On-farm evaluation of cobalt/vitamin B_{12} supplementation for lamb growth on southern South Island properties

G.C. PRINGLE[1], B.H. BECKINGSALE[2] and A.K. METHERELL[3]
[1]*Agriculture New Zealand, Balclutha*
[2]*Farm Management Consultant, Invercargill*
[3]*AgResearch, Lincoln University, Canterbury*
[1]graemepringle@clear.net.nz

Abstract

On-farm cobalt/vitamin B_{12} supplementation trials were carried out with 3-month-old weaned lambs (N = 50) on six southern South Island properties that were considered to be deficient or marginal for cobalt over the years 1996–1999. No significant liveweight responses of the lambs were recorded over a 3-month period on any of the farms in any year. When lambs were raised on cobalt-treated pasture and were injected with vitamin B_{12} or had rumen cobalt pellets administered, liver and serum vitamin B_{12} concentrations increased. Plot trials showed two light sprays of cobalt sulphate at 60 g/ha, 2 months apart over summer, was an effective means of maintaining herbage concentrations in the desirable range, i.e., >0.1 mg Co/kg DM. Monitoring of herbage cobalt and tissue vitamin B_{12} concentrations of animals was essential to indicate when lambs may need cobalt or vitamin B_{12} supplementation. Current reference values over-estimated the probability of responses in this set of experiments.

Keywords: Cobalt, cobalt herbage level, lamb growth, vitamin B_{12}

Introduction

Cobalt deficiency has been recognised in Southland since the 1930s. However, it does not occur on all farms or soil types and its incidence varies between years (Andrews 1960; Metherell 1989; Sherrell *et al.* 1989). During the 1990s survey (O'Connor *et al.* 1995), farmer, veterinarian, laboratory and consultant information highlighted increasing numbers of farms and animals showing low concentrations of this important trace element. Farmers were adopting a wide variety of methods to raise cobalt and/or vitamin B_{12} levels (Smart 1998). Owing to an industry perception of an increasing incidence of cobalt deficiency in South Otago and Southland, questions were being asked about which were the most cost effective and efficient treatments to overcome poor lamb growth rates. Concerns were also expressed that responses had occurred at already adequate levels of vitamin B_{12}. Farmers were receiving conflicting information on critical levels and adequacy of treatments.

On-farm demonstration experiments, funded by Meat New Zealand, were run on reportedly marginally deficient farms in Southland and South Otago each summer for 3 years, comparing various lamb and pasture treatments of vitamin B_{12} or cobalt, measuring their effects on lamb growth rate and on herbage cobalt concentrations.

Workshops

Before the programme began, a workshop of interested people was held to set up the methodology and project design. Following analysis of results each season, a workshop for all participants was held to discuss the implications, results were reviewed and where necessary, the programme modified for the next season. This was considered a key part of the project as agreement across the various parts of the 'Cobalt' industry was an integral part of ensuring a unified message was received by farmers. The workshop each year consisted of 25–30 people. Representatives came from Alliance Freezing Industry, MAF, Southfert, Schering-Plough, Bomac, AgResearch, LabNet, five Veterinary practices (Clutha, Gore, Edendale, Winton and Otautau), Agroscience Consultancy, Agriculture New Zealand, Beckingsale Consultancy and Meat New Zealand. The farmers taking part in the project were participants at the workshops, reporting the results and observations on their farms.

Methods

Farm selection

Three farms, with a history of low vitamin B_{12} concentrations in lambs, were initially chosen. In the second year, a fourth farm and in the third year, two more farms were added to the study. All farms were selected on the basis of data supplied by veterinarians, meat processing works and consultants. The selected farms represented the major soil groups farmed in southern New Zealand (Table 1).

Table 1 Farms' soil types, location and years of participation in a cobalt/vitamin B_{12} supplementation study in the southern South Island.

Farm Number	Soil group	Soil series	Location	Years in experiment
1	Yellow – grey earth	Te Houka	Te Houka, South Otago	1996–97 1997–98 1998–99
2	Lowland yellow brown earth	Kaiwera	Mokoreta, Eastern Southland	1996–97 1997–98 1998–99
3	Yellow grey – yellow brown intergrade	Pukemutu	Tussock Creek, Central Southland	1996–97 1997–98 1998–99
4	Recent soil	Tuatapere	Otautau, Western Southland	1997–98
5	Recent soil	Tuatapere	Otautau, Western Southland	1998–99
6	Lowland podzolised yellow brown earth	Hina Hina	Caberfeidh, Catlins	1998–99

Treatments

Each farm had a control (untreated) paddock and a cobalt sulphate ($CoSO_4.7H_2O$) treated paddocks with 2–4 cobalt/vitamin B_{12} treatment groups of lambs within each paddock (Table 2). From weaning (late December/ early January), six groups of 50 randomly selected male lambs were each eartagged and allotted to treatments for 3 months.

Collection of samples

The following data were collected; monthly lamb growth rates for each lamb; monthly serum vitamin B_{12} levels from the monitor lamb groups; liver vitamin B_{12} levels ('Optigrow') from five lambs slaughtered from each group monthly; monthly pasture levels of cobalt, iron and manganese.

Herbage cobalt treatment

To demonstrate the effect on pasture cobalt concentrations of the application of cobalt sulphate in both solid and liquid form, separate plot trials were carried out over three seasons. Each plot trial lasted one season and was situated on a different soil type.

From year 1, the treatments were cobalt sulphate 175 g/ha (solid and liquid), cobalt sulphate 350 g/ha (solid and liquid), and cobalt sulphate 60 g/ha (liquid only). In year 2, a treatment with solid cobalt sulphate at 60 g/ha was added. All year 1 and year 2 applications were monthly. In year 3, liquid cobalt sulphate at 60 g/ ha applied every 2 months was added. For the solid treatments, cobalt sulphate was mixed with sand and spread evenly over the plot. The liquid treatments consisted of cobalt sulphate mixed in water and sprayed over the plot.

The plots were on Pukemutu soils at Tussock Creek in Central Southland, on Kaiwera soils in Eastern Southland and Te Houka soils in South Otago in years 1, 2 and 3, respectively.

Table 2 Design of a cobalt/vitamin B_{12} supplementation study in the southern South Island.

Pasture treatment	Animal treatment
Nil	Nil
	Rumen Bullet (10 g) Permaco, Schering-Plough
	Vitamin B_{12} injection (2 mg) Prolaject, Bomac, at weaning only
	Vitamin B_{12} injection (2 mg) Prolaject, Bomac, monthly
Cobalt sulphate treated (175g $CoSO_4.7H_2O$ /ha as a single spray)	Nil
	Rumen Bullet (10 g) Permaco, Schering-Plough

Results and discussion

The seasons covered included one normal for rainfall and temperature, one moister and cooler, and one dry and warmer than typical, although this did vary from site to site. As the amount of data collected over the 3 years was considerable, and as the results were similar, data are only presented for farms in year 3 (1998–1999) (Tables 3–6). The effects of pasture treatments on lamb, liver and serum v Vitamin B_{12} concentrations for all farms are shown in Tables 4 and 5, respectively. Table 6 shows the average lamb growth rates for all treatments. Results for all treatments on farm six from Caberfeidh, Catlins, for the 1999–2000 season are presented in Tables 7–10.

All farms showed cobalt marginal or deficient pasture concentrations for part of each season (Table 3). On farm six, pasture herbage cobalt concentrations on the control areas were in the deficient range during January, March and April 1999, i.e., 0.08 mg Co/kg DM or less (Clark 1998), although an adequate level was measured in February (Table 3). The cobalt-treated paddock was sprayed with cobalt sulphate at 175 g/ha

Table 3 Changes in herbage cobalt (mg Co/kg DM) concentrations for untreated and cobalt sulphate-treated pastures on the six trial farms (1998–1999).

	Untreated					Cobalt Sulphate Treated (175 g $CoSO_4.7H_2O$ /ha sprayed)				
	Dec	Jan	Feb	Mar	Apr	Dec	Jan	Feb	Mar	Apr
Farm 1	.16	.09	.16	.09	.10	.29	.25	.42	.59	.29
Farm 2	.17	.12	.10	.07	.06	.10	.14	1.5	1.38	.16
Farm3		.24	.16	.11	.08		.32	.29	1.13	.35
Farm 4		.45	.13	.06	.06		.98	.21	.17	.15
Farm 5	.10	.53	.20	.12	.07	.15	1.15	3.8	.84	.40
Farm 6	.10	.04	.11	.04	.07	.10	1.54	.53	.25	.19
Response	.13	.17	.14	.08	.07	.14	.52	.65	.57	.24
LSR(5%)						2.21	3.86	3.06	1.95	1.42
						n.s.	n.s.	*	**	**

Table 4 Changes in liver Vitamin B_{12} concentrations (nmol/kg fresh tissue) for lambs on untreated and cobalt-treated pastures for trial farms, 1989/99 (n=5).

	Untreated				Cobalt-treated Pasture (175 g $CoSO_4.H_2O$ /ha sprayed)			
Farm	Jan	Feb	Mar	Apr	Jan	Feb	Mar	Apr
2			496	404			508	380
3	658	652	514		648	734	678	
5		666	582			696	586	
6	242	316	374	232	376	620	720	406

Table 5 Changes in serum vitamin B_{12} concentrations (pmol/litre) for lambs on untreated or cobalt-treated pastures for five trial farms, 1998/99 (n=10).

	Untreated				Cobalt-treated Pasture (175 g $CoSO_4.H_2O$ /ha sprayed)			
Farm	Jan	Feb	Mar	Apr	Jan	Feb	Mar	Apr
1*		971	1279	949				
2	767	641	724	646	650	>1500	1439	1057
3	1447	1279			1490	1383		
5	1196	946	547		1161	>1500	1409	
6	337	435	729	645	>1500	1457	1489	1274

*Farm 1 did not have access to treated pasture in this year but were injected with 2 ml vitamin B_{12} instead.

in December 1998, resulting in high levels in January, which fell rapidly over the next 3 months.

Liver vitamin B_{12} levels were adequate in lambs on both untreated and cobalt-treated pastures on farms 2, 3 and 5 (Table 4). For farm six (Tables 4 and 7), the control lambs were generally showing liver vitamin B_{12} concentrations low enough for a growth rate response to be expected. All treatments resulted in an increase in liver vitamin B_{12} levels (Table 7). The serum vitamin B_{12} levels of control lambs on farm 6 in January and February 1999 were also marginal. Serum vitamin B_{12} responses to treatment were considerable and significant for some treatments (Table 8). On the other farms, serum vitamin B_{12} levels remained adequate throughout the season (Table 5).

Table 6 Effect of cobalt and vitamin B_{12} supplementation on lamb growth rates (g/day) 1998/99.

Treatment	Farm 1*	Farm 2	Farm 3	Farm 5	Farm 6
No applied cobalt					
Control	193	272	322	128	162
Rumen bullets				94	161
Vitamin B_{12} once	200			112	163
Vitamin B_{12} monthly				140	157
LSD 5%				28	15
Cobalt applied at 175g $CoSO_4.7H_2O$ /ha					
$CoSO_4$ pasture		227	277	141	191
$CoSO_4$ + Rumen bullets				131	180
LSD (5%)				28	15

*Growth was only analysed for four weeks on farms 1–3 owing to drought and early lamb selling.

Table 7 Lamb liver vitamin B_{12} levels (nmol/kg) from Farm 6 Caberfeidh, Catlins, in 1998/99 (n=5).

	Jan	Feb	Mar	Apr
Untreated paddock				
Control	242	316	374	232
Rumen bullet	436	548	464	406
Vit B_{12} once	340	416	420	276
Vit B_{12} monthly	346	492	560	468
LSD (5%)	123	182	162	158
Significance of Effects*				
Rumen bullet	**	*	n.s.	*
B_{12} (avge)	n.s.	n.s.	n.s.	*
Once vs monthly	n.s.	n.s.	n.s.	*
Within "Co" paddock				
$CoSO_4$	376	620	720	406
$CoSO_4$ + Rumen bullets	402	478	618	512
LSD (5%)	130	98	156	172
Significance of Effects				
Rumen bullet	n.s.	**	n.s.	n.s.

*ns = non-significant; * = P<0.05; ** = P<0.01.

Table 8 Lamb serum vitamin B_{12} level (pmol/litre) from Farm 6 Caberfeidh, Catlins, in 1998/99 (n=10).

	Jan	Feb	Mar	Apr
Untreated paddock				
Control	337	435	729	645
Rumen bullets	1420	1259	1205	1247
B_{12} once	453	440	770	512
B_{12} monthly	436	546	935	806
LSR (5%)	1.34	1.40	1.34	1.37
LSR (1%)	1.48	1.56	1.48	1.52
Significance of Effect*				
Rumen bullet	**	**	**	**
B_{12} (avge)	*	n.s.	n.s.	n.s.
Once vs monthly	n.s.	n.s.	n.s.	**
Within "Co" paddock				
$CoSO_4$	>1500	1457	1489	1274
$CoSO_4$ + Rumen bullets	>1500	>1500	>1500	1419
LSR (5%)	-	-	-	1.21
LSR (1%)	-	-	-	1.30
Significance of effect				
Rumen bullets	-	-	-	n.s.

*ns = non-significant; * = P<0.05; ** = P<0.01.
NB: The LSR is the least *ratio* which is statistically significant. For example, for January the Rumen bullet treatment (at 1420) is different from the control (at 337) at P<0.01, since their ratio is 1420/337 = 4.21, which exceeds the LSR (1%) of 1.48.

Vitamin B_{12} injections and rumen bullets were effective in raising serum and liver vitamin B_{12} concentration. Generally the injection resulted in a shorter-term elevation with the longer lasting bullets having an effect over the whole time from weaning to April slaughter (Table 8).

However, in each year on all farms, the control animals grew as fast as treated animals. No significant differences were found in lamb liveweight gain between no treatment (Tables 6 and 9), cobalt Rumen bullets, vitamin B_{12} injection once, and monthly vitamin B_{12} injection groups of lambs within the control paddock. Furthermore, there were no significant differences between the no treatment group and the rumen bullet treated group within the cobalt-treated paddock (Table 9).

Table 9 Liveweight gain (kg) for Farm 6, Caberfeidh, Catlins, in 1998/99 (n=50).

	Dec–Jan	Jan–Feb	Feb–Mar	Mar–Apr	Total
Untreated paddock					
Control	7.7	5.1	1.6	0.9	14.6
Rumen bullets	7.5	4.4	2.2	1.1	14.5
B_{12} once	7.8	5.0	1.7	0.9	14.7
B_{12} monthly	7.7	5.0	1.4	1.0	14.2
LSD (5%)	0.7	0.9	0.8	0.9	1.4
Significance of Effects*					
Rumen bullet	n.s.	n.s	n.s.	n.s.	n.s.
B_{12} (avge)	n.s.	n.s.	n.s.	n.s.	n.s.
Once vs monthly	n.s.	n.s.	n.s.	n.s.	n.s.
Within "Co" paddock					
$CoSO_4$	7.0	6.4	3.8	0.5	17.2
$CoSO_4$ + Rumen bullets	6.8	6.0	3.9	0.3	16.2
LSD (5%)	0.7	0.7	0.8	1.1	1.4
Significance of effect					
Rumen bullets	n.s.	n.s.	n.s.	n.s.	n.s.

*ns = non-significant

Herbage cobalt treatment

Monitoring of herbage cobalt concentrations in the plot trials over 3 years showed that:

1. The lowest herbage cobalt concentrations in the control treatments occurred in the period of January to March. Table 10 shows the typical response using the Te Houka site. Data from the other two sites are not presented.
2. Liquid application gave a higher concentration of herbage cobalt 1 month after application than the same rate of cobalt sulphate applied in solid form.
3. A single application resulted in an initial peak of herbage cobalt (1.5–1.75 mg Co/kg DM) followed by a rapid decline to near baseline levels over the following 2 months.
4. Increasing the rate of application generally increased the initial peak concentration, but did not increase the duration of response.
5. Cobalt sulphate at 60 g/ha applied in liquid form in December and February maintained high herbage cobalt concentrations through the lamb growing season.

Table 10 Effect of cobalt application on herbage cobalt in 1998/99 (Te Houka Site).

	Dec	Jan	Mar	Apr
Control	.39	.11	.15	.34
L60 x 2 monthly	.88	.18	.26	.98
L60 monthly	.49	.39	.95	1.55
L175 once	1.31	.19	.17	.31
L350 once	2.51	.32	.17	.41
S60 monthly	.38	.17	.22	.47
S175 once	.45	.12	.15	.44
S350 once	.70	.19	.19	.48
LSR (5%)	2.19	1.85	1.65	1.78
LSR (1%)	2.97	2.36	2.00	2.23

[L = an aqueous solution, S = solid (+ sand) mixture]
Significance of contrasts

	Dec	Jan	Mar	Apr
Control vs Treated	*	*	*	*
L vs S main effect (excluding L60 x 2-monthly)	**	**	**	n.s
175 vs 350 (once) main effect	n.s.	*	n.s.	n.s.
L vs S x (175 vs 350) interaction	n.s.	n.s.	n.s.	n.s.

Note: The LSR is the least ratio which is statistically significant. For example, for Dec the second treatment (at 0.88) is different from the control (at 0.39) at P<0.05 since their ratio is 0.88/0.39 = 2.26 which exceeds the LSR (5%) of 2.19.
To make the statistical analysis valid, a log (base 10) transformation of the data was carried out prior to analysis.

These findings are similar to results obtained in other studies where applications to herbage cobalt have been evaluated (Metherell 1989; Morton & Smith 2000; Sherrell 1990).

As a result of the monitoring programme, all farmers involved with this study have reduced their spending on cobalt pasture spray and individual animal treatments, and shifted the timing of treatments to a targeted period. Veterinarians involved with the programme have reviewed their procedures and are now able to advocate more accurate and confident advice to the farmers' advantage.

The current farmer practice of applying cobalt sulphate at 350 g/ha in October/November in liquid or solid form to pastures grazed by lambs was shown to be inappropriate for the trial years in the southern South Island. Caution is necessary as variations will occur year by year. However, for ameliorating low pasture cobalt concentrations, it is clear that monitoring and applying cobalt sulphate from December/January will be more effective.

The herbage cobalt study showed that small, regular, cobalt sulphate spray treatments to pasture were the most effective in increasing and maintaining herbage cobalt concentrations. This was effective on three soil types. Herbage cobalt concentrations dropped to base (control) concentrations 2–3 months after application, with most of the effect gone in 4–6 weeks. Increasing the cobalt application rate did not increase the response period.

The reasons for carrying out this investigation were based on the premise that the cobalt and vitamin B_{12} concentrations in pasture and liver samples were often low, and that growth rate responses were predicted to occur with the application of cobalt to pasture, or vitamin B_{12} treatment to the animals.

The threshold levels used were 500 pmol/litre for serum vitamin B_{12}, 375 nmol/kg fresh tissue for liver and 0.10 mg/kg DM for pasture. These relate to marginal response levels (Clark *et al.* 1989; Clark 1998) where on average, no liveweight gain is expected. Lower 'deficient levels' of 336 pmol/litre serum and 280 nmol/kg fresh tissue liver for at least 1 month were defined on the basis of a 50% likelihood of a liveweight gain response greater than 10 g/day (Clark *et al.* 1989). Note that a response of 10 g/day could not have been statistically detected in 1 month in these trials, but could have been detected in liveweight gain over 3 or 4 months. There were no occasions where mob mean serum vitamin B_{12} was below the 'deficient' threshold however deficient liver-vitamin B_{12} levels in control lambs were recorded on the Te Houka property from January to March in year 1, on the Aparima property in January in year 2, and in January and April on the Caberfeidh property in year 3 (Table 4). Considering the lack of statistically significant liveweight responses even at these levels, some questioning of the appropriateness of the tissue reference values is necessary. It is recommended that the lower 'deficient' reference values be used to justify treatment for cobalt deficiency.

Conclusions

- Cobalt deficiency on South Otago and Southland farms appears to be not as common as popularly perceived.
- Many farmers could be treating a non-existent cobalt deficiency, and therefore, should monitor vitamin B_{12} tissue concentrations in animals before administering cobalt remedies.
- Cobalt deficiency may occur over the districts and soil types represented by the survey.
- The lowest herbage cobalt concentrations occurred from February to April (over the years monitored).
- Cobalt sulphate at 60 g/ha sprayed in December and February is highly effective in preventing cobalt deficiency.
- All treatments including pasture cobalt application as solid or as a spray, vitaminB_{12} injections and rumen bullets were effective in raising lamb serum and liver B_{12} concentrations.

- A review of New Zealand tissue vitamin B_{12} reference ranges is recommended.

The farmers involved considered the results were meaningful in terms of determining cobalt status and cobalt vitamin supplementation responses. These farmers are now enjoying cost savings from a reduced spending on cobalt by using a more targeted approach to cobalt supplementation.

ACKNOWLEDGEMENTS

Meat New Zealand was the major funder. Farmers involved for the use of their land, animals, equipment and time: G. Moffat (Te Houka), T. McEwan (Mokoreta), J. Clark (Tussock Creek), N. Paterson (Otautau), B. Egan (Otautau), K. Ross (Catlins). D. Saville (AgResearch) for statistical analysis. AgResearch analysed the pasture samples, consultants and farmers collected the monthly liveweights, veterinarians collected the blood samples, with Alliance and Blue Skies facilities assisting with the lamb liver samples. Industry assistance from Schering-Plough (materials and funding), Southfert (funding and participatory) and Bomac Ltd (materials).

REFERENCES

Clark, R.G. 1998. Cobalt/Vitamin B_{12} deficiency from lamb to adult ewe. *Proceedings of the 28th Seminar of the Society of Sheep and Beef Cattle Veterinarians NZVA 180*: 105–122.

Clark, R.G.; Wright, D.F.; Millar, K.R.; Rowland, J.D. 1989. Reference curves to diagnose cobalt deficiency in sheep using liver and serum vitamin B_{12} levels. *New Zealand Veterinary Journal 37*: 7–11.

Metherell, A.K. 1989. The cobalt enigma – some observations and strategies for Otago and Southland. *Proceedings of the New Zealand Grassland Association 50*: 101–08.

Morton, J.; Smith, L.C. 2000. Pasture uptake from solid and liquid applications of cobalt and copper sulphate. *Proceedings of New Zealand Grassland Association 62*: 45–48.

Sherrell, C.G.; Brunsden, P.; McIntosh, P.D. 1987. Pasture cobalt concentration and its effect on vitamin B_{12} status of sheep grazing upland and lowland pastures in the Kaiwera District, Eastern Southland, New Zealand. *New Zealand Journal of Agricultural Research 30*: 325–331.

Sherrell, C.G. 1990. Effect of cobalt application on the cobalt status of pastures. 3. Comparison of chelate and sulphate as cobalt sources for topdressing deficient pastures. *New Zealand Journal of Agricultural Research 33*: 313–317.

Smart, J.A. 1998. Cobalt deficiency in sheep. A review of available therapies. *Proceedings of the 28th Seminar of the Society of Sheep and Beef Cattle Veterinarians 180*: 123–135.

■