Copper levels in livers of red deer in the South Island and their relationship with soil group

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Introduction

The geology of New Zealand is extremely varied and soils from adjacent areas. derived from different parent materials. are likely to vary markedly in mineral composition. Furthermore. large differences in the degree of weathering and leaching of the soils are possible. depending on climate and age of the soil Copper (Cu) concentrations. or more importantly. available Cu concentrations of the soils are controlled by these factors In New Zealand strong inverse relationships have been demonstrated between EDTA-extractable soil Cu (assumed available to plants) and the degree of weathering/leaching of the soil (McLaren et al 1984: McIntosh et al. 1986).

Copper intake by grazing animals is dependent on herbage Cu levels which. in turn. are affected by plant availability of soil Cu The correlation between plant Cu and extractable soil Cu. although significant (McLaren et al. 1984. Sherrell & McIntosh. 1987). accounts for a relatively small proportion of the total variation in plant Cu levels (McLaren et al. 1984). this being affected by such factors as soil pH. soil organic matter and the presence of other minerals (Delhaize et al 1987) and also age and species of the plant (Gladstones et al. 1975).

Farmed deer in New Zealand are most often restricted to pasture. predominantly of a ryegrass-white clover mixture. whereas feral deer obviously have access to a wide variety of grass species plus bushes. trees and possibly lichens. While the feral deer of New Zealand are able to maintain high levels of liver Cu (Reid et al 1980) without apparently suffering from toxicity. the sufficiency of Cu intake of deer maintained under common New Zealand intensive farming practices is seriously questioned Clinical cases of Cu deficiency of farmed deer are often reported. particularly by the Animal Health Laboratories. However. the extent of marginal or subclinical deficiency. or that which often causes the greater reduction in farming profitability. is not known

This paper reports the preliminary findings of a comparison between the liver Cu concentrations of farmed and feral deer and an investigation of the possible relationship between soil groups and liver Cu concentrations of deer farmed in the South Island

Materials and Methods

Liver samples were collected from the three main Deer Slaughter Premises (DSP's) of the South Island. Of the total number. 1685 samples were obtained from the Ashburton DSP during the summer of 1986/87. and 342. 825 and 811 samples obtained from the Ashburton. Hokitika and Mossburn DSP's respectively during the summer of 1987/88 The majority of samples collected were from red deer. however. an unknown proportion were from wapiti and red/wapiti hybrid deer

These latter types were not expected to have affected the overall results greatly, consequently there was no attempt to distinguish between these species even though it is known that their Cu metabolism may be different to that of red deer (Mackintosh et al 1986a). In addition, liver samples from 457 feral deer, processed at the Mossburn DSP at the same time as the farmed animals, were collected.

Samples were collected by removal of the caudate lobe of each liver during normal post-mortem health inspection. It was therefore possible to identify each liver with its carcase. The samples were placed in individual containers and frozen. For analysis, small sections of each liver (approximately 0.25g dry weight) were cut from the samples and dried. These were prepared for atomic absorption spectrophotometric analysis of Cu by digestion in a mixture (4:1) of nitric and perchloric acids. Concentrations are expressed in terms of μmol Cu/kg on a wet mass basis (WMB).

The name and address of the supplier of each animal was provided, under confidentiality, by the DSP's involved. The soil group upon which an animal grazed was crudely estimated by fitting the address of the supplier to a map (scale 1:1 000 000) of soil groups and series (New Zealand Soil Bureau Bulletin No 26). A relationship between soil group and mean liver Cu concentration was detectable from the estimation, inviting more accurate investigation. Hence, a questionnaire was sent to each supplier (approximate total of 200), requesting details of soil group, pasture or animal mineral supplementation history and evidence of symptoms of deficiency. From the returns to this questionnaire (40-50% were completed and returned) the estimation of soil group was refined and the corrected data were re-analysed.

Results

The results of the liver Cu analyses for the different DSP's are given in Table 1.

Table 1. Numbers of samples analysed, the number of farms from which the animals were derived, the mean ($\pm$SE), median and range of liver Cu concentrations (μmol/kg WMB) for the different DSP's.

DSP	No.	Farms	Cu concentration (μmol/kg WMB) mean $\pm$SE	median	range
Ashb '86/87	1685	121	184.6 $\pm$4.49	136.0	15.7 - 1223.8
Ashb '87/88	342	38	283.5 $\pm$12.5	252.6	40.3 - 1229.1
Hokitika '87/88	825	39	125.5 $\pm$3.92	100.9	16.2 - 716.5
Mossburn '87/88	811	35	154.3 $\pm$5.12	111.9	12.6 - 1265.7
Total	3661	233	176.8 $\pm$3.39	126.0	12.6 - 1229.1
Feral	457	---	630.7 $\pm$14.75	621.8	71.7 - 1908.9

Since not all suppliers responded to the questionnaire, the analysis of liver Cu concentrations according to soil group was comprised of smaller numbers (Table 2).

Table 2 Numbers of deer killed and mean liver Cu concentration (µmol/kg WMB) according to soil group for the different DSP's. Yellow grey is abbreviated to YG and yellow brown to YB. Only data with correctly identified soil groups have been included.

Soil group	Ashb '86		Ashb '87		Hokitika		Mossburn		Total	
	No	[Cu]	No	[Cu]	No.	[Cu]	No.	[Cu]	No	[Cu]
Recent	78	226 9	25	410 0	6	290 3	42	294 9	109	272.5
Gley recent	--	---	--	---	106	184.1	--	---	106	184 1
YG earth	82	191.4	--	---	52	156.4	3	153 2	134	177 8
YG/YB earth	68	115.1	14	351.4	239	96 8	49	123 9	292	107 2
YB stony	44	293.9	48	199.3	76	130.2	--	---	169	192 9
YB earth	234	154 8	30	104.1	65	117 7	18	336 3	330	142 8
Podzol	--	---	--	---	51	78 5	--	---	51	78 5
YB sand	--	---	--	---	8	74 3	--	---	8	74 3
Gley	8	248.4	8	268 8	3	335 8	--	---	19	270 9
YB loam	--	---	--	---	--	---	20	141 2	20	141 2
Rendzina	2	661 6	10	489 5	--	---	--	---	12	518 3

Discussion

A remarkable feature of Table 1 is the great difference in liver Cu concentration between feral and farmed deer, in agreement with the results of Reid et al. (1980). Although high concentrations of Cu were found in the livers of some farmed deer (>600 µmol/kg WMB), similar to those of feral deer, these levels were considered to be extreme and such deer had presumably received some form of supplementation. Thirteen feral animals had more than 1500 µmol Cu/kg in their livers.

The first seven soil groups in Table 2 (recent to podzol soils) are arranged in order of increasing weathering/leaching. Within the overall variation between DSP's and soil groups it is possible to detect a decrease in mean liver Cu concentration as the degree of soil weathering/leaching increases. Although this trend was clearest for the Hokitika data there is general agreement with the data from the other DSP's

The recent soils are freely drained with a relative lack of weathering and, together with their poorly drained variants - the gley recent soils, may be expected to contain the highest concentrations of extractable Cu (McLaren et al 1984). Liver Cu concentrations of deer grazing on these soils were indeed highest. Deer on the gley soils also had high liver Cu concentrations. Developed under waterlogged conditions, these soils tend to have higher concentrations of nutrients than the associated local soils because of the accumulation of ions in the drainage water from higher areas

In contrast, podzol soils are the most weathered and leached and liver Cu concentrations would be expected to be lower on these soils. The yellow brown sandy soils would also be expected to be low in Cu as a result of their parent material (largely quartz). Liver Cu concentrations were lowest on these soils. The soils of the rendzina group, in addition to being weathered, contain high levels of organic matter which decreases the extractable Cu content. The high liver Cu concentrations associated with this soil group (518.3 µmol/kg) are therefore contrary to expectations. There was no evidence that they were the result of supplementation.

Relationships between extractable soil Cu and liver Cu have been found in feral deer on the island of Rhum in Scotland (McTaggart et al 1981) and between area of grazing and incidence of hypocupraemia in cattle (Leech & Thornton 1987) On the other hand, Morton (1986) found no significant correlation between Cu in soil or pasture and Cu in serum or liver of lambs even though pasture Cu levels were considered marginal The present study examines the correlation between deer liver Cu concentration and soil group *per se* That such correlations were demonstrable may be a specific function of Cu metabolism of deer Copper is much more rapidly cleared from the liver of deer than from sheep (Harrison et al 1989) Liver Cu concentrations of deer are therefore more likely to represent current intake of available Cu Furthermore, Osman et al (1989) demonstrated that deer are less sensitive to the interaction of molybdenum and sulphur with Cu metabolism which interferes with the accuracy of prediction of Cu availability While analysis of the possible influence of dietary antagonists to Cu availability has been omitted from the present study, it is accepted that these could have reduced or enhanced the relationships observed

Of all farmed deer killed in the South Island during the summer, more than 40% had liver Cu levels below 100 μmol/kg (Figure 1), the liver Cu concentration at which plasma Cu concentration begins to fall (Mackintosh et al 1986b, Harrison, unpublished data) and were at risk of subclinical deficiency (Suttle 1986) Clark and Hepburn (1986) and Mackintosh et al (1986b) suggested that 60 μmol Cu/kg is a 'critical' liver Cu concentration below which enzootic ataxia may occur in some deer By this latter criterion, 20% of surveyed deer were at risk of clinical deficiency This is a surprisingly high proportion of the population and may account for the finding of Familton et al (1985) that Cu appears to be the trace element of major concern to both the veterinarian and deer farmer Moreover normal seasonal variation in liver Cu concentrations (Mackintosh et al. 1986b) would lead one to expect lowest liver Cu concentrations during late winter and early spring, thus suggesting that the present data may underestimate the extent of Cu deficiency.

In conclusion, it appears that soil group has a strong influence on liver Cu concentrations of deer, the more weathered soil groups resulting in lower liver Cu concentrations Such information, although not absolute, should be of assistance in the estimation of the necessity for supplementation in particular areas More widespread use of supplementation is probably justifiable on a regular basis in order to maintain liver Cu concentrations and possibly optimal animal productivity The danger of Cu toxicity in deer as a consequence of supplementation is probably much less than for sheep because of the more rapid excretion of excess Cu by deer (Harrison et al. 1989)

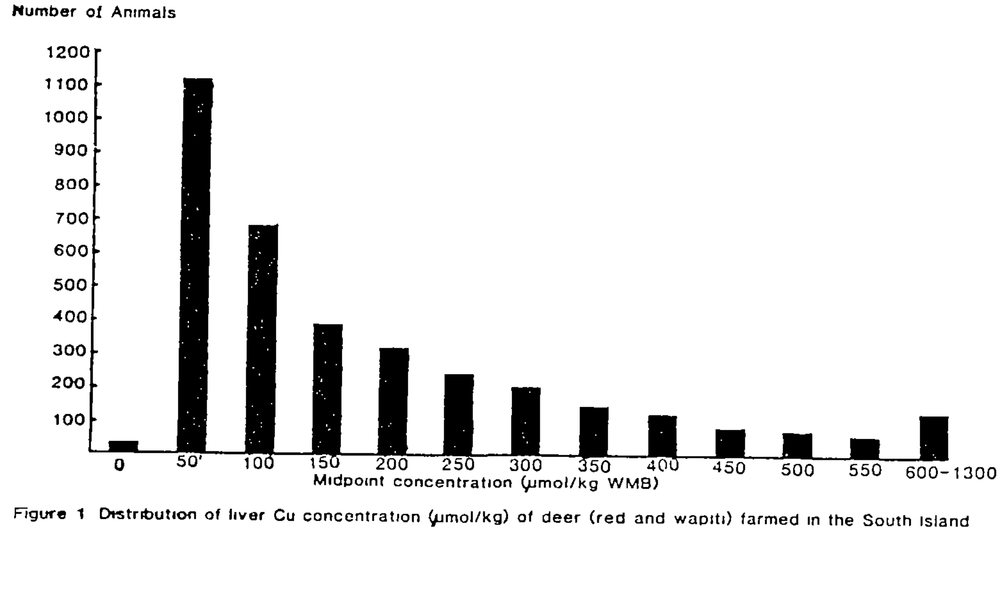

Figure 1 Distribution of liver Cu concentration (μmol/kg) of deer (red and wapiti) farmed in the South Island

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