CADMIUM CONCENTRATIONS IN NEWFOUNDLAND MOOSE

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ABSTRACT: Moose liver, kidney and meat samples were collected from east, central and western regions of the island of Newfoundland during 1987 and 1988 and tested for the heavy metal cadmium. Concentrations found were similar or lower to those reported elsewhere in eastern North America. Significant differences in the concentrations of cadmium in liver were noted between seasons, and between areas of different percent cover or overstory. Results suggest that age of moose was best correlated with kidney cadmium concentrations. The Newfoundland public have been advised that the eating of moose liver and/or kidney would probably result in their exceeding WHO standard intake limits for cadmium for that week of consumption.

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Within the past decade concerns have been raised in Europe and North America as to the levels of cadmium (Cd) being found in the organs of wild ruminants (Froslie *et al* 1986, Scanlon *et al* 1986). Concern is principally for the health of humans consuming organs or meat containing Cd in excess of human health standards. National and regional governments have responded to these findings by issuing public health announcements as to the implications of consuming parts of animals with higher than acceptable concentrations of cadmium.

Hill (1984) reported that most Newfoundlanders hunt game for its food value. Anticipating a public interest and concern over the concentration of Cd in local game animals, the Wildlife Division planned to sample various species for Cd concentrations. In 1987 and 1988 moose (*Alces alces*) and to a lesser extent caribou (*Rangifer tarandus*) and snowshoe hare (*Lepus americanus*) were selected for sampling. This report deals with the moose sampling effort. The objectives of the study were to (1) determine if Cd concentrations in moose exceed currently acceptable human health standards (2) determine the relationships between Cd concentrations measured for moose liver and kidney accounting for sex, age, regions, year, season and habitat and (3) develop a model to predict and monitor future Cd concentrations of harvested moose.

METHODS

Moose liver, kidney and meat samples were collected from animals killed as a result of vehicle collisions and from animals harvested during the 1988-89 fall and winter hunts from different regions of the province (Fig. 1). A selected group of hunters had been asked to submit samples from their kill. All samples were individually packaged in plastic bags and appropriately labelled with the name of the person submitting, date and location of kill, and sex of the animal. Age of

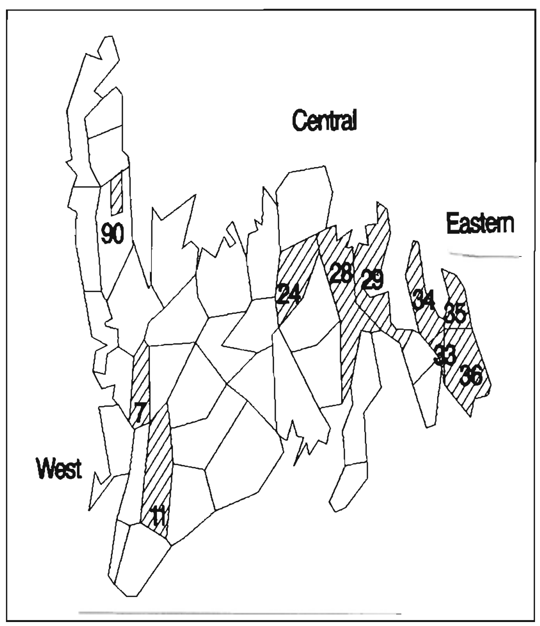

Fig. 1. Management units in Newfoundland where moose liver, kidney and meat samples were collected in 1987 and 1988.

animals was later determined by counting annual cementum layers from incisors.

Each sample was homogenized in a meat grinder following which an aliquot of sample was taken and weighed. Samples were dried and moisture content calculated. Samples were then taken to a muffle furnace and heated at 600°C for 16 hours to remove organic material. Ten ml of 2N HCl was added to each ashed sample and left overnight to dissolve metallic residues. Samples were run on an atomic absorption spectrophotometer and Cd content in ug/g wet weight was calculated. Precautions were taken at each step to ensure samples were not contaminated. Results were broken down by region (Fig. 1), age group (0.5-1.5 yrs., 1.5-4.5 yrs., >4.5 yrs.), sex, season (fall, winter), and by percent open cover (0-20%, 20-40%, >40%). Hancock (1981) calculated percent cover types, including open cover for Newfoundland Moose Management Units from the "global inventory" conducted by the Newfoundland Department of Forestry.

When determining the variable relationships (region, age, sex, season, percent open cover,) standard parametric two-tailed tests with F and t- statistics were used (Sokal and Rohlf 1969). These tests along with analysis of variance, cluster, correlation, regression and canonical discriminant analysis were performed on an AT microcomputer using SAS statistical packages (SAS Institute Inc. 1987). Correlations were tested using Pearson product-moment correlation coefficient. All probability values are two-tailed and when two samples differ, this indicates a significant difference at the 0.05 level or at a higher level of significance.

RESULTS

A total of 172 samples were tested, 88 kidney, 79 liver and 5 muscle tissue. The unadjusted mean concentration of Cd in kidney was 5.52 ug/g (+5.39) and in liver 1.04 ug/g (+0.85). The Cd concentration in meat ranged from 0.03 to 0.06 ug/g. All values are wet weight.

We tested for differences in liver and kidney cadmium levels for harvested and road killed moose due to years, seasons, sex, age, regions and percent open cover (Table 1). No significant differences in Cd concentrations were found between years for liver and kidney samples. Significantly lower Cd concentrations for harvested moose were found for the winter season for liver samples (1.33 versus 0.60). No significant differences in Cd concentrations were detected due to sex of animal. Significant differences in Cd concentrations due to age were found for kidney samples with greater amounts recorded in older age groups (Fig. 2). Although not significant, a similar pattern was found for measured liver Cd concentrations. No significant differences in regions were found unless we accounted for the age of harvested animals with kidney samples (P=0.03; Fig. 3).

Multiple regression analysis was used to determine which dependent variables best estimate Cd levels. Although, we could describe a significant predictive function to estimate kidney Cd concentrations using the variable moose age, no variable met the entry requirements to estimate liver Cd concentrations.

Significant correlation was found between some of the measured dependent variables (Table 2). For liver samples significant correlations were found between Cd concentrations and regions and open cover. For kidney samples a significant correlation was found between the moose age and possibly a relationship existed with open cover.

DISCUSSION

The World Health Organization (WHO) provisional tolerable weekly intake of Cd for humans is 500 ug/g (WHO 1972). This is the standard used by health officials in Newfoundland (Dr. F. Stratton, pers. comm.). Canadians on average consume a minimum of 350 ug/g Cd per week. Assuming an aver-

Table 1. Analysis of variance tests for differences in cadmium levels for harvested moose in Newfoundland due to years, season, sex, age, region and % forest cover.

Test/Organ	df	F	Prob.	Categories		
Year/Season				1987 Fall	1988 Fall	1988 Winter
Liver	76	4.23	0.02	a[1] 1.33 (35)	a 0.87 (35)	b 0.60 (9)
Kidney	85	0.18	0.83	a 5.19 (37)	a 5.92 (38)	a 5.31 (13)
Sex				Males	Females	
Liver	66	0.01	0.93	a 1.00 (35)	a 0.99 (33)	
Kidney	70	0.01	0.93	a 5.80 (37)	a 5.68 (35)	
Age (years)				0.5-1.5	1.5.4.5	>4.5
Liver	51	0.19	0.83	a 0.76 (16)	a 0.82 (27)	a 0.89 (11)
Kidney	57	12.3	0.0001	a 2.44 (19)	b 5.79 (34)	c 10.50 (7)
Regions				Eastern	Central	Western
Liver	67	2.49	0.09	a 1.33 (35)	a 0.90 (21)	a 0.83 (14)
Kidney	72	0.45	0.64	a 5.19 (37)	a 6.49 (23)	a 5.05 (15)
Percent Open Cover				<20%	20-40%	>40%
Liver	55	3.26	0.05	a 0.81 (30)	ab 1.28 (19)	b 1.58 (9)
Kidney	59	2.91	0.06	a 5.79 (34)	a 4.33 (20)	b 10.18 (8)

[1] means with the same letter within a row are not significantly different according to duncans multiple range test.

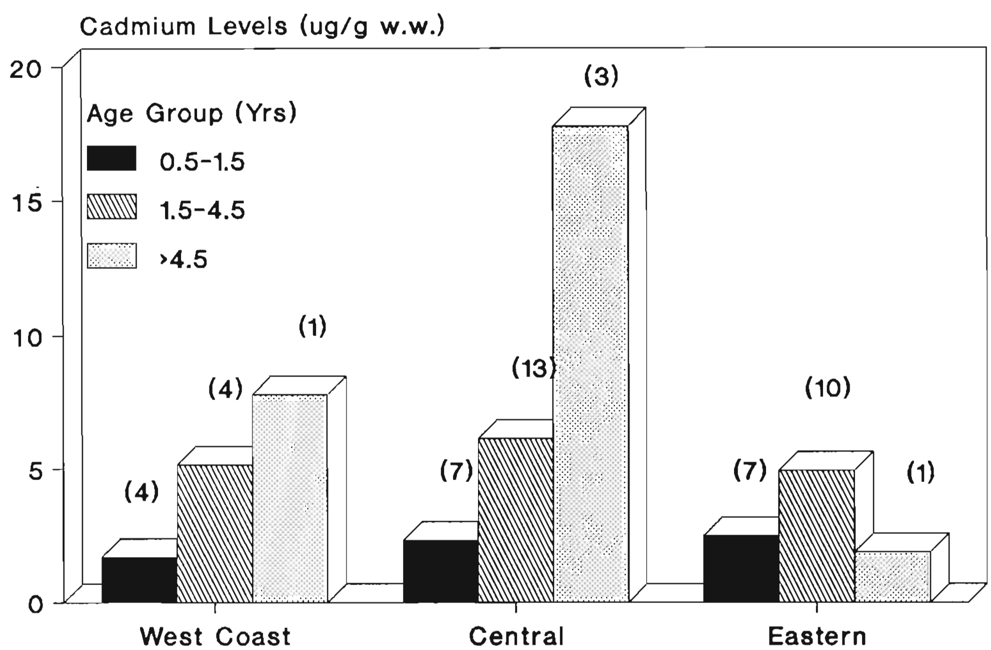

Fig. 2. Cadmium levels found in moose kidneys for three age groups and regions in Newfoundland.

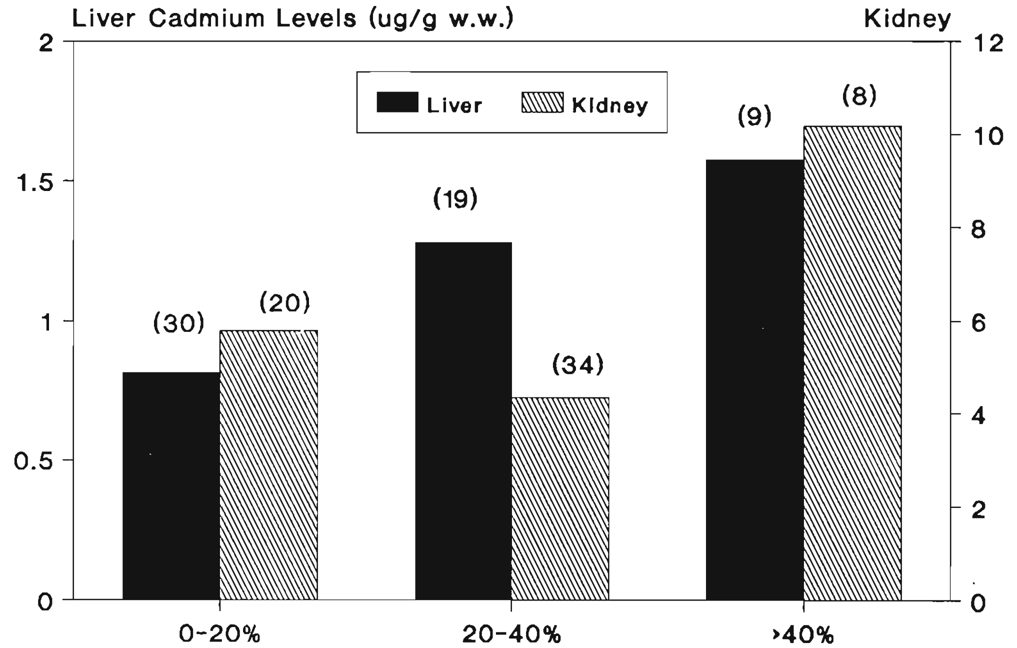

Fig. 3. Cadmium levels for moose livers and kidneys for three groupings of Newfoundland management units based on percent open cover.

Table 2. Correlation matrix for 4 variables that possibly relate to measures of liver and kidney cadmium in Newfoundland (Pearson's correlation coefficient/probability/sample size).

Variable	Liver Cadmium	Kidney Cadmium
Age	0.094	0.583
	0.49	0.0001
	55	61
Region	0.247	-0.018
	0.04	0.88
	70	75
Sex	-0.010	-0.010
	0.93	0.93
	68	72
% Open	0.367	2.05
Cover	0.004	0.10
	60	64

age meal of 110 g of meat or organ per serving then it is probable that the consumption of Newfoundland moose liver or kidney but not meat would cause the consumer to exceed the WHO standard for that particular week that the product was eaten. Preliminary results gathered in 1987 similar to the final results reported here formed the basis of a press release informing the public of these `elevated' Cd levels and the potential for exceeding WHO weekly limits. Questions regarding human health risks and long term chronic exposure were and will continue to be referred to medical professionals.

Age related differences in Cd concentrations have been found by others (Frank 1986, Glooschenko *et al* 1988). Our results confirm this pattern of accumulation over time with older animals having higher concentrations, at least for kidneys. Our results also indicate that age may be used as a predictor for moose kidney Cd concentrations provided such variables as region and percent open cover are accounted for.

Concentrations of Cd in the livers of moose were found to be higher in fall than in winter. This is contrary to what Crête *et al* (1987a) found in caribou, i.e. concentrations higher in winter than fall. Their findings were explained by physical changes which occur in caribou between seasons. Our seasonally related differences cannot be so readily explained. Small sample size and age related variation may account for some of the discrepancy.

Regional differences for Cd concentrations in moose kidney (accounting for age) were noted. The reason(s) for such differences cannot be explained until we have a better understanding as to what the sources of Cd might be. Potential sources within Newfoundland might be natural occurrence, mine tailings, sewage, combustion of fossil fuels and ore processing (eg. phosphorus reduction). Except for Cd which might occur naturally all other local sources are considered minor, localized and contained, or not readily available to moose. The Provincial Department of Mines and Energy have tested for heavy metals including Cd in lake sediment samples throughout the province (Peter Davenport, pers. comm.). While the analysis for the whole island is not yet complete the results that are available show some areas with higher Cd levels than others. This does not necessarily mean that all or part of the Cd found in the sediment samples is of natural origin. There is however circumstantial evidence to suggest that naturally occurring Cd is available in the environment. Locations where Cd levels would be expected to be higher because of their known association with other metals (eg. zinc) are showing up as such in the sediment samples. Another possible source of Cd is long range airborne transport from highly industrialized areas (Froslie *et al* 1986, Scanlon *et al* 1986). Newfoundland does not have industries such as smelters which produce Cd containing emissions. Crête *et al* (1987b) found their highest Cd concentrations in moose near a smelter. Glooschenko (1989) found elevated Cd levels in mosses at only 2 sites, both smelters, in a study of Cd concentrations across northern Canada. It is possible that some aerial deposition of Cd is occurring in Newfoundland from outside sources. It is however premature to identify sources of Cd without further study.

Concentrations of Cd in Newfoundland moose are at or below concentrations found elsewhere in eastern North America (Table 3) assuming that comparisons are not significantly influenced by variables such as age and season. Differences cannot be readily explained. We suspect however that our relative isolation from the influences of industrialization may be a part of that difference.

Table 3. Cadmium concentrations in moose livers and kidneys from eastern North America.

Location	Year	Cadmium concentration (wet weight)		Source
		Liver	Kidney	
Newfoundland	1988	1.04	5.52	this report
New Brunswick	1987	7.05	27.66	Redmond 1987
Maine	1984	1.61	5.53	Scanlon *et al* 1986
Quebec, east	1985	1.02	8.05	Crête *et al* 1987
Quebec, south	1985	2.07	11.99	"
Quebec, west	1985	4.53	15.13	"

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