Calcium balance in mid and late pregnancy and vaginal prolapse

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ABSTRACT

Given the hypothesis that Ca status may be implicated in bearings, the purpose of the research in experiment 1 was to observe Ca status in old twin ewes in normal commercial conditions to determine whether an association exists, and in the second experiment to manipulate Ca status to determine its effects on the incidence of bearings. In experiment 1, Romney ewes, scanned as twin (n=12) or single (n=12) pregnant, on each of 7 farms were identified and sampled at approximately 60, 30 and 7 d before the onset of flock lambing. Whole flock bearing incidence was recorded. Eleven to 41% of pregnant ewes from different farms had marginal serum Ca and Mg concentrations at 60 and 30 d before onset of lambing. No relationship was found between serum minerals and metabolite concentration and bearing incidence among farms.

The objective of experiment 2 was to reduce bearings on farms with high historical incidences of bearings by increasing Ca loss in urine in mid-pregnancy (60 to 30 d pre-lambing) followed by increasing Ca supply in late-pregnancy (30 to 0 d pre-lambing). Five farmers fed 100 twin pregnant ewes 35 g of anionic salts in 300-500 g of supplemental pellets (DCAB -814 meq/kgDM) from 60 to 30 d before lambing. From 30 d these ewes were then injected with 4 ml of a long-acting vitamin D formulation (5 farms) while one farm also had an additional group supplemented with Ca (8 g lime (ground calcium carbonate) /ewe) in an attempt to increase Ca availability. In addition, groups of ewes not treated with anionic salts were injected with vitamin D (2 farms) or supplemented with Ca (1 farm) from 30 d. Following consumption of anionic pellets in mid-pregnancy, the pH of the ewes' urine was lower and urinary Ca:creatinine ratios were higher after 2 (6.73 *vs*. 7.32, $P<0.002$; 0.47 *vs*. 0.16, $P<0.003$) and 4 weeks (6.26 *vs*. 7.23, $P<0.001$; 0.58 *vs*. 0.14, $P<0.003$) of treatment. However, neither the feeding of anionic salts in mid-pregnancy nor the Ca or vitamin D supplements in late-pregnancy consistently changed Ca serum concentrations or bearing incidence.

Keywords: Ewes; pregnancy; blood; calcium; anionic; Vitamin D; prolapse vagina.

INTRODUCTION

The increase in the fecundity of the NZ sheep flocks is increasing the incidence of vaginal prolapse (bearings) which mainly occurs in twin ewes. A survey indicates 5.6% of ewes with multiples have bearings and nationally the cost of bearings in ewes has been estimates as $30-50 million per year (Lambert *et al*., 1998). Bearings are likely to have multifaceted causes associated with excessive internal pressures and/or premature birth tract relaxation (Lambert *et al*., 1998). Premature relaxation may be associated with low calcium (Ca) status. Vaginal prolapse occurs on average 13 days before lambing, is more common in older ewes with multiples and farmers report a lower incidence in ewes with Finn ancestry (Lambert *et al*., 1998).

In healthy ewes, calcium (Ca) requirements increase one to two months before lambing and ewes may enter a period of substantive negative Ca balance, which can be observed as a drop in serum Ca concentration (Sansom *et al*., 1982; Grant *et al*., 1988; Wilson, 1999). Ewes then adapt by progressively increasing the absorption of dietary Ca and mobilisation of Ca from the bone (Wilson, 1999). Normally this ensures peak requirements in late pregnancy and early lactation are met. However, both of these adaptation processes may be impeded (Takagi & Block, 1991; Block, 1994) by the high dietary cation-anion balance (DCAB, Na+K-S-Cl) (200-900 meq/kg DM) found frequently in New Zealand pastures in winter and spring (Wilson *et al*., 1998). Low Ca status associated with high DCAB in mid to late pregnancy in ewes may be one predisposing factor leading to premature relaxation of the birth canal.

Given the hypothesis that Ca status may be implicated in bearings, the purpose of the research in experiment 1 was to observe Ca status in twin ewes in normal commercial conditions to determine whether any such association exists, and in the second experiment to manipulate Ca status to determine its effects on the incidence of bearings. In the second experiment anionic salts were fed in mid pregnancy to reduce overall Ca balance by stimulating the excretion of Ca in urine which then speeds up the increase in both the dietary Ca absorption and mobilisation of Ca from the bone (Takagi & Block 1991). Then in late pregnancy Ca supply was increased by either supplementing directly with Ca or by large doses of Vitamin D (Thomas *et al.*, 1981).

METHOD

Experiment 1

In the spring of 1998, old (> 4 years) Romney ewes with twin (n=12) or single (n=12) pregnancies were identified by scanning on 7 farms (Hawkes Bay, Tararua, Manawatu and Taihape regions) with high historical bearing incidence and blood sampled at approximately 60, 30 and 7 d before the onset of flock lambing. On two of these farms (Farm 1 and 3) an additional 12 ¼ Finn ¾ Romney twin-pregnant ewes were included. The tagged ewes were managed within larger mobs under normal farm management practices.

Experiment 2 (a)

A pilot study was conducted to test potential harmful side effects (*e.g.* hypocalcaemia) of treatments before application on commercial farms with high bearing incidence. It commenced on 4 April 2000, 60 single-pregnant, early lambing, Romney ewes were randomly allocated (balanced for liveweight, serum Ca, and urine Ca:creatinine ratio) to 4 treatments on Ballantrae Research Station at Woodville. Ballantrae normally has a low incidence of bearings. Five weeks before lambing, half the ewes were strip grazed on 2-day shifts on pastures which had been sprayed with anionic salts (AnS for three weeks) while the other half of the group grazed untreated pasture (C). Two weeks before lambing, the grazing was changed for half of the AnS group and they grazed pastures dusted with lime. On 26 April 2000, a Vitamin D injection was give to the other half of the AnS ewes (AnS+VitD) and to half of the C ewes (C+VitD). Anionic salts (49 g/ewe/d (-500 meq/ewe) of equal portions by weight of magnesium sulphate, magnesium chloride (Agrifeeds), and ammonium chloride (BDH 271495R) were dissolved in 100-150 mL/ewe of water and sprayed on the pasture. Ewes were injected with 3 ml of vitamin D (400 000 iμ/mL) The AnS+VitD, C+VitD and the group of untreated control ewes (C+C) grazed together until lambing. Ewes started lambing on 8 May and had a mean lambing date of 15 May. Ewes were weighed on 4 April, 26 April, 9 May, and 26 May and other measurements were collected weekly.

Experiment 2 (b)

In the spring of 2000, 4-year or older Romney or Coopworth ewes scanned with twin-pregnancies and marked by the ram to lamb within the first 20 days of the start of lambing, were selected from one Pahiatua farm (40 km from Palmerston North) and six Southland farms (within 200 km of Invercargill). These farms had a history of 3-10% bearings in multiple-pregnant ewes. Treated and control (C) ewes groups (Table 1) of 100 ewes were strip grazed on daily or 2-daily shifts in the same paddock split in half or together in the same break when appropriate. Anionic salts were fed 8 to 4 weeks before lambing either by dusting on the new break (Pahiatua farm, Farm 4) or by daily feeding of pellets (Southland farms). Unlike the Pahiatua farm, the Southland sheep were used to eating concentrate supplements during late pregnancy making pellets a viable treatment option. Anionic salts (35 g salts/sheep (-400 meq/ewe/d, 31.5% magnesium sulphate; 31.5% ammonium sulphate; 31.5% magnesium chloride; 5% sodium chloride (Agrifeeds and Ravensdown) were dusted on the Pahiatua farm (dose rates were

Table 1: Various treatment combination on 7 farms comprising anionic salts fed either as a pellet (AnP) or by dusting on pasture (AnD) from 8-4 weeks before lambing or by injecting with vitamin D (D) or supplementing with lime (Ca) 4-0 weeks before lambing or untreated control ewes (C) in experiment 2a.

Treatment	Treatment Structure				
8-4 weeks pre lamb	Anionic Salts		Control		
4-0 weeks pre lamb	Ca	VitD	VitD	Ca	Control
Farm 1[2]		AnP+D			C
Farm 2[2]		AnP+D			C
Farm 3[2]			D		C
Farm 4[1]	AnD+Ca	AnD+D	D		C
Farm 5[2]				Ca	C
Farm 6[2]		AnP+D			C
Farm 7[2]		AnP+D			C

[1]Pahiatua farm; [2]Southland farms

doubled on the last week of treatment) onto pasture or fed in a protein-based concentrate. The pellets contained 10% anionic salts (DCAB -814 meq/kg DM) and on a DM% basis contained 4.8 N, 1.1 Ca, 1.8 Cl, 1.3 K, 1.1 Mg, 0.53 Na, 1.4 S and was group fed at 300-500 g/ewe/day. Ewes were injected with 4 mL of vitamin D (400 000 iμ/mL).

For ewes eating pellets, the size of the pasture breaks were progressively reduced as pellet intake increased, to be two-thirds that of C ewes. Number of ewes with a bearing was recorded on all farms. Measurements of blood, urine and stock weight were taken on 5 of the 6 Southland farms (not farm 6) with an Southland farmer (farm 5) choosing to not measure at set stocking. Ewes were weighed on 4 Southland farms and the Pahiatua farm.

Animals were managed according to AgResearch Limited Code of Ethical Conduct for the use of Animals in Research, Testing and Teaching.

Measurement

In all experiments ewes were mustered a few hours before blood sampling, weighing and condition scoring (1= emaciated to 5 = extremely fat; Geenty, 1997). Urine samples were collected (by the hand-over-the-nose technique, experiment 2 only) and blood samples were drawn by jugular venipuncture from the same 8 (experiment 2a) or 12 (experiment 1, 2b) ewes. Blood samples were analysed for β-hydroxybutyrate (BOH), and major cations (Ca, Mg) and anions (P) using a Hitachi Automated Biochemistry Analyser and methods supplied either by Roche Diagnostics (Ca, Mg, P) or as described in McMurray *et al.* (1984) . Urine was stored at 7°C and measured for pH using a calibrated pH meter within 48 hours of sample collection. When urine pH differed between treatment groups, individual urine samples were then submitted for Ca and creatinine ratio analysis (Agriquality, Palmerston North). Pre-grazing herbage samples representative of the ewe's diet and pellets were collected and analysed for mineral (Ca, Cl, K, Mg, N, Na, P, S) concentration. The dietary cation-anion balance was defined as the summation in milliequivalents (meq/kgDM) of cations sodium (Na^+) and potassium (K^+) minus anions chloride (Cl^-) and sulphate (S^{2-}). In experiment 2a, weekly measurements of pre and post grazing mass were collected using a rising plate meter.

Statistical analysis

In experiment 1, data were analysed by analysis of variance using general linear model procedures of SAS (SAS, 1990) at separate sample dates and by fitting farm, breed and fecundity as factors. In Experiment 2, the effect of treatment on measured parameters was analysed using general linear model analysis on individual measurement dates (SAS, 1990). The effect of treatment on bearing incidence was tested using chi square analysis (SAS, 1990).

RESULTS

Experiment 1

Mean (ranges) herbage element, DCAB, quality and concentrations of pasture offered to pregnant ewes is presented in Table 2. Herbage Ca concentration increased with sample collection date (P<0.01) and changed differently on farms with collection date (P< 0.04, date*farm).

Twin-pregnant ewes were 2.8 (P<0.02), 3.7 (P<0.0001), and 4.0 (P<0.004) kg heavier than single ewes at 60, 30, and 7 d before lambing but ewe condition was similar (Table 3). Twin-pregnant ewes had higher levels of BOH than single bearing ewes from 30 d and 7 d before lambing (Table 3).

The variability of blood Ca and Mg concentrations was greater when mean Ca values were less than 2 mmol/L (Figure 1). Serum concentrations of Ca were lower (P<0.0001 Table 3) and variability was higher in samples collected more than 30 d before lambing than those collected within 7 d of lambing. There was a significant correlation (r=0.35 P<0.03) between herbage Ca concentration and blood Ca concentrations in data pooled across sample dates. Immediately before lambing circulating Ca concentrations were higher in flocks of ewes that had low BOH concentrations (r=-0.78 P<0.001).

Pasture DCAB was not correlated with either serum Ca or Mg concentrations. Mean serum concentrations of Ca and Mg in pregnant ewes grouped by farm and pregnancy status were positively correlated at 60 d (r=0.65 P<0.01) and 30 d before lambing (r=0.80 P<0.001). However, 7 days before onset of lambing blood concentrations of Ca and Mg were negatively related (r=-0.58 P<0.03). This dissociation was not due to a change in relative concentration of Ca and Mg in the herbage as they were positively correlated at all three sample periods (r=0.78 P<0.002; r=0.58 P<0.04; r=0.75 P<0.002).

There was no difference between Romney and ¼ Finn cross ewes in live weight, condition score, serum concentrations of BOH and phosphate either overall or on individual sample dates. Overall serum Ca and Mg concentrations were lower (Ca 1.74 vs. 1.91 mmol/L, P<0.01; Mg 0.56 vs. 0.66 mmol/L, P<0.0001) in ¼ Finn compared to Romney ewes but breed differences only occurred when serum Ca was less than 2.2 mmol/L. Farm 1

Table 2: Mean (range in mean values for individual farmers) herbage energy content, crude protein, dietary cation anion balance (DCAB) estimated by NIR (Meq/kg DM) and mineral concentrations offered to pregnant sheep at approximately 60, 30 and 7 d before lambing on 7 Southern North Island hill country farms in experiment 1.

	Approximate days before flock lambing		
	-60 d	**-30 d**	**-7 d**
Energy (MJME/kg DM)	10.0 ^{b} (8.0-10.8)	10.3 ^{b} (8.6-11.5)	10.9 ^{a} (9.9-11.7)
Crude Protein (%)	29.7 (24.6-36.0)	29.7 (22.9-32.8)	30.6 (19.8-37.4)
DCAB (meq/kg DM)	523 (220-650)	510 (202-615)	514 (148-639)
Calcium (%DM)	0.39 ^{b} (0.30-0.51)	0.45^{b} (0.30-0.83)	0.55 ^{a} (0.36-0.93)
Magnesium (%DM)	0.24 (0.20-0.30)	0.25 (0.19-0.34)	0.23 (0.19-0.28)
Sodium (%DM)	0.18 (0.09-0.36)	0.16 (0.09-0.40)	0.18 (0.12-0.30)
Potassium (%DM)	3.1 (2.3-4.2)	3.1 (2.3-3.9)	3.3 (1.9-4.4)
Sulphur (%DM)	0.40 ^{b} (0.29-0.50)	0.39 ^{b} (0.29-0.55)	0.47 ^{a} (0.28-0.86)
Phosphorus (%DM)	0.46 (0.36-0.56)	0.47 (0.34-0.64)	0.46 (0.28-0.65)

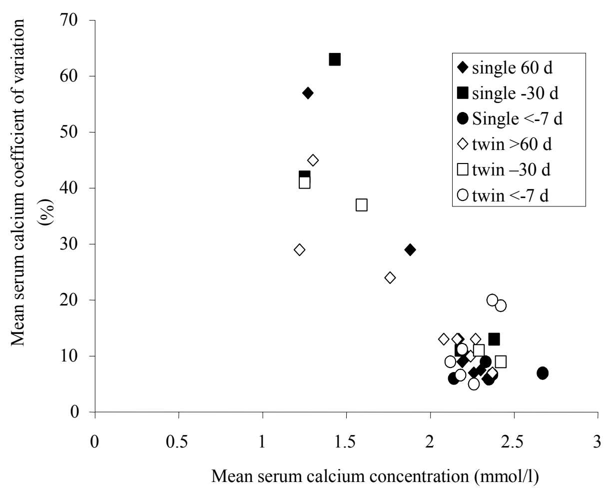
Means within rows different superscripts are significantly different (P<0.05)

Table 3: Effect of single or twin foetuses on mean (range of mean farm values) ewe liveweight, condition score and blood mineral and metabolite concentrations in healthy sheep at approximately 60, 30 and 7 days before start of flock lambing in experiment 1.

Days	**Liveweight (kg)**	**Condition score**	**BOH (mmol/L)**	**Calcium (mmol/L)**	**Magnesium (mmol/L)**	**Phosphate (mmol/L)**
- 60 d						
Single	56.1 (49.5–64.1)	2.31 (1.75-3.0)	0.19 (0.10-0.27)	2.16 (1.27-2.40)	0.64 (0.33-0.80)	1.83 (0.99-2.79)
Twin	58.9 (52.5–67.8)	2.33 (1.86-3.0)	0.19 (0.11-0.27)	2.11 (1.44-2.33)	0.58 (0.29-0.84)	1.70 (0.78-2.62)
P<	0.02	NS	NS	NS	NS	NS
- 30 d						
Single	57.6 (54.5-60.4)	2.48 (2.21-2.87)	0.17 (0.08-0.35)	1.98 (1.25-2.46)	0.65 (0.31-0.84)	1.41 (0.48-2.02)
Twin	61.3 (58.9-66.5)	2.43 (2.18-2.80)	0.21 (0.14-0.43)	1.72 (1.22-2.42)	0.57 (0.36-0.84)	1.22 (0.83-1.96)
P<	0.001	NS	0.05	0.007	NS	0.02
-7 d						
Single	64.3 (63.7-68.6)	2.48 (1.93-2.83)	0.39 (0.22-0.57)	2.33 (1.95-2.67)	0.76 (0.59-1.07)	1.51 (1.05-1.93)
Twin	68.3 (63.1-73.4)	2.48 (1.95-2.88)	0.61 (0.39-1.06)	2.20 (1.93-2.38)	0.75 (0.60-1.08)	1.43 (0.98-1.76)
P<	0.001	NS	0.001	0.002	NS	NS
Day P<	0.0001	NS	0.0001	0.0001	0.001	0.001

P values indicate when singles differs from twins or where days differ.

Figure 1: Relationship between mean serum calcium concentration and coefficient of variation in serum calcium concentration collected from single and twin-pregnant healthy sheep at approximately 60, 30 and 7 days before lambing in experiment 1.



had lower levels of Ca and Mg at all sampling dates compared to Farm 3. The incidence of bearings in the flock ¼ Finn compared to Romney ewes in the monitored twin pregnant flock was 8% and 25% respectively in Farm 1 and 0% for both on Farm 3.

The average bearing incidence across the flocks of the seven monitored farms was 1.3% which when expressed as a proportion of multiple-pregnant ewes was 4.2%. No relationship could be found between serum minerals and metabolite concentration as measured in a small number of ewes and flock bearing incidence.

Experiment 2a

For the first three weeks of treatment, DCAB of the pasture consumed by C ewes was low (210 meq/kgDM) but further reduced (P<0.02) to –320 meq/kgDM in AnS ewes. Urine pH (6.73 *vs*. 7.7 P<0.005) and urine Ca:creatinine (0.46 *vs*. 0.15, P<0.05) were lower in AnS compared to C ewes in the second week of treatment. In the third week of treatment the AnS ewes developed a noticeable aversion (grazing residual AnS 2240 *vs*. C 1560 kg DM/ha) to grazing the sprayed pasture and had a higher (P<0.03) BOH (0.73 *vs*. 0.52 mmol/L) and lower (P<0.05) serum Ca (2.21 *vs*. 2.35 mmol/L, P<0.05) than C ewes. At the end of week 3, AnS ewes were lighter (P<0.001) than C ewes (60.4 *vs*. 65.6 kg).

From week 3 to week 6 nutritional levels of AnS+D and AnS+Ca ewes were similar as shown by similar grazing residuals (average 1720 kg DM/ha) and BOH (average 0.48 mmol/L) concentrations. Ca supplementation increased Ca on herbage from 0.52% DM to 0.65% DM (P=0.11). Over this time there was no effect of treatments on either serum Ca concentration (2.28 mmol/L) or urine pH (8.14).

Experiment 2b

Dusting anionic salts on 1600 kg DM/ha pasture on the Pahiatua farm reduced DCAB of pasture from 398 to 116 meq/kgDM (P<0.05). Pastures were grazed to an average 1000 kg DM/ha residual. At week 2, C and AnD ewes had similar urine pH (6.5), urine Ca:creatine (0.14), BOH (0.3 mmol/L) and serum Ca concentration, (2.3 mmol/L). At 4 weeks AnD ewes had similar urine pH (6.5 *vs*. 6.3), lower (P<0.05) urine Ca:creatinine (0.14 *vs*. 0.28), lower (P<0.0001) serum BOH (0.44 *vs*. 0.88 mmol/L) and higher (P=0.11) serum Ca (2.20 *vs*. 2.12 mmol/L) concentrations than C ewes.

On the Southland farms, Farm 7 had a moderately high pasture DCAB (540 meq/kg DM) while the others were low (average 310 meq/kg DM). All of the ryegrass white clover pastures had high levels of Ca (0.61-0.77 %DM) and average pre-grazed herbage mass was 2500 kg DM.ha and pastures were grazed down to 900 kg DM/ha. .

Despite being used to consuming concentrates the AnP ewes of Farms 1 and 7 took more than 2 weeks to adapt to eating pellets. Farm 2 was lambing later than the other 2 farms, and the farmer fed his sheep some barley before supplementing with the pellets and his sheep consumed all pellets immediately. There was no difference between C and AnP ewes in liveweight, condition score, serum BOH and Ca concentrations (Table 4).

Table 4: Serum ß hydroxybutyrate (BOH mmol/L), serum Calcium (Ca mmol/L)), urine pH and urine Calcium:creatinine ratio (Ca:Ct) in twin-pregnant ewes consuming 300-500 g/ewe of anionic pellets (AnP) 8 to 4 weeks before lambing as an average for the 3 farms (All) or for each individual Farm 1, 2 and 7 in experiment 2b.

Treatments		**Week 6 before lambing**				**Week 4 before lambing**			
		Serum		**Urine**		**Serum**		**Urine**	
	Farm	**BOH**	**Ca**	**pH**	**Ca:Ct**	**BOH**	**Ca**	**pH**	**Ca:Cr**
Average of farms									
AnP	All	0.37	2.41	6.73	0.47	0.51	2.40	6.26	0.58
C	All	0.35	2.39	7.32	0.16	0.51	2.41	7.23	0.14
TRT (P<)		NS	NS	0.002	0.003	NS	NS	0.01	0.003
Individual farms									
AnP	7	0.36	2.51 ^{a}	7.28 $^{b\,c}$	0.66	0.44	2.37	7.45 ^{a}	0.58
C	7	0.38	2.28 ^{c}	7.89 ^{a}	0.14	0.44	2.37	7.66 ^{a}	0.11
AnP	2	0.40	2.35 $^{b\,c}$	5.55 ^{d}	0.57	0.84	2.47	4.97 ^{c}	0.59
C	2	0.38	2.45 $^{a\,b}$	6.75 ^{c}	0.25	0.73	2.51	7.29 $^{a\,b}$	0.32
AnP	1	0.35	2.36 $^{b\,c}$	7.36 $^{a\,b}$	0.18	0.27	2.36	6.35 ^{b}	0.56
C	1	0.30	2.43 $^{a\,b}$	7.32 $^{a\,b\,c}$	0.08	0.36	2.35	6.74 $^{a\,b}$	0.004
Farm (P<)		NS	NS	0.0001	0.04	0.0001	0.0078	0.006	NS
Farm*Trt (P<)		NS	0.0004	0.03	NS	NS	NS	0.08	NS

Where subscripts differ for individual farms in the same column treatments are statistically different (P<0.05)

Table 5: Bearing incidence in multiple-pregnant older ewes following treatment with anionic salts, vitamin D and Ca supplementation on 7 farms in experiment 2b.

Treatment pre-lambing	**Bearing incidence in multiple pregnant ewes (%)**					
8-4 weeks	**Anionic salts**		**Control**			
4-0 weeks	**Ca**	**Vit D**	**Vit D**	**Ca**	**Control**	**Main mob**
Farm 1[2]		6			2	3.4
Farm 2[2]		2			5	4.7
Farm 3[2]			0		0	0.7
Farm 4[1]	4	4	2		3	na
Farm 5[2]				5	3	4.4
Farm 6[2]		3			3	4.9
Farm 7[2]		3			1	2.2

[1]Pahiatua [2]Southland

Following consumption of anionic pellets in mid pregnancy, the pH of the ewes' urine was lower and urinary Ca:creatinine ratios were higher. Treatment was more effective on Farm 2 where the pellets were eaten more readily than the other two farms (Table 4).

There was no effect of a single vitamin D injection or Ca supplementation on measured blood metabolites, urine pH or ewe condition. On Farm 1 at set stocking the blood Ca was higher in AnP+D than C ewes (2.52 *vs*. 2.30 mmol/L, $P<0.05$).

Overall the bearing incidence was unaffected by treatments (Table 5).

DISCUSSION

In the first experiment ewes were offered herbage containing more than the recommended minimum dietary concentration of minerals required for single and twin-pregnant ewes in late pregnancy (Grace, 1983). Nonetheless 15 to 40% of individual ewes had marginal blood Ca (<1.95 mmol/L) and Mg (<0.54 mmol/L) concentrations at 60 or 30 d before lambing (Masters & White, 1996). The severity of the drop in blood Ca in twin ewes in this experiment was surprising (Sansom et al., 1982; Wilson, 1999) and indicates that low Ca status is an issue in commercial twin ewes. Because bearing incidence is higher in older ewes, older ewes were used in this study and they are known to respond more slowly to changes in Ca balance (Braithwaite & Riazuddin, 1971). While Romney ewes had low serum Ca, the loss of homeostatis was even greater in Finnx ewes but these ewes subsequently had fewer bearings.

It is possible that the high DCAB forages fed to New Zealand sheep could exacerbate the loss of Ca homeostasis in sheep in mid-pregnancy. But in Experiment 1, no association was found between herbage DCAB and serum Ca concentrations.

In Experiment 2, feeding a lower DCAB diet induced metabolic acidosis as seen by a drop in urine pH. Metabolic acidosis acts directly on the renal tubular cells causing a decrease in Ca re-absorption and, an increase in urine Ca concentration (Takagi & Block, 1991). In the literature the consequence of this increase in urine Ca concentration on blood Ca is inconsistent. Depending on the absorption of Ca from the diet, mobilisation from bone, and Ca requirements, serum Ca may fall (Wilson *et al.*, 1999) or remain unchanged (Takagi & Block, 1991).

Using urine pH as an index of the success of treating with anionic salts, spraying and dusting of anionic salts on to pasture were found to be ineffective either due to failure of the ewes to consume the treated forage or to the salts not sticking to the short forage. The inclusion of anionic salts into a concentrate supplement, when actually consumed by the ewes, did successfully reduce urine pH and increase Ca excretion in the urine.

In this study, with the possible exception of the AnP+D group on one farm at set stocking, changes in blood Ca seemed mainly to be associated with differences in nutrition as assessed by Ca content in herbage and serum BOH concentrations. BOH is elevated during fat mobilisation and is an established tool for assessing ewe nutritional status (Everts, 1990). In these experiments, it was found that ewes in groups with lower BOH levels had higher serum Ca concentrations. Grant *et al.* (1988) also found blood Ca concentrations were responsive to feeding level when ewes were consuming lush spring pastures.

Vitamin D improves active absorption of Ca from the intestine and pharmacological doses of Vitamin D can improve Ca absorption and reduce milk fever (Takagi & Block, 1991). However, Vitamin D treatment did not increase blood Ca in this study and neither did the feeding of supplemental Ca.

Minimal changes in the homeostatically controlled serum Ca concentrations were generated by treatments so it is impossible to determine whether Ca balance was indeed perturbed. When Ca excretion was increased no effect was observed on bearings. In another study bearings also could not be induced by *ad libitum* feeding ewes in late pregnancy on high DCAB (620 meq/kg DM) pastures (Litherland *et al.*, 2000). In addition, no relationship could be found between serum mineral concentration and bearing incidence on 12 Scottish farms (Hosie *et al.*, 1991) and a large New Zealand epidemiological study on 210 farms (Hilson *et al.*, 2002). However, Hilson *et al.* (2002) did find that ewes with a higher serum phosphate were subsequently 2.6 times more likely to have a bearing than those with lower concentrations. Phosphate and calcium metabolism are closely linked sharing common regulatory systems (Grace *et al.*, 1983).

It is the authors' opinion that there is a strong "environmental" component in bearings, not associated with feeding level, seen when bearing outbreaks occurs in some years and not others, on some farms and not others, and in some paddocks and not others. However the factors or combination of factors which make up this environmental component remain frustratingly elusive.

CONCLUSIONS

There is no clear evidence from this study that Ca metabolism or balance is associated with bearings incidence on New Zealand farms.

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