damage, osteoporosis and osteomalacia. Long range transport distributes cadmium widely over the environment, and natural mineralizations may serve as point sources. Lichens absorb cadmium directly from the air, eventually passing it on to caribou that feed on the lichen. Plants differ in their ability to absorb cadmium from soil and water, some species accumulating relatively high concentrations if they grow in cadmium-rich soil. Cadmium accumulates in long-lived herbivores, generally not in high enough levels to impair their health. Industrial uses of cadmium include production of cadmium-plated metal, nickel-cadmium batteries, pigments and plastic stabilizers, mining and refining of copper, lead and zinc (Jaworski, 1980).

In this study cadmium increased with age in moose (Fig. 1). Although cadmium concentrations have been reported for moose in the literature, most have not reported associated ages, so accurate comparisons are not possible. Glooschenko et al. (1988) did report cadmium levels in Ontario moose for different age classes, and these appeared to be consistently lower than those in Yukon moose (Fig. 4).

The lack of a significant relationship between kidney cadmium and age in the Porcupine caribou herd is probably because of the small sample size (N=10). Because a strong significant relationship has been shown in this herd in the past (Gamberg and Scheuhammer, 1994; Gamberg, 1997), the caribou cadmium data is presented as it relates to age (Fig. 5). Regression lines from data from past years are shown for reference purposes, and have incorporated herd-specific data from the current study. Data points are shown for 1997 caribou from three herds and for Dall Sheep, none of which had enough data to reasonably construct a regression line.

Cadmium concentrations were lowest in the Porcupine and Bonnet Plume caribou herds, which were similar to other arctic caribou (Fig. 5). Levels were highest in moose and the Finlayson and Tay caribou herd (Fig. 5), while levels in the Hart River herd spanned the difference between the two groups.

The individual Dall sheep in this study had a notably low concentration, which was similar to those found in other Yukon sheep (average was 12 ppm kidney cadmium with an average age of 9 years of age; Gamberg, unpubl. data).

Renal tubule dysfunction has been shown to occur at kidney cadmium levels of 400-800 ppm dry weight for most birds and mammals studies (Elliot et al., 1992; Kjellstrom, 1986). Averages for each species are well below this level, and there are no cases of individuals approaching this critical concentration. Although there is no evidence from this study that cadmium levels are causing renal stress in these animals, the 1996 study (Gamberg, 1997) indicated that there may be a small number of moose who may experience some renal dysfunction as a result of high cadmium concentrations in their kidneys.

Health Canada has evaluated the previous work of this type in the Yukon (Gamberg, unpubl. data) and recommended limiting consumption of kidneys from moose and caribou among other species. A summary of the recommendations can be found in appendix 3. The data from this year's study showed that the level of cadmium in moose and caribou has not changed over the last year, so the recommendations should still be relevant.

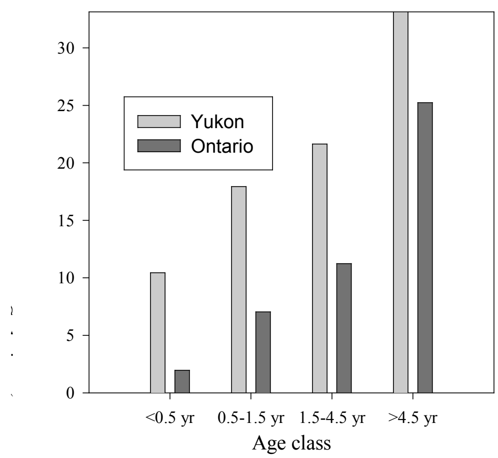

Figure 4. Cadmium concentrations in Yukon and Ontario moose. 1996 and 1997 data were used for Yukon moose, and Ontario moose data are from Glooschenko et al. (1988).

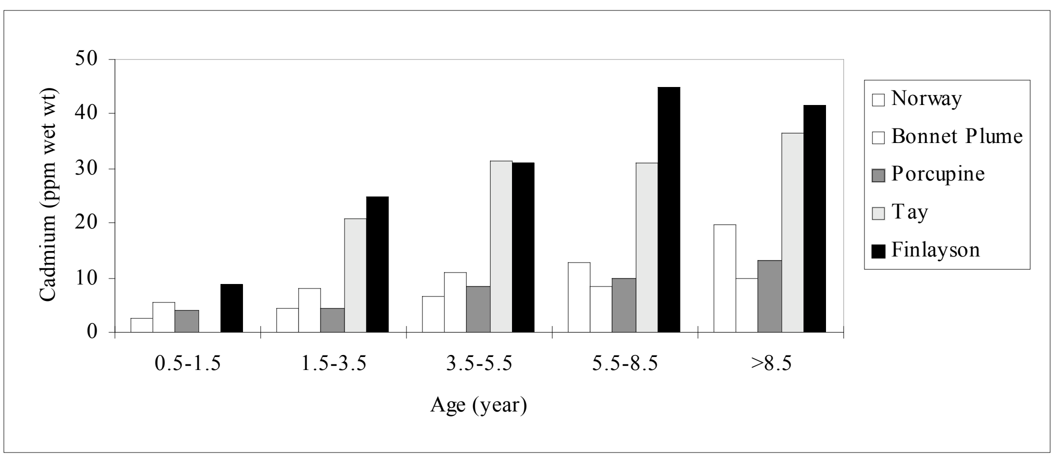

Figure 5. Cadmium concentrations in caribou from the Yukon and Norway. Yukon data are from the current study and Gamberg (1997 and unpubl. Data). Norway data are from Froslie et al. (1986).

Copper is an essential element. Since it is homeostatically controlled, excess Cu is excreted in the urine, and toxicity is rare under normal conditions. Toxic effects may occur, however, and can include dermatitis, anemia, gastric ulcers, renal damage and hemolysis (Aaseth and Norseth, 1986). Copper deficiency has been noted in Alaskan moose with faulty hoof keratinization and reduced reproductive rates (Flynn et al., 1977). Industrial uses include production of electrical equipment and alloys, plating, plumbing, heating, and uses in mining and smelting.

Copper levels in kidneys were very consistent among species and caribou herds ranging from a mean of 13.7 ppm in moose to 27.5 ppm in Clear Creek caribou (Table 1). These levels are slightly lower

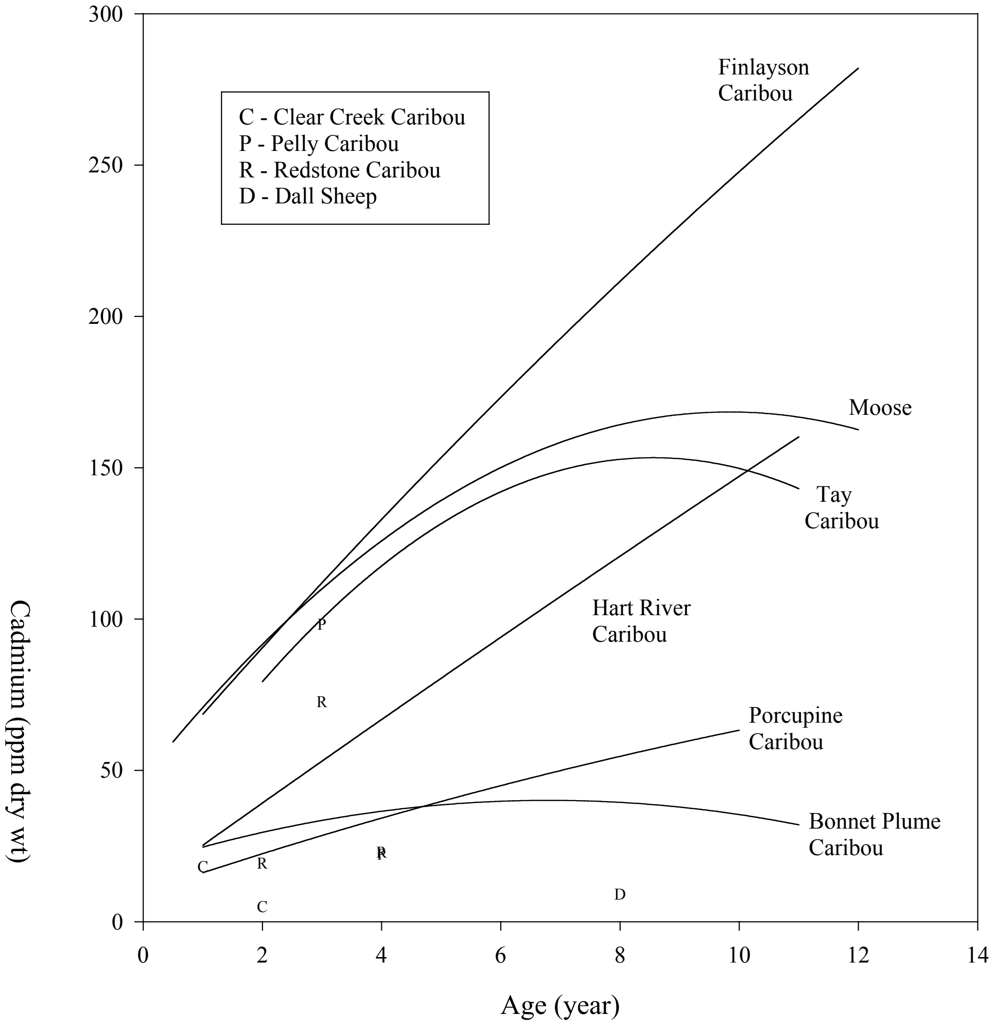

Figure 6. Cadmium concentrations in Yukon moose and caribou. Regression lines taken from Gamberg (1997, unpubl. data).

than those found for NWT caribou (means ranged from 27.76 - 49.73 ppm dry wt; Elkin and Bethke, 1995), but are more similar to concentrations found in the Finlayson caribou herd from the Yukon (mean=24.68 ppm; Gamberg, 1993). Kidney copper concentrations found in this study fall within the adequate category for domestic cattle (Puls, 1994), and should be considered background levels for this area.

Lead is a toxic element that is stored for the long term in bone tissue, and in the short-term, in liver and kidney. Toxic signs include anemia, anorexia, fatigue and blindness. Common sources of lead include mining, smelting and refining of lead and other ores, burning petroleum fuels containing lead additives, burning coal and oil and use in shotgun pellets. Lead may also be found in paint (even 'lead-free paint may contain up to 1% lead), waste engine oil, lead batteries, putty, roofing tiles, linoleum, solder and golf balls. Some pipe joint or thread compounds (used on drilling sites) can contain up to 40% lead powder (Puls, 1994).

Kidney lead concentrations in this study are consistently low and similar to lead levels found in NWT caribou (0.10 - 0.47 ppm dry wt; Elkin and Bethke, 1995). Lead levels tend to be somewhat higher in moose than in caribou (Table 1), but all levels are well below the threshold level of 80 ppm that is indicative of lead poisoning (Scheuhammer, 1991). Lead levels in this study should be considered background levels.

Mercury is a toxic element that accumulates in brain and kidney tissue, affects neurological functions and may cause gastrointestinal disturbance, reduction of food intake, poor growth, renal damage or death. Prenatal exposure may lead to cerebral palsy (Berlin, 1986). Inorganic mercury may be transformed to methylmercury (a more toxic form of mercury) by natural microbial action in lakes. This process may be promoted by excess sulphides from atmospheric deposition or nutrification of lakes. Aquatic life is generally more sensitive to methylmercury than terrestrial species. Environmental sources of mercury include mining, milling and smelting of mercury-containing ores, chlor-alkali plants, coal-burning plants, municipal wastewater treatment plants, pulp and paper mills and fungicides. Natural mercury occurs as volcanic gases, natural mineralizations and evaporation from oceans (World Health Organization, 1989).

Kidney mercury concentrations in caribou and Dall Sheep were somewhat higher than in moose (Table 1), but all were low relative to those found in NWT caribou (2.76-14.14 ppm dry wt; Elkin and Bethke, 1995). These researchers, among others (Eaton and Farant, 1982; Braune et al., 1991) suggested that observed high levels of mercury in the Canadian arctic reflect naturally occurring geological sources rather than industrial pollution. Previous work (Gamberg, unpubl. data) has shown that methylmercury concentrations in Porcupine caribou kidneys were below detection limits, indicating that the mercury present was in the less toxic form of inorganic mercury. Mercury levels found in this study should be considered natural background levels.

Selenium is an essential element, which interacts with vitamin E to ensure optimum functioning of the immune and reproductive systems. Because some geographical areas are naturally low in selenium, deficiencies are possible, causing white muscle disease, reduced growth and reproductive rates, and reduced immune response. Signs of toxicity may include emaciation, lameness, cracked or deformed hooves and loss of hair. It has been thought that excess selenium also caused 'blind staggers', but this may be due to other compounds in the selenium-accumulating plants (*Astralagus* sp.) responsible for this disease (Puls, 1994). Industrial uses of selenium include electronics, photography, glass production, fungicides, insecticides and pigments in plastics, paints, enamels, inks and rubber.

Kidney selenium concentrations were relatively consistent among species in this study (Table 1). Although selenium in the Porcupine caribou was significantly lower in 1997 than 1996, levels from both years, along with all levels found in this study, fall within the 'adequate' category for domestic cattle (Puls, 1994), and should be considered background levels.

Zinc is an essential, homeostatically controlled element, and is an important component of many proteins and enzymes. Zinc deficiency may result in reduced conception rate, reduced feed intake and growth rate, and thickening and shortening of bones. Toxic effects include anemia, poor bone mineralization, arthritis, general osteochondrosis and lameness (Sileo and Beyer, 1985). Zinc is released into the environment through mining, smelting and residential and industrial effluents and is used industrially in electroplating, the combustion of fossil fuels, petroleum by-products and solid wastes.

Renal zinc concentrations were very consistent among species (Table 1), and although levels were lower in 1997 than in 1996 for both moose and Porcupine caribou, means from both years are similar to concentrations found in NWT caribou (96-75 - 120.86 ppm dry wt; Elkin and Bethke, 1995). These concentrations should be considered normal levels.

CONCLUSIONS

For the most part, element concentrations found in Yukon moose and caribou kidneys are at background levels and are not of concern to the animals themselves, or those who consume them. However, Health Canada has recommended limiting consumption of kidneys from Yukon moose and caribou because of high cadmium concentrations in kidneys from both moose and caribou, and high mercury levels in caribou. It is likely that these elements are accumulating from natural sources in this mineral-rich area, and are acquired by the animals through the consumption of specific plants that are adept at absorbing these elements from the natural environment. Although cadmium levels tend to be higher in older animals, there has been no significant change in the levels found in moose or Porcupine caribou over the last two years. Similarly, there has been no significant change in mercury levels in the Porcupine caribou over the last two years. These elements do not appear to be changing over time. Those concerned about the consumption of cadmium or mercury from moose or caribou should follow the guidelines provided by Health Canada.

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Appendix 1. Sample letter sent to hunters

Gamberg Consulting

Environmental Research Telephone: (403) 536-2157
Box 747 Fax: (403) 536-
2159
Watson Lake, Yukon Y0A 1C0 e-mail: gamberg@watson.net

«Collector»
«Address»
«Town», YT
«Postal_Code»

December 5, 1997

I am a private consultant working on the 'Contaminants in Moose and Caribou' project in cooperation with the Yukon Territorial Government. I would like to take this opportunity to thank you for your sample submissions to the project this fall. Thank you in particular for submitting a tooth from your «Common_name». The teeth have been sent to a lab for aging, and you will be notified of the age of your animal as soon as the results are available.

Each hunter submitting samples had his/her name put into a draw for a free charter flight, once for each tissue sample submitted. For example, if you brought in a liver and kidney, your name went in twice. If you brought in all samples requested (liver, kidney, muscle and a tooth), your name went in five times (one bonus time for being so thorough!). The draw took place on December 1, and the winner was Darren Shipman of Whitehorse. Darren wins a flight with Coyote Air out of Teslin up to a value of $1000.

This project is studying levels of contamination in Yukon moose and caribou, and in the past has also looked at other large and small mammals. In general Yukon wildlife is very clean, healthy and free of contamination. The only real concern is a heavy metal called cadmium which accumulates in the liver and kidneys of some animals - in particular, moose and caribou. Other studies have shown that this cadmium is from natural sources in the Yukon. It is important to remember that it does not concentrate in the muscle or meat of the animal, and this is perfectly good to eat. Health Canada has reviewed these data, and has recommended limiting consumption of some organs from some animals. I am enclosing a summary of this advisory and a general background for your information. If you should have concerns or questions about it, please contact your local Health Canada office.

Again, thank you for your support of this project.

Sincerely,

Mary Gamberg
Biologist
Gamberg Consulting

Appendix 2. Background of cadmium in Yukon wildlife

Cadmium in Yukon Wildlife

Ongoing research on contaminants in wild foods has shown that, for the most part, mammals, birds and plants in the Yukon are free from contamination. However, some animals do have 'high' levels of cadmium in their livers and kidneys.

Cadmium is a toxic heavy metal that is found in abundance in natural ecosystems in the Yukon. Our unique geology that makes mining so profitable here, also means that certain metals work their way into some ecosystems. Cadmium is one of those troublesome metals. The cadmium works its way into the soil, and then into plants through the roots. Animals eating those plants will then absorb the cadmium.

Once it is in the body, the liver and kidney work at removing the cadmium. They are effective to a degree, but if the animal (or person) takes in more cadmium than these organs can get rid of, it will accumulate in the liver and kidney over the lifetime of the animal. For this reason, older animals (or people) tend to have higher levels of cadmium than younger ones. If cadmium levels reach a threshold level in the kidney, there is potential for kidney dysfunction.

The World Health Organization (WHO) has determined the level of cadmium intake that is considered safe for humans. Health Canada has used this level, along with concentrations found in Yukon wildlife, to recommend limiting consumption of kidneys and livers of certain animals. For some, the limit is quite high - 485 snowshoe hare kidneys per person per year, and 382 Mountain Goat kidneys. For caribou the recommendation varies among herds, but ranges from 7-32 kidneys/person/year, and 4-16 livers/person /year. The recommended limit for moose liver and kidney is one of each per person per year. It should be noted that cadmium does not accumulate in the meat or the muscle tissue of any animal, and Health Canada has not recommended limiting consumption of meat from any species.

While health advisories of this sort are relatively new to the Yukon, advisories against eating livers and kidneys of certain species have been issued in other provinces of Canada. Manitoba has a health advisory for moose and elk, Ontario for moose and deer, Quebec for moose and caribou and Newfoundlanders have been advised that the consumption of moose liver or kidney would probably result in their exceeding the WHO standard intake limits for cadmium for that week of consumption. Most of these advisories do not recommend limiting consumption, but advise avoiding consumption completely. Health officials in the Yukon have attempted to be sensitive to the culture and desires of Yukoners, and gone through the extra step of determining what a safe level of consumption would be.

To increase our understanding of cadmium in moose and caribou, this year we again requested tissue samples from Yukon hunters. Hunters were requested to submit liver, kidney, muscle and a tooth or jaw for aging purposes. All hunters submitting samples will have their names entered into a draw for a free flight with Coyote Air in Teslin. Coyote Air generously donated half the cost of the flight to the project.

Anyone with further concerns or questions about levels of contamination in Yukon wildlife should contact Yukon Health and Social Services, or their local Renewable Resources Office.

Appendix 3. Health Advisory

ANIMAL	Maximum # of Kidneys per year Recommended for Consumption	Maximum # of Livers per year Recommended for Consumption
Caribou		
Bonnet Plume	32	16
Nahanni	28	13
Porcupine	25	12
Forty-mile	20	12
Wolf Lake	15	8
Finlayson	8	5
Tay	7	4
Moose	1	1
Sheep	178	no limit
Goat	382	26
Beaver	15	46
Porcupine	13	17
Snowshoe Hare	485	no limit

There are no limitations on the amount of muscle (meat) that can be consumed from any animal

For further information please call Health and Social Services at 667-5302

Appendix 4. Quality control data for laboratory analysis: Element concentrations (ppm) in preparation blanks, recoveries for standards and differences between sets of duplicate and blind samples. Differences were calculated only when element concentrations were greater than 10 x the detection limit.

Element	Preparation Blanks	Recovery of Standards (%)	Difference between duplicates (%)	Difference between blinds (%)
Aluminum	<0.05	97	10	84
Antimony	<0.01			
Arsenic	<0.01	94	12	
Barium	<0.005		3	17
Beryllium	<0.01			
Boron	<0.1			
Cadmium	<0.01	90	3	9
Calcium	<0.5	94		
Chromium	<0.1	98	7	
Cobalt	<0.005	98	6	36
Copper	<0.01	98	5	15
Iron	<0.2	92	7	4
Lead	<0.01		5	
Magnesium	<0.05	88	3	12
Manganese	<0.01	93	6	11
Mercury	<0.05	95	1	18
Molybdenum	<0.01		4	33
Nickel	<0.05	86		
Selenium	<0.05	94	2	57
Silver	<0.005	98		
Strontium	<0.005	96	2	17
Thallium	<0.005		3	11
Tin	<0.01			
Uranium	<0.005			
Vanadium	<0.01	98	6	
Zinc	<0.05	90	4	4
Average		**94**	**5**	**23**