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The diet and trace element status of sambar deer (*Cervus unicolor*) in Manawatu district, New Zealand

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Abstract In Manawatu, sambar deer cause damage to pine forests by stripping bark off trees. In August-September of 1994 and 1995 samples of rumen contents and liver were collected from sambar to determine the incidence of pine in the diet and the trace element (copper, selenium, cobalt) status of these animals. Unidentified grasses were the predominant plants in 34 of the 40 rumen content samples. In the remaining samples, flax (*Phormium tenax*) predominated in three and pine (*Pinus* spp.) in three. Pine needles and/or stems were found in 25 samples, and constituted more than 10% of the dry weight of 11 samples, but pine bark was found in only three samples. The levels of selenium (>850 nmol/kg) and vitamin B_{12} (>220 nmol/kg) in the 22 liver samples would be considered adequate for sheep, red deer, and cattle and probably also for sambar. The liver copper levels were inadequate (<100 μmol/kg) in three of four samples taken from deer shot in Moutoa whose diet consisted of grass and flax. The varied diet of sambar allows them to obtain sufficient selenium and copper in an area where the soils are deficient in these elements from the standpoint of livestock production.

Keywords sambar deer; *Cervus unicolor*; diet; pine; flax; copper; selenium

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INTRODUCTION

In the Manawatu coastal area, sambar deer (*Cervus unicolor*) cause considerable damage to pine forests (*Pinus radiata*) by stripping the bark off young trees (Douglas 1983). They also feed on pine leaves (needles) and thrash trees with their antlers. The habitat of the sambar is varied, and includes flax swamp, pine forest, and rough cover (marram grass, lupin, gorse, pampas grass) on sand dunes. Farther inland it contains swamp vegetation, small shelter belts of exotic trees, farm forestry blocks, remnant patches of indigenous forest, and farmland (Douglas 1983). The soil in this area is deficient in copper (Cunningham 1960) and selenium (Robertson & During 1961), but not deficient in cobalt (Blackmore & Mitchel 1978), in terms of livestock production off pasture.

Sambar have been classified as an intermediate feeder (grazer/browser) (Hofmann 1985) with a tendency towards roughage grazing (Stafford 1995). In southern Asia they live in rain forest, feeding on leaves, fruit, and the bark of trees (Kurt 1990). However, they adapt to jungle clearance, and in Thailand they feed on grasses (Kurt 1990).

In Manawatu, sambar living in the Moutoa flax swamp fed on 16 plant species including flax (*Phormium tenax*) and tall fescue (*Festuca arundinacea*) during winter and on floating sweet grass (*Glyceria declinata*) and reed canary grass (*Phalaris arundinacea*) during summer (Kelton 1981). In the Manawatu pine forests sambar feed on grasses, briars (*Rosa canina*), and blackberry (*Rubus fruticosus*) (Douglas 1990).

This study was carried out to investigate the copper, cobalt, and selenium status of sambar and to determine the incidence of pine bark and needles in rumen samples taken from these deer.

METHODS

Hunters provided 22 liver samples and 40 samples, each of about a litre, of rumen contents from deer killed in August-September of 1994 and 1995. Rumen contents and liver samples together were obtained from only six animals. The rumen samples were stored frozen until analysis was possible. Samples were obtained from throughout the naturalised range of sambar.

For analysis, rumen samples were thawed and washed over a 4.0 mm sieve and the retained material was sorted macroscopically (Nugent 1983; Nugent & Challies 1988); each item was assigned to one of five plant categories and then identified, usually to species (Table 1). Plant parts (stem, green leaf, old leaf, flower, seed pod, fruit) were differentiated. The sorted materials were oven dried to constant weight and weighed (±1 mg). Grasses were not identified to species level because this is difficult to do macroscopically.

The fresh liver samples were analysed for copper, selenium, and vitamin B_{12}, which reflects cobalt status, by the Animal Health Laboratory of the Ministry of Agriculture. Copper was measured by atomic absorption spectrophotometry (Ross 1990), selenium by an automated fluorimetric technique (Watkinson 1979), and vitamin B_{12} by radioisotope dilution (Miller et al. 1984).

A Student t-test was used to compare the liver copper levels and the number of plants in rumen samples from deer killed in different locations.

RESULTS

A total of 41 plant types, plus hair and feather, were identified in the rumen samples (Table 1). Seven plant types formed more than 10% of the dry weight of at least one sample. Unidentified grasses were found in all samples, and formed 65% of the total dry weight of all samples. Flax constituted 14% of the total dry weight of all samples but was found in only 33% of samples. Pine, including needles, stem and bark, was the third most common plant, constituting 11.4% of the total dry weight of all samples and found in 63% of samples. Unidentified woody stems were found in 78% of samples.

Grasses were the dominant plant type in 34 of the rumen samples, and constituted more than 50% of the dry matter in 28 of the samples examined. In the other six samples, flax was predominant in three and pine in three. Grasses and flax in roughly even proportions constituted 99% of the dry matter of eight samples. Pine needles constituted more than 10% of the dry weight of 11 samples. Pine bark constituted 7, 9, and 39% of the dry weight of three samples

Table 1 Plant types found in rumen material from sambar deer (n = 40) in Manawatu.

	Samples (%)	Total dry weight (%)
Woody species		
Pinus spp (all parts)*	63	11.4
Unidentified woody stems	78	3.2
*Rubus fruticosus**	20	1.8
Coprosma spp	10	0.4
Ulex europaeus	18	0.3
Melicytus ramiflorus	10	0.2
Rubus cissoides	3	0.1
Griselinia littoralis	5	0.1
Cytisus scoparius	3	<0.05
Ferns and tree ferns		
*Pteridium esculentum**	30	0.6
Blechnum capense	8	0.3
Asplenium bulbiferum	5	<0.05
Asplenium flaccidum	3	<0.05
Asplenium polyodon	5	<0.05
Blechnum fluviatile	3	<0.05
Dicksonia spp	3	<0.05
Unidentified tree fern	8	<0.05
Unidentified fern	18	<0.05
Grass and flax		
Grass*	100	65
*Phormium tenax**	33	14
Juncus spp	3	<0.05
Unidentified fibre	3	<0.05
Unidentified monocotyledon	5	<0.05
Herbs		
Unidentified herb*	90	1.2
Lotus pedunculatus	3	0.2
Myosotis spp	5	0.1
Trifolium spp	15	0.1
Unidentified thistle	5	0.1
Cerastium fontanum	5	0.06
Galium aparine	3	<0.05
Lotus major	3	<0.05
Lotus spp	3	<0.05
Melilotus spp	3	<0.05
Potamogeton suboblongus	3	<0.05
Ranunculus spp	3	<0.05
Rumex acetosella	5	<0.05
Stellaria media	3	<0.05
Trifolium repens	3	<0.05
Dandelion type	8	<0.05
Miscellaneous		
Hair*	20	0.2
Unidentified moss	8	<0.05
Unidentified lichen	8	<0.05
Feather	3	<0.05

*Formed more than 10% of at least one rumen content sample.

taken from deer shot at Santoft and two unknown locations, respectively.

The number of plant types in a sample varied from 2 to 18. The samples consisting principally of flax and grasses had significantly ($P < 0.05$) fewer plant types (3.8 ± 1.36; $n = 8$) than the remaining samples (8.9 ± 3.68; $n = 32$). Excluding grasses, flax, and pine, few of the remaining plant types were found in many samples, and then usually in very small amounts (Table 1).

The vitamin B_{12} and selenium levels were adequate in all liver samples (Table 2). Copper levels were adequate in all individuals except for three animals from the Moutoa swamp, whose mean liver copper levels (106 μmol/kg) was significantly lower ($P < 0.05$) than that of animals from other areas. The number of plant types found in rumen samples from Moutoa deer (5.5 ± 2.5) was significantly lower ($P < 0.05$) than in samples from the other areas combined (9.1 ± 3.9) or individually, with the exception of Himatangi (Table 3). Rumen contents from Moutoa consisted principally of grass and flax.

DISCUSSION

The rumen samples analysed in this study, collected from throughout the naturalised range of sambar, show that their diet is more varied than that found by Kelton (1981) in the Moutoa flax swamp. Moreover, there were two distinct diets: one of grasses and flax, seen in samples from Moutoa, and the other a more varied diet, which often contained significant amounts of pine material, usually the needles.

This study shows that, although 25 of the sambar had fed on pine, only three had pine bark in their stomachs. In one of the latter, bark made up 39% of the dry weight of the sample. The damage caused by sambar to pine plantations is due primarily to bark stripping. The small number of animals with bark in the rumen suggests either that most deer eat bark only occasionally, or that concentrated bark stripping is an individual behavioural trait, not detected in this study, rather than a widespread habit.

The concentration of copper, selenium, and vitamin B_{12} in the liver is a good indicator of the status of these trace elements in the animal (Ellison & Feyter 1988). The selenium status of these deer would be considered adequate for farmed red deer (Ellison 1995). There is no information available regarding what level of vitamin B_{12} in the liver is adequate for deer, but levels above 375 and 220 nmol/kg are adequate for sheep and cattle, respectively, and so the values reported here are probably adequate for sambar (Ellison & Feyter 1988).

Table 3 Number of plant types found in rumen samples (mean ± SD) from sambar deer from Manawatu.

Sample source	n	No. of plant types
Moutoa	11	5.5 ± 2.5
Rangitikei	8	9.8 ± 4.4
Himatangi	2	4 ± 2
Tangimoana	2	7.5 ± 1.5
Wanganui	2	14 ± 1
Santoft	3	10 ± 1.7
Unknown	12	8.7 ± 3.6

Table 2 Liver concentrations of copper, selenium, and vitamin B_{12} (mean ± SD) in sambar deer from Manawatu.

Sample source	n	Copper (μmol/kg)	Selenium (nmol/kg)	Vitamin B_{12} (nmol/kg)
Adequate levels*		>100	>850	>220
Moutoa	4	106 ± 96	1027 ± 46	673 ± 91
Rangitikei	2	875 ± 84	1280 ± 520	905 ± 359
Himatangi	3	591 ± 57	1966 ± 249	583 ± 62
Tangimoana	4	534 ± 152	1900 ± 374	905 ± 359
Harakeke	3	515 ± 176	873 ± 164	787 ± 170
Wanganui	1	471	1800	520
Dudley Lake	1	977	990	630
Santoft	1	333	1100	950
Turakina	1	623	2900	1200
Bulls	1	287	1800	840
Unknown	1	1094	1700	590

*Ellison (1995).

However, the copper level in three out of four liver samples taken from sambar in Moutoa were considered inadequate, being below 100 µmol/kg (Ellison 1995), suggesting that their diet, less diverse than in deer from other areas and consisting principally of grasses and flax, was deficient in copper. The aetiology of copper deficiency is complex and may reflect either insufficient copper in the diet *per se* or excess molybdenum or iron interfering with copper absorption (Ellison 1995).

Sambar are grazer/browsers, and hand-reared fawns observed by Semiadi et al. (1993) started gnawing bark chips and browsing at 18 and 21 days of age, respectively. When offered a range of grasses, red clover, lotus, lupin, and willow branches, sambar preferred willow; in contrast, red deer preferred the forage legumes (Semiadi et al. 1995). Sambar have much higher levels of condensed tannin-binding proteins in their saliva than red deer (A. E. Hagermann, quoted in Semiadi et al. 1995) and have a more efficient rumination pattern (Semiadi et al. 1994). These factors may allow them to digest bark more efficiently than red deer and to utilise it as a source of energy. However, bark stripping is practised also by red deer and other deer (Clutton-Brock & Albon 1989).

The reasons why sambar eat pine bark are unknown, but suggestions include the possible high nutritive value of bark at particular times of the year, its trace element content, or the presence of vermicidal phenoles. Research to define the seasonality and circumstances of bark-stripping behaviour, and the nutritive value of pine bark, is continuing.

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