Liver trace elements in farmed and feral deer

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Abstract

Liver samples were collected from a South Island deer slaughter premise and game packing house in November 2000 Data on site of origin was recorded Deer were classified as 1-year-old (yearling) or older (adult) on the basis of permanent incisor number A sub-sample of 107 livers, both sexes combined, was selected with up to 10 samples per age group from farmed deer from Central Canterbury, Nelson and Westland, and from feral deer from North, Central and South Westland. Samples were analysed for copper, selenium and vitamin B_{12}. Mean liver copper concentrations for farmed and feral yearlings were 267 and 889 µmol/kg, respectively, and for adults 206 and 677 µmol/kg, respectively There were significant differences between farmed and feral deer, and between feral adults and yearlings Mean liver vitamin B_{12} concentrations in farmed yearlings and adults were 456 and 428 µmol/kg, and for feral deer, 742 and 869 µmol/kg, respectively Farmed and feral deer vitamin B_{12} concentrations were significantly different, and feral adults had significantly higher concentrations than feral yearlings. Mean liver selenium concentrations in farmed yearling and adults were 2050 and 1938 nmol/kg, respectively, and in feral yearlings and adults, 1539 and 1625 nmol/kg, respectively There were no significant differences in liver selenium concentrations between farmed and feral deer or between age groups from farmed or feral origin

Introduction

Trace elements are a key feature of sustainable agricultural systems (Lee *et al.* 1999) Copper, selenium, cobalt and iodine are the most significant trace elements in pastoral livestock species (Clark and Towers, 1983). Copper and selenium deficiency syndromes are reported (Wilson and Grace, 2001), but vitamin B_{12} deficiency has yet to be shown in farmed deer Relationships between biochemical measurements of tissue trace element concentrations, clinical disease and production responses are an important aspect of diagnosis and monitoring for trace element deficiencies (Wilson and Grace, 2001) Copper deficiency is the major trace element deficiency in farmed deer and current knowledge has been reviewed recently (Wilson, 1999) Dietary intake of copper, and potentially competing elements, are important determinants of animal trace element status. Recent evidence (Barry *et al*, 2001) has shown liver copper concentrations in deer were related to forage species grazed

There is widespread anecdotal belief that the trace element status of feral deer is superior to that of farmed deer based on the assumption that the varied diet available in the feral environment allows animals to consume vegetation with higher trace element concentrations compared with those available on ryegrass/white clover pastures Reid *et al* (1980) observed that liver copper concentrations were higher in mature feral red deer than in similar farmed animals and that liver copper concentrations were higher in foetal, neonatal and immature deer. Those authors also showed differences in feral deer related to geographic origin. There have been no reports of comparison of trace elements from deer of farmed and feral origin

This paper presents liver copper, selenium and vitamin B_{12} concentrations from 1-year-old (yearling) and adult deer from three farmed and feral locations

Materials and Methods

Liver samples were collected from deer of feral and farmed origin at a deer slaughter premise (DSP) and game packing house (GPH) in South Westland, November 20-24 2000 The caudate lobe was collected immediately upon slaughter from 233 farmed deer at the DSP, and from 60 feral deer presented at the GPH within 7 days of death. Deer were aged by examination of permanent incisor teeth (Tisdall *et al* , 1985) Deer with four or fewer permanent incisors were classified as 1-year-old (yearlings), while those with more than four permanent incisors were classified as adult The region,

location and farm of origin were recorded as appropriate Liver samples were stored frozen for analysis

Farms sampled were clustered around Central Canterbury, Nelson and Westland, while those of feral origin were clustered in North, Central and South Westland Up to 10 samples, as available, from each age group within each region were randomly selected for trace element analyses (see Tables 1 and 2). In total, 55 and 52 liver samples were selected from farmed and feral deer, respectively, for trace element analysis.

Table 1. Region, location, age (Y = Yearling A = Adult) and number of samples collected and selected for trace element analysis from feral deer

Region	Location	Age	No. samples collected	Analysed
South Westland	Fox Glacier	Y	0	9
		A	1	1
	Jacob's Creek	Y	2	2
		A	1	1
	Mauitahi	Y	0	0
		A	1	0
	Paringa	Y	3	3
		A	6	5
	Okuna	Y	2	2
		A	0	0
	Landsborough	Y	2	2
		A	2	2
	Haast River	Y	1	1
		A	1	1
		Total/ region	**22**	**20**
North Westland	Wanuanui River	Y	4	4
		A	4	4
	Upper Mikonui River	Y	1	1
		A	2	2
	Mikonui River	Y	0	0
		A	1	1
		Total/region	**12**	**12**
Mid Westland	Hobson	Y	0	0
		A	1	0
	Greymouth	Y	1	1
		A	1	1
	Arakura	Y	3	3
		A	5	4
	Kokatua River	Y	8	6
		A	7	5
		Total/region	**26**	**20**

Table 2 Region, location, farm, age (Y = Yearling A = Adult) and number of samples collected and selected for trace element analysis from farmed deer

Region	Location	Farm	Age	No. of samples collected	Analysed
Nelson	Wakefield	A	Y	16	3
			A	10	5
		B	Y	10	1
			A	4	1
	Brightwater	A	Y	6	1
			A	0	0
	Richmond	A	Y	3	0
			A	0	0
		B	Y	0	0
			A	4	2
		C	Y	4	2
			A	0	0
	Upper Moutere	A	Y	5	3
			A	2	0
		B	Y	5	0
			A	0	0
	Martindale	A	Y	0	0
			A	7	2
	Total/area			**76**	**20**
Canterbury	Oxford	A	Y	2	0
			A	9	1
	Christchurch	A	A	7	1
			Y	0	0
		B	Y	3	0
			A	0	0
	West Melton	A	Y	24	2
			A	2	2
	Rakaia	A	Y	12	2
			A	2	0
		B	Y	4	3
			A	0	0
		C	Y	26	1
			A	0	0
	Colgate	A	Y	3	0
			A	13	8
	Total/area			**107**	**20**
Westland	Dobson	A	Y	10	3
			A	2	2
		B	Y	6	2
			A	0	0
	Greymouth	A	Y	13	2
			A	2	2
	Hokitika	A	Y	5	1
			A	10	2
	Whataroa	A	Y	2	2
			A	0	0
	Total/area			**50**	**15**

Copper, selenium and vitamin B_{12} were analysed using standard techniques employed by the AgriQuality Animal Health Laboratory, Palmerston North

Analysis of variance for concentration of each trace element used PROC GLM of SAS (2000) A linear model included the effects of deer type (feral or farmed), location for both feral and farmed deer, age (yearling and older), and interaction between origin and age Both sexes were combined for analysis since previous data (Reid *et al*, 1980, Wilson and Audige, 1998) showed no differences between sexes

Results

Mean and ranges for each trace element liver concentration categorised by age and location are presented in Table 3 There was wide variation in each of the trace elements measured in both ages in all locations While there were insufficient numbers to allow individual farm or feral deer location differences, inspection of the data suggests the variation was similar

Table 3. Mean and range of liver trace element concentrations for each age (Y = yearling, A = Adult) and location, and overall least squares means

			Copper (µmol/kg)		Selenium (nmol/kg)		Vitamin B_{12} (µmol/kg)	
Location	**Age**	**N**	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*
FARMED								
Canterbury	Y	10	146	52-310	1470	280-4300	447	220-590
	A	10	180	69-450	952	770-1200	467	370-620
Nelson	Y	10	357	59-1400	3370	1300-5000	483	210-700
	A	10	290	43-830	3700	1400-6000	367	190-820
Westland	Y	10	277	72-670	1180	300-2000	435	72-670
	A	5	130	51-270	1426	540-2600	482	220-750
Least squares means			**237**		**1994**		**442**	
FERAL								
North Westland	Y	5	804	320-1200	1850	850-2500	678	490-980
	A	7	802	440-1000	1551	960-3400	840	570-1100
Central Westland	Y	10	1000	720-1500	1700	350-3700	710	490-850
	A	10	752	56-2000	1509	490-2100	711	450-1200
South Westland	Y	10	808	440-1500	1134	650-1400	797	710-1100
	A	10	502	100-1300	1522	1100-4100	951	700-1300
Least squares means			**813**		**1582**		**805**	

Copper

Overall, the mean liver copper concentration in feral deer was significantly higher than in farmed deer ($p<0.0001$) There were no differences between locations within farmed or feral origin Mean liver copper concentration in yearlings was higher than in adults from feral origins ($p = 0.0028$), but not from farmed origins

Selenium

Mean liver selenium concentrations in farmed deer in Nelson were significantly higher than in those from Canterbury and Westland ($p<0.0001$) It was notable that selenium concentrations from all farms

sampled in Nelson were high Overall, selenium concentrations in farmed deer were significantly higher than in feral deer ($p = 0.04$). There were no age differences

Vitamin B_{12}

Liver vitamin B_{12} concentrations in adult feral deer were significantly higher than those of yearling feral deer ($p = 0.02$) Liver Vitamin B_{12} concentrations in feral deer from South Westland were significantly higher than those from Central Westland ($p = 0.047$). Overall, liver vitamin B_{12} concentrations were significantly higher in feral deer ($p<0.0001$) There were no significant differences in liver Vitamin B_{12} within farmed locations

Discussion

While there has been one report in the literature comparing farmed and feral deer copper concentrations (Reid *et al*, 1980), these are the first published data comparing selenium or vitamin B_{12} from those locations

Higher liver copper concentrations in feral deer observed in this study concurred with the observation of Reid *et al* (1980) These differences are likely to be dietary through higher copper concentrations in grazed and browsed forage in the feral environment compared with the predominantly ryegrass/white clover diet of farmed deer It has been shown that different forages contain different copper concentrations (Barry *et al*, these Proceedings) An alternative explanation may be different proportions of elements such as molybdenum, sulphur and iron in the diet that may interfere with copper uptake and absorption It is especially likely that farmed deer would consume more soil, and therefore more iron than feral deer

It has been proposed elsewhere (Wilson and Audigé, 1998) that lower copper concentrations in adult deer compared with weaners and yearlings may be associated with higher grazing pressure, resulting in higher soil intakes. Data in this study contrasts with that of Wilson and Audige (1998), and shows no difference between yearling and adult liver copper concentrations in deer from farmed origin However, liver copper concentrations in young feral deer were significantly higher than in adult feral deer While this may reflect differences in diet selected, there could also be physiological changes in copper metabolism that contribute to age differences Grace *et al* (these Proceedings) demonstrated lower liver copper concentrations at 16 months of age compared with the same animals when they were 4 months of age grazing the same pasture It could be expected that diet on offer to feral deer would not differ greatly between ages, whereas management on farms could significantly influence dietary intake of different age groups

The copper supplementation history of farmed deer in this study is unknown It is possible that the lack of difference between age groups on farms could be attributable to copper supplementation Thus, potential trace element supplementation is a confounding effect in interpreting these data

Reid *et al* (1980) showed neonatal and newborn deer to have consistently higher liver copper concentrations than older deer This age group was not evaluated in the present study.

It is notable that 10 of 55 farmed deer sampled (18%) had liver copper concentrations less than 60 µmol/kg, the range at which animals are at risk of clinical disease according to Wilson and Grace (2001). A further 10 liver copper concentrations fell in the marginal range of 60-100 µmol/kg In contrast, 1 of 52 feral deer had a liver copper concentration less than 60 µmol/kg, It was recorded at the time of sample collection that this animal looked particularly old A further 2 animals from feral origin contained liver copper concentrations in the marginal range

The overall mean liver selenium concentration in farmed deer was higher than that in feral deer There was, however, a significantly higher selenium concentration in farmed deer from the Nelson region Mean liver selenium in Canterbury and Westland farmed deer were lower than those of feral deer Thus, the difference in overall means was attributable to the significantly higher levels in Nelson farmed deer All farms of origin from that area had high selenium concentrations. The Nelson area contains soils known to be low in selenium (Moreton *et al*, 1998) and growth responses to selenium

have been observed in that district (Andrews *et al*, 1968). Therefore, one explanation for high selenium concentrations is supplementation. However, Canterbury is also known to be low in selenium, and supplementation is common, yet liver selenium concentration from deer from that area were not as high as those in Nelson. Thus, care must be exercised in interpreting this data in the absence of supplementation history.

High selenium concentrations in feral deer have occurred in the absence of supplementation Feral sambar deer in the Manawatu/Rangitikei region (Stafford, 1997) maintain high selenium status when nearby farms require selenium supplementation to maintain animal health status. Stafford (1997) also reported a varied diet selected by those deer

Mean liver vitamin B_{12} concentration in feral deer was significantly higher than that of farmed deer. Young feral deer had lower vitamin B_{12} concentrations than older feral deer. There was also a marginally significant difference in vitamin B_{12} concentration between Central and South Westland feral deer It is possible that some deer farms had supplemented with vitamin B_{12} It is likely that the higher vitamin B_{12} status of feral deer is also associated with dietary intake through selection of browse and graze forage Feral location differences may reflect differences in vegetation and/or deer habitat Differences between adult and young feral deer are difficult to explain Cobalt is believed to be highest in woody plant material, and these may be consumed more frequently by older deer

Analysis of diet was beyond the scope of this study Results presented suggest significant differences in trace element concentrations in diet Further study should be directed to establishing the diet selected by feral deer compared with farmed deer, and to measure the trace element and macro-element content of the major components of the diet Identification of browse or grazing species with high trace element status may provide a means of maintaining trace element status of farmed deer without artificial supplementation Investigation of this aspect of deer farm management may achieve more significance in the future as the use of artificial chemicals becomes less acceptable to our marketplace for deer products, and as the demand for more natural production systems increases (Loza MJ, these Proceedings)

Conclusion

Intensive deer farming is characterised by high inputs of chemicals, including anthelmintics and trace element supplementation for animal production, and fertilisers, herbicides and pesticides for pasture production and maintenance This study highlights that it is possible for red deer to maintain adequate concentrations of the major trace elements in the feral environment in New Zealand. It is possible that evaluation of trace element status of various dietary components of feral deer may identify some plants with particularly high trace element concentrations. The potential role of incorporation of various native herbage species into deer farming systems, to improve their sustainability without artificial supplementation warrants investigation An outcome which reduced artificial chemical inputs would be consistent with the marketing thrust for New Zealand deer products as being from natural production systems

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