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Prevention of trace element deficiencies in grazing ruminants: an evaluation of methods

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Abstract

The prevention of cobalt, copper, selenium and iodine deficiencies is an important feature of stock health programmes on many New Zealand farms. Various methods of prevention involving direct supplementation to animals and topdressing pastures have been evaluated. Protocols for the amounts administered and frequency of supplementation for Co, Cu, Se and I have been outlined.

Keywords: cattle, cobalt, copper, deficiencies, iodine, deficiencies, prevention protocols, selenium, sheep

Introduction

Selenium, cobalt, copper and iodine deficiencies are an important feature of the New Zealand livestock industry, and once a trace element deficiency has *been* diagnosed the most effective method of preventing the deficiency has to be decided on. The options available to increase the intake and improve the mineral status of animals include topdressing the pasture, oral dosing and injections. New technologies such as the controlled-release systems are being incorporated into new products such as glass boluses which are placed in the rumen and are designed to improve the efficacy of the trace element supplement.

To be effective the supplement must increase and maintain the mineral status of the animal for long periods. The supplements therefore should be given directly to the animal or topdressed *on to the* grazed pasture to increase the trace element content of the herbage. The use of water troughs or salt blocks as vehicles for trace element supplementation is not satisfactory as the daily intakes of water and salt are highly variable.

Establishment of treatment protocols

The protocols for the amounts of trace element to be administered and the frequency of administration have been determined from a consideration of (a) the trace element requirements, that is, the daily intakes that are required to ensure an adequate mineral status, good health and maximum productive performance and (b) the trace element status of an animal as assessed *from* blood trace element levels (e.g. Cu. Se), vitamin concentrations (Co) and enzyme activities (Cu and Se), as well as the trace element and vitamin contents of the liver.

The observed changes in trace element concentrations when pastures are topdressed or when animals are supplemented will now be discussed and proven methods for the prevention of trace element deficiencies recommended.

Cobalt

(a) *Topdressing pasture*

The application of 350 g ha/$CoSO_4.7H_2O$ along with fertiliser causes a rapid increase in pasture Co concentrations (e.g. 0.04 mg to 0.5 mg/kg DM) within 4-6 weeks which is then followed by a marked decline over the next 4 to 6 weeks (0.5 to 0.12 mg/kg DM) and a slower decline (0.12 to 0.09 mg/kg DM) during the next 9-10 months (Sherrell 1984). The magnitude of the response is depended on soil type and the soil Co status while Co content of clover is higher than that of grasses. Once the Co status of the soil has been increased by regular applications of Co it is possible to reduced the amounts of Co applied (175g ha/$CoSO_4.7H_2O$) and still maintain adequate pasture Co levels.

To prevent Co deficiencies in weaned lambs, which are most sensitive to Co deficiency, pasture must contain at least 0.1 mg Co/kg DM (Clark 1983).

(b) *Administration to the animal*

Co deficiency is actually a vitamin B_{12} deficiency as the rumen micro-organisms require Co to synthesise vitamin B_{12} which is then absorbed and stored in the liver. From supplementation studies with Co and vitamin B_{12} it has been established that in animals of an adequate Co status the vitamin B_{12} concentrations in the serum and liver must be greater than 370 pmol/l and 220 nmol/kg fresh tissue respectively (Clarke 1983). Injected Co cannot be converted to vitamin B_{12} and therefore Co must be administered orally as a drench, a bullet or a soluble glass bolus.

Table 1 Effect of vitamin B_{12} injections and Co drenches on growth rates and tissue vitamin B_{12} concentrations in lambs.

	Growth rate g/day	Plasma vitamin B_{12} µg/ml	Liver vitamin B_{12} nmol/kg fresh tissue
Study A			
No vitamin B_{12}	101	0.14	140
1 .O mg vitamin B_{12}/month	153	0.51	474
2.0 mg vitamin B_{12}/month	147	0.63	549
Study B			
No Co drench	131		
1 mg Co/day	275		
7 mg Co/week	236		
14 mg Co/2 weeks	194		
26 mg Co/month	149		

For a 20-25 kg lamb l-2 mg of vitamin B_{12} injected monthly is adequate to promote good weight gains and maintain blood and liver vitamin B_{12} levels. (Hogan *et al.* 1973). Likewise, daily (1 mg/dose) or weekly (7 mg/dose) drenching of Co is necessary to ensure good growth but has the disadvantage of being too labour intensive (Stewart *et al.* 1955). Thereisno doubt that the Co bullet and the soluble glass bolus, releasing 0.6 mg day/Co, are effective in increasing the vitamin B_{12} content of the liver and blood for 6 to 12 months (Millar *et al.* 1984). However the NZ experience is that these can be readily regurgitated and lost while those remaining in the rumen *become* coated with a deposit of Ca_2 (PO,),.

Selenium

(a) *Topdressing*

Pastures must contain at least 30 pg Se/kg DM to ensure that a Se deficiency does not occur. Topdressing pasture with Se (10 g Se/ha) will rapidly increase the Se concentrations from 20 to over 600 µg Se/kg DM in about 8 weeks followed by a marked decline (600-50 pg Se/kg DM) over the next 2-3 months and then a slower decline over 8-10 months (50-20 µg Se/kg DM) (Watkinson 1983). Animals grazing these pastures also show marked changes in blood Se levels as these increase from 125 to over 2500 nmol/l after 3 months' grazing Se-treated pasture. The blood level then slowly declines over the next 9 months (2500-250 nmol/l) (Watkiion 1983). Thus Se topdressing of deficient pastures with sodium selenate ($Na_2SeO_4 \cdot 10H_2O$) will maintain an adequate Se status of grazing animals for 12 months.

The whole area of the farm need not be topdressed with Se, as strategic grazing can maintain the Se status of all animals because adequate amounts of Se can be 'stored' after 16 weeks of grazing a Se-treated pasture to maintain blood Se levels for another 3040 weeks.

(b) *Treatment* of animals

The Se status of sheep and cattle are considered to be adequate when the blood and liver Se concentrations are above 250 nmol/l and 450 nmol/kg fresh tissue respectively (Clark 1983).

Table2 **Effect of Se given orally as** a **drench,** a **Fe/Se bullet and a** soluble **glass bolus or as an** injection of **Ba selenate** on the blood Se **(nmol/l) concentrations** in sheep.

Days after treatment	10	50	100
Study A			
No Se drench	65	65	65
oral drench $Na_2SeO_4.10H_2O$ (0.1 mg Se/kg LW)	630	500	360
Study B			
No Se given	260	250	250
Se bullet (5% Se 95% Fe) releasing 0.5-l .3 mg Se/day	1500	3200	3600
Soluble glass bolus releasing 0.35 mg Se/day	400	1600	2000
Study C			
No Se given	215	215	215
injected as $BaSeO_4$ (1 mg Se/kg LW)		4900	4200

Although in sheep the response curves after 2 days for blood Se were similar for animals either drenched or injected, the blood Se levels always remained a little higher for the injected animals. The Se given as a drench or injection will maintain Se blood levels for at least 3-4 months. As the glass boluses were observed to be readily expelled by sheep (50% lost in 4 months) they are not satisfactory. The same problem has also been observed in sheep for the Se bullet (Miller et al. 1984). The Ba selenate injection gave very high blood Se levels peaking at 100-150 days (4200 nmol/l) and then declined to 1428 nmol/l 360 days after the injection (Metherell *et al.* 1984).

Copper

(a) *Topdressing pasture*

The effectiveness of increasing the Cucontent of pasture by the application of Cu salts depends on the composition of the pasture and soil type (Sherrell & Rawnsley 1982). The uptake of Cu and its persistence by clover is greater than for the grasses.

In contrast to Co and Se which are not essential elements for plant *growth,* pasture DM responses to Cu havebeenobserved (Sherrelll982). An applicationof 2-4 kg Cu/ha as copper sulphate ($CuSO_4.5H_2O$) increases herbage Cu concentration from 5-12 mg/kg DM within 4 weeks and then it decreases markedly to 8 mg/kg DM followed a slow decline over the next 9-10 months (Cunningham *et* al. 1946).

At pasture Mo and Fe concentrations of below 1 mg Mo/kg DM and 300 mg Fe/kg DM. the Curequirements of sheep and cattle are met by pasture Cu levels of 5-6 mg/kg DM and 8-9 mg/kg DM respectively (Grace 1983; Grace & Lee 1990). As the Cu requirements of cattle are greater than for sheep increases the concentrations of pasture Mo, in presence of S, and Fe have a greater influence on the Cu status of cattle. If the pasture Mo concentrations exceed 2-3 mg Mo/kg DM, then topdressing with Cu may not be effective in increasing pasture Cu levels to ensure that the Cu:Mo ratio is greater than 3.

(b) *Treatment of animals*

Cu can be administered to animals orally or as an injection. The best indicator of the Cu status of sheep and cattle is the change in the liver Cu concentrations because SO-60% of the body Cu can be found in the liver. An adequate Cu status is reflected by liver and blood Cu concentrations of greater than 20 mg Cu/kg DM (95 µmol/kg fresh tissue) and 8 µmol/l respectively.

A marked seasonal variation in liver Cu concentrations occurs with levels being lowest during the winter. Drenching sheep with 300 mg Cu has a short term effect on Cu status, with no difference observed between untreated and treated animals after 49 days. Treatment with CuO needles and Cu injections maintained elevated liver Cu levels for 180-200 days.

More severely Cu-deficient animals would be protected for a shorter period (Langlanda et al. 1986).

Iodine

(a) *Topdressing*

The application of I salts (e.g. KI or KIO_3) to pasture as a way of increasing the I intake is not satisfactory as these salts are expensive and decompose on storage. To prevent I deficiency, in absence of a goitrogen. the diet should contain at least 0.2 mg I/kg DM.

(b) *Treatment of the animal*

To date an evaluation of the efficacy of I supplementation as been done usually through observations on animal performance. Iodine deficiency has been diagnosed from the incidence of enlarged thyroids (Sinclair & Andrews 1961). It has been well documented that treatment of pregnant ewes fed brassica crops 8 and 4 weeks before lambing with 280 potassium iodide or 360 mg potassium iodate will prevent (Sinclair & Andrews 1958) I deficiency in the lambs. Likewise a 1 ml intramuscular injection with iodised oil (475 mg I/ml) protects sheep for at least 3 years against I deficiency (Sinclair & Andrews 1961).

Treatment protocol to prevent Co, Se, Cu and I deficiencies

From the data presented here together other information on tissue mineral concentrations and animal perform-

Table 3 Effect of Cu given orally as a drench, CuO needles and as an injection on liver Cu concentrations (mg Cu/kg DM) of sheep or cattle

	Sheep				
Days after treatment	0	49	101	271	355
Study A hoggets (45 kg LW)					
No Cu	47	47	56	126	163
300 mg Cu oral	46	69	61	144	175
Study B lambs (21 kg LW)					
No Cu	307	369	366	264	382
2.5g CuO oral	239	796	727	313	401
50 mg Cu Ca-edetate subcutaneously	272	849	606	324	448
	Cattle				
Days from treatment	0	50	100	245	888
Study C (cows 327 kg LW)					
No Cu	77	95	104	117	142
40 g CuO oral	89	225	296	209	181
150 mg Cu Ca-edetate subcutaneously	73	154	151	182	155

ance the following supplement protocols are recommended to prevent trace element deficiencies in sheep and cattle. The information can also be extended to deer and goats provided that it is realised their trace element requirements have not been so well defined.

Cobalt

(1) Topdress pasture with 350 g cobalt sulphate/ha/yr.
(2) Sheep: Lambs inject with 1-2 mg vitamin B_{12} every 4-6 weeks.
(3) Cattle: Calves inject with 2 mg vitamin B_{12} every 4-6 weeks.

Selenium

(1) Topdress pasture with 10 g Se/ha/year as sodium selenate ($Na_2SeO_4 . 10H_2O$).
(2) Sheep: Ewes inject or dose 5 mg Se/animal as Na selenate 3-4 weeks before mating and lambing. Lambs inject or dose l-2 mg Se/animal as Na selenate at docking and thereafter 3-4 mg Se at 2-monthly intervals.
(3) Cattle: Inject with 0.1 mg Se/kg liveweight using Na selenate every 2-3 months.
(4) Sheep and cattle: Inject with $BaSeO_4$ (1mg/kg liveweight)4-6 weeks before mating annually.

Copper

(1) Topdress pasture 5 kg copper sulphate (1 kg copped/ha/year.
(2) Sheep: Ewes dose with 2-4 g CuO needles every 6-12 months.
Lambs dose with l-2 g Cuo needles every 6-12 months.
(3) Cattle: Cows dose with 10-30 g CuO needles every 6-12 months.
Inject 120-240 mg Cu at 4-8 months.

Iodine

(1) Sheep: Ewes dose with 250 mg potassium iodide or 300 mg potassium iodate 8 and 4 weeks before lambing.
Inject with 1 ml iodised oil every 3 years.
(2) Cattle: Cows inject with 4 ml iodised oil every 2 years.

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