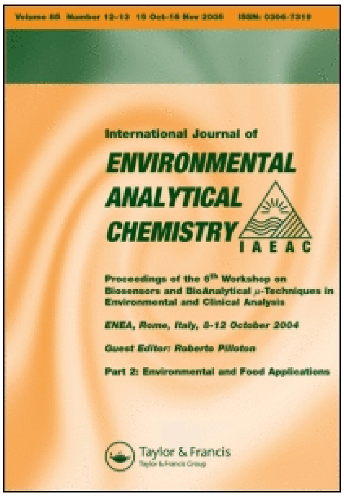

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AN INVESTIGATION OF THE TRACE ELEMENT STATUS OF BISON IN WOOD BUFFALO NATIONAL PARK AND OF RANCH-RAISED BISON IN SASKATCHEWAN, CANADA

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Trace metal levels were compared in ranched bison receiving a dietary supplement and in wild bison in Wood Buffalo National Park. Data collected in this study were also assessed with regard to information previously published on healthy wild bison resident in the Mackenzie Bison Sanctuary. Ninety percent of ranched animals contained lead, with mean levels of 0.06 and 0.10 ppm in liver and kidney, respectively, while lead was present in only 20% of samples from wild bison. Similarly, arsenic was more prevalent in ranched animals, though at levels below 0.05 ppm. Cadmium levels were significantly higher in the wild bison and traces of mercury were also more prevalent in the wild herd.

Levels of copper, manganese, selenium and zinc, which are considered essential nutrients, showed variations between the ranched and wild bison, but were within the range considered acceptable for cattle, with the exception of selenium. This was found to be lower in the wild herd.

Further research is required to define the nutritional requirements of healthy bison. Variations observed in this investigation could be attributed to a variety of factors, including age, diet, and health status, which cannot be differentiated based on the available samples.

KEY WORDS: Trace elements, lead, cadmium, selenium, bison.

INTRODUCTION

Trace metal element analysis of tissues collected from healthy wood bison (*Bison bison athabascae*) in the Mackenzie Bison Sanctuary (MBS) of the Northwest Territories (NWT) has previously been reported.[1] That study was undertaken to provide baseline values for essential trace metals in free-ranging bison. In addition, levels of selected toxic trace elements were measured in the earlier study to determine if they were significant in assessing the overall health of these animals.

The herd of hybrid bison (*B. bison bison* × *B. bison athabascae*) in Wood Buffalo National Park (WBNP) has been the subject of intensive study over the past five years to define their health status and to attempt to explain their poor reproductive success. There is a high incidence of bovine tuberculosis and brucellosis in the population.[2] There has been speculation that the decline in this bison herd may also be due to wolf predation and nutritional stress from habitat deterioration. An analysis of available samples from this herd was therefore undertaken to determine if differences in concentrations of various essential and

Table 1 Description of bison sampled from Wood Buffalo National Park

Sample no.	*Age*	*Disease status*	*Cause of death*	*Tissues sampled*	
				Liver	*Kidney*
W104	cow	tuberculosis	hit by vehicle	+	+
W105	calf	—	hunter	+	+
W106	calf	—	hunter	+	+
W107	calf	—	hunter	+	−
W109	bull	tuberculosis, brucellosis	hunter	+	+
W110	cow	tuberculosis	hunter	+	+
W111	cow	—	hunter	+	+
W112	cow	—	hunter	−	+
W113	cow	tuberculosis	hunter	+	−
W114	calf	—	hit by vehicle	+	+
W116	calf	—	hunter	−	+
W117	calf	—	hunter	+	+
W118	bull	brucellosis	hunter	+	+
W119	bull	tuberculosis	hunter	+	+
W120	cow	—	hunter	+	+
W174	cow	—	hunter	+	+
				12	12

toxic elements would be found between this group and the previously published data on the MBS herd.

To provide additional data for comparison with the free-ranging wild WBNP bison, samples were also obtained from ranched bison slaughtered for retail sale. These were analyzed to determine if there were significant differences in levels of essential trace metals or toxic heavy metals between the wild bison in the two herds and ranched animals which received a ration supplemented with vitamin/mineral mix.

MATERIAL AND METHODS

Sample Collection

Sixteen bison of various ages were sampled from the Wood Buffalo National Park herd. Estimated age, sex, physical condition and cause of death for these animals are given in Table 1. Only liver and kidney were available from these animals.

Samples were also collected by departmental inspection staff at slaughter from twelve young healthy male bison raised on ranch operations in the area of Swift Current, Saskatchewan (eleven 2-year-old, one 5-year-old). The owner provided a commercial vitamin/mineral mix for cattle in the ration given to these bison. Liver and kidney were also sampled from these animals for trace metal analysis.

All samples were frozen immediately following collection and shipped frozen to the laboratory, where they were stored at −20 °C until analyzed.

Trace Metal Analysis

Liver and kidney samples were analyzed for arsenic, cadmium, copper, lead, manganese, mercury, selenium and zinc by atomic absorption spectrometry using a Varian 975 AA equipped with a VGA76 hydride generation accessory, graphite furnace and standard flame, as previously described.[1] All samples were prepared for AA analysis using an automated acid digestion procedure.[3]

Materials

Analytical grade acids and standards used were as previously described.[3]

Statistical Analysis

Data obtained from the animals in the present study were compared for significant differences between the two populations studied, as well as with data previously reported,[1] using the null hypothesis (t-test) for comparison of means having population standard deviations which are not equal.[4]

RESULTS AND DISCUSSION

Trace Element Analysis

Concentrations of trace elements as determined by atomic absorption spectroscopy are reported in Table 2. These are discussed below, under sub-headings Toxic Elements and Essential Elements.

Toxic Elements

The potentially toxic elements arsenic, cadmium, lead and mercury, when present in the samples tested, were at concentrations one to two orders of magnitude below those known to be toxic to cattle.[5] This was similar to results previously reported for wild bison in the Mackenzie Bison Sanctuary.[1] There were, however, some differences between the two populations in the present study and the animals studied previously.[1]

Predictably, the ranched bison from southwestern Saskatchewan were found to contain significantly higher lead residues ($P=0.01$) than either the Wood Buffalo National Park (WBNP) or Mackenzie Bison Sanctuary (MBS) animals, while no significant difference was found between lead concentrations in livers and kidneys of the WBNP and MBS animals. Detectable lead residues were found in approximately 20% of the samples tested from wild bison, but in 90% of those from the ranched animals. The difference was attributed to the proximity to urban centres and major highways of the ranched bison, as compared to the remote locations of the two wild herds sampled.

Table 2 Trace metal levels (ppm) in bison

Element	*Detection limit (ppm)*	*Tissue*	*Wood Buffalo National Park (n=14)*			*Game ranch stock (Saskatchewan) (n=12)*		
			Mean[a]	*Range*	*s.d.*[a]	*Mean*[a]	*Range*	*s.d.*[a]
Arsenic	0.02	L	0.00A[b]	—	—	0.03A	<0.02– 0.04	0.01
		K	0.05A	<0.02– 0.10	0.04	0.04A	<0.02– 0.08	0.02
Cadmium	0.01	L	0.37A	0.07– 1.44	0.40	0.09A	0.03– 0.19	0.04
		K	2.75A	0.20–11.8	3.50	0.52A	0.16– 1.49	0.48
Copper	0.60	L	15.3M	5.20–30.4	8.37	32.4A	12.4 –62.4	14.5
		K	6.38A	5.45– 7.82	0.75	7.76A	5.72–10.4	1.39
Lead	0.04	L	—	<0.04– 0.12	—	0.06A	<0.04– 0.10	0.03
		K	—	<0.04– 0.06	—	0.10A	<0.04– 0.12	0.04
Manganese	0.30	L	2.31M	1.48– 4.28	0.68	3.19A	2.02– 4.52	0.76
		K	0.92M	0.49– 1.48	0.27	1.44A	0.67– 2.00	0.39
Mercury	0.01	L	0.01A	<0.01– 0.02	0.00	—	<0.01– 0.02	—
		K	0.02A	0.01– 0.07	0.02	0.03A	<0.01– 0.12	0.05
Selenium	0.04	L	0.11D	0.03– 0.23	0.06	0.65A	0.31– 1.00	0.23
		K	0.58M	0.34– 0.90	0.24	1.27A	0.58– 2.16	0.41
Zinc	0.25	L	52.8A	30.0 –99.3	23.2	34.3A	27.7 –46.4	5.44
		K	22.4A	14.7 –35.8	6.65	21.4A	15.9 –28.7	4.08

[a]Mean and s.d. not calculated when fewer than 3 tissues contained detectable residues.
[b]A = adequate/normal, M = marginal, D = defiicient, H = high; nutritional status based on normal levels for cattle.[5]

Similarly, arsenic was detected in less than 20% of the wild bison sampled in this investigation (3 out of 16), but was present in low concentrations (0.02–0.08 ppm) in kidneys of eleven of the ranched bison tested, as well as in livers from five of these animals. The highest concentration observed was 0.10 ppm in the kidneys of one WBNP animal, which biased the mean for that population. Otherwise, the concentrations of arsenic in the tissues of ranched bison were significantly higher ($P=0.01$) than values found in the WBNP populations, or in the previous MBS study.[1]

In contrast, cadmium and mercury were present in higher concentrations in the wild bison populations. Cadmium values were lower in ranched bison in both livers and kidneys than levels found in both the WBNP ($P=0.05$) and MBS ($P=0.01$) bison. No significant difference was observed in cadmium concentrations between the two wild populations. Mercury was found in 9 out of 14 livers and all kidneys tested from the WBNP bison (mean concentration, 0.01 ppm), but in only 2 liver and 5 kidney samples from the ranched bison. The greater prevalence of cadmium and mercury residues in the wild animals may be related to a greater bioavailability of these elements in the diet of the two northern populations, or to the older mean age of these animals at time of sampling. None of the samples tested for arsenic, cadmium, lead and mercury contained these elements at concentrations which would pose a risk to humans consuming the meat.

Essential Elements

Copper, manganese, selenium and zinc are considered essential elements for nutritional health.[5] We had previously reported that MBS bison contained these elements in liver and kidney samples at levels considered acceptable in cattle.[1] We therefore were interested in the relationship between the concentrations of these elements in the WBNP herd, ranched bison receiving standard supplements used in beef production, and the previously reported MBS bison population. Although levels of these elements differed among the three bison populations, all were within the acceptable range for cattle,[5] with the exception of the low selenium values in the livers of bison from WBNP. It has previously been reported[6] that approximately three-quarters of all the samples of plant species consumed by bison, based on samples collected at three low-land locations in northwestern Canada, were dietarily deficient in selenium by a beef cattle feed standard.

The mean selenium concentrations in liver and kidneys of ranched bison were significantly higher than those of WBNP bison ($P=0.01$) and MBS bison (liver, $P=0.01$; kidney, $P=0.05$). There was no significant difference in selenium levels in livers of bison from the WBNP and MBS populations, but renal levels were lower in WBNP bison ($P=0.02$). Selenium levels found in the WBNP bison and previously reported for the MBS bison are lower than those reported in a national survey of Canadian cattle, while those found in the ranched bison are in the upper range of reported values from that study.[7]

Concentrations of copper in liver and kidneys of WBNP bison were significantly lower than in ranched bison ($P=0.01$), and the concentration of copper in liver was lower in WBNP bison compared to MBS bison ($P=0.01$). Similarly, manganese was found in lower concentrations in tissues of WBNP bison than in ranched bison (liver and kidney, $P=0.01$) and MBS bison (liver, $P=0.01$; kidney, $P=0.05$). Manganese levels in the kidneys of MBS bison were also significantly lower than in ranched bison ($P=0.05$). The WBNP bison had higher concentrations of zinc in their livers than either the ranched bison ($P=0.02$) or the MBS bison ($P=0.01$).

The differences in trace element concentrations among the three populations of bison could be related to a number of factors associated with the variability in age, sex, health, environmental stress, and diet among the groups, coupled with non-randomized sampling. These factors cannot be separated out for analysis, so both apparent differences and similarities found should be taken in this context. The results indicate a need for further research with appropriate randomized sampling. They should not be considered definitive. For example, the lower levels of copper and manganese in the WBNP bison may have resulted from the number of diseased animals in the sample, from the high proportion of calves in the sample, from the bioavailability of these elements in their forage, or from a combination of these and other factors. These animals were collected on the basis of availability (hunter samples, road-kills) and consequently the age and health of these bison were less uniform than in the bison from ranches or in the previous MBS study.[1] Higher concentrations of trace elements in the farmed bison were attributed to the known mineral supplementation of their ration, but may also have reflected higher trace element levels in domestic forages in that area.

These are the only available data on trace element levels in bison, and no research has been done to correlate tissue levels with the physiological requirements of bison, which may be different from cattle. Hence, it is difficult to determine the significance of these concentrations of trace elements in bison tissues. Signs of trace element deficiencies have not been observed in the MBS herd, which has had an exponential rate of population growth. There is no evidence to suggest that the poor reproductive success of the WBNP bison is related to inadequate intake of trace elements. Reproductive failure is not a specific sign, nor the sole sign, of nutritional deficiency. Other signs associated with nutritional deficiencies have not been reported in the WBNP bison, and the high incidence of brucellosis and tuberculosis in the population must also be considered when assessing reproductive performance of that population.

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