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Growth rate responses to magnesium or sodium supplements in lambs grazing dual-purpose wheats*

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ABSTRACT

Lambs grazed vegetative wheat crops in south-east Australia with and without Mg or Na supplements. Relative to the requirements for lamb growth, wheat forage was marginal for Mg, adequate for Ca, excessive for K and very low in Na. In Experiment 1, a combined Mg/Ca/Na supplement led to a 54% increase in lamb liveweight gain compared with unsupplemented lambs. Further experiments were then conducted to separate the responses to Mg or Na. In Experiment 2, Mg or Na supplements increased liveweight gain by 24 and 37%, respectively. In Experiment 3, Mg intake by lambs was increased by fertilizing the wheat crop with $MgSO_4$. This increased wheat forage Mg from below (0.10% DM) to above (0.17% DM) that required by lambs and resulted in 24% faster liveweight gain at a stocking rate of 18/ha. At higher stocking rates (33, 47 sheep/ha), the response to Mg declined as herbage supply became increasingly limited. In the final experiment, Na-supplemented lambs grew 25% faster than unsupplemented lambs. The observed responses to Mg and Na may be separate responses, but diets low in Na and high in K have been shown to impair ruminal Mg absorption. The wheat forage in Experiments 1-4 contained 3-4% of DM as K and very low Na concentrations. We present evidence suggesting that the response to Na could partly be due to improved Mg absorption, arising from a reduction in dietary K:Na ratio.

KEY WORDS: winter wheat, potassium, sodium, calcium, magnesium, liveweight gains, sheep

INTRODUCTION

The grazing of long-season, dual-purpose wheats by lambs can result in rapid liveweight gains (e.g., 320-360 g/day) but there can also be marked variability in daily gains (140-360 g/day) in animals grazing seemingly similar crops (Dove,

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2006). This can partly be related to lamb genotype, with Merino lambs usually having lower rates of gain (140-240 g/day), but even when re-expressed as a percentage of liveweight, there is still a 2-fold range in gains of lambs grazing dual-purpose wheat (0.5-1.0% of liveweight; Dove, 2006). The nutritive value of winter wheat forage is very high (OM digestibilities 75-90%; crude protein contents 22-26% DM) and estimated forage intakes are sufficient for high rates of gain (Dove, 2006). We therefore investigated whether wheat forage, when grown under southern Australian conditions, is deficient in any minerals that would limit or cause variability in liveweight gain of grazing lambs.

Berger (1992) reported that low Mg levels in winter wheat could limit livestock growth. In south-eastern Australia, wheat forage can also be low in Mg due to reduced plant Mg absorption when the crop grows in low pH soils with high K content (Coventry et al., 1987; Dove, 2007). In 4 wheat-grazing trials, we therefore investigated weight gain responses to Mg supplementation of young sheep. Responses to Na supplementation were also studied, because survey data indicate that wheat forage can be very deficient in Na (Dove, 2007).

MATERIAL AND METHODS

Experiments 1 and 2

In Experiment 1, liveweight gain was measured over a 28-day grazing period (11 July-8 August) in crossbred lambs (mean initial weight 37 kg) grazing 6 plots of winter wheat (*Triticum aestivum* cv. Wedgetail) at a stocking rate of 35 lambs/ha. In 3 of the plots, lambs received no supplement, whilst in the other 3 plots, lambs received a supplement of 2:2:1 magnesium oxide (MgO):limestone ($CaCO_3$):salt (NaCl) at the rate of 20 g/lamb per day. The salt was required to ensure that the supplement was consumed. Wheat forage availability over the grazing period was such that herbage intake was not limited.

In Experiment 2, separate Mg and Na supplements were used, to distinguish between responses to Mg or Na, which were confounded in Experiment 1. Liveweight gain was measured over 29 days in late winter in crossbred lambs (mean initial weight 37 kg) grazing Wedgetail wheat at 20/ha. The trial involved 3 treatments: no supplement, a Na supplement (NaCl at the rate of 4 g/sheep per day) and a Mg supplement (MgO at the rate of 17 g/sheep per day). Due to the low palatability of MgO, it was fed together with a small quantity (approximately 80 g/sheep per day) of poor-quality roughage (DMD <50%). By contrast with Experiment 1, the trial was conducted under drought conditions and available herbage restricted intake and thus liveweight gain over the period.

Experiment 3

Merino lambs (mean initial weight 30 kg) grazed winter wheat (cv. Mackellar) at 18, 33 or 47 lambs/ha between 14 August and 15 September, 2006. They either remained unsupplemented or were 'supplemented' indirectly with Mg by fertilizing some plots with $MgSO_4$ (425 kg/ha), 3 weeks before grazing commenced, to increase forage Mg concentrations. Liveweight gains were estimated from initial and final fasted liveweights.

Experiment 4

Merino lambs from the same group as Experiment 3 grazed at 36/ha on 2 replicates in a separate area of the same crop used in Experiment 3, but which had not received Mg fertilizer. From 14 August-15 September, 2006, these lambs were either unsupplemented or had *ad libitum* access to Na fed as loose salt in shallow troughs. Fasted liveweight gain was determined as in Experiment 3.

Chemical and statistical analyses

Samples of wheat forage from all 4 experiments were assayed for their OM digestibility and crude protein content using standard procedures. In addition, concentrations of the major minerals were determined in all 4 experiments by X-ray fluorescence (Norrish and Hutton, 1977).

All 4 experiments were conducted as replicated randomized blocks and responses were evaluated using analysis of variance for this design.

RESULTS

The OM digestibility of all grazed crops was in the range 75-90%; crude protein was in the range 22-26% of DM. The nutritive value of the forage was thus very high and would not have limited liveweight gain. The concentration of selected major minerals in the forage DM is shown in Table 1, together with the requirements for growth in young sheep (SCA, 1990). Relative to the sheep requirements for growth, all wheat forages were marginal for Mg except the fertilized crop in Experiment 3, in which the application of $MgSO_4$ fertilizer increased forage Mg content above animal requirements. The Ca content of the crops was close to or exceeded animal requirements. By contrast, the crops contained 6-7 times the amount of K required by animals. With the exception of the forage in Experiment 1, which contained Na at the level required by animals, the other crops were markedly deficient in Na. No systematic difference in mineral content was observed between the two wheat cultivars used in this work.

Table 1. Mineral concentrations in wheat forage (Experiments 1-4) in relation to requirements for growth in young sheep

Item	Mineral, % DM			
	Mg	Ca	K	Na
Requirement for growth	0.12	0.15	0.50	0.05
Forage content				
range, Experiments 1-4	0.10-0.17	0.15-0.30	2.96-3.50	0.005-0.05
experiment 3: unfertilized	0.10	0.20	3.50	0.005
fertilized	0.17	0.23	3.27	0.008

In Experiment 1, supplemented animals grew significantly faster (54%; P<0.05) than their unsupplemented cohorts (Table 2). Since the forage contained adequate Ca for growth and Na content was equal to sheep requirements, the response was attributed to Mg. However, the possible confounding effect of the Na was the reason for separate supplementation with Na and Mg in Experiment 2. In this case, there were significant responses to both Na and Mg supplements (P<0.05). Sheep given the Na supplement grew 37% faster than unsupplemented sheep, whilst the equivalent figure for sheep given the Mg supplement was 24%.

Table 2. Liveweight gains of supplemented or unsupplemented lambs grazing Wedgetail wheat forage

Item		Liveweight gain, g/day
Experiment 1:	unsupplemented	184
	Mg-supplemented[1]	283
Experiment 2[2]:	unsupplemented	131
	Na-supplemented	179
	Mg-supplemented	162

[1] supplement consisted of 2:2:1 mixture of MgO:$CaSO_4$:NaCl in Experiment 1. In Experiment 2, Na was provided as NaCl and Mg as MgO

[2] lower liveweight gains in this study reflect drought conditions

In Experiment 3, there was a marked response of wheat forage Mg concentration to the application of Mg fertilizer. In the unfertilized crop, forage Mg concentration was always lower (0.09-0.11% DM) than the level required for growth in young sheep (0.12% DM). Application of Mg fertilizer raised this concentration significantly (P<0.05), to as high as 0.26% DM in the week following application; for the actual grazing period (days 19-51 after application), forage Mg concentration in fertilized plots averaged 0.17% DM. There was a marked interaction between stocking rate and fertilizer application on lamb liveweight gain (P<0.01). On the unfertilized forage, sheep grazing at 18, 33 and 47/ha grew at 148, 162 and 164 g/day; the main effect of stocking rate was not significant.

On Mg-fertilized wheat, the equivalent gains were 185, 169 and 138 g/day. The liveweight gain responses to Mg fertilizer were thus 25, 4 and -16%, respectively, at these 3 stocking rates. The progressive reductions in response can be related to herbage supply, which declined more rapidly ($P<0.01$) to low levels in sheep grazing at the higher stocking rates.

In Experiment 4, lambs offered salt consumed, on average, 30 g/day, equivalent to about 12 g Na/day, and grew at 211 g/day, 25% faster than unsupplemented lambs (169 g/day; $P<0.05$).

DISCUSSION

In the United States, Mg supplements have reduced the incidence of grass tetany in cattle grazing winter wheats. Wheat forage is often also deficient in Na and responses to Na supplements have also been noted (Berger, 1992). Our data extend such findings by demonstrating liveweight responses in lambs showing no symptoms of clinical Mg deficiency. Marked responses to Na supplementation were also observed. Given the very low Na content of most of the wheat forages in the present study, this may represent a true Na response. For example, the consumption of 30 g salt/day (Experiment 4) would raise the effective dietary concentration of Na well above the daily Na requirement for lamb growth. However, there are also sound reasons for expecting a range of minerals, especially Mg, K and Na to influence the Mg content of plant tissue (Coventry et al., 1987) and the ruminal absorption of Mg by livestock (Martens et al., 1987; Berger, 1992).

In south-east Australia, wheat is often grown in areas with topsoils of low pH and high K content (Coventry et al., 1987). These soil conditions reduce Mg uptake by plants (Coventry et al., 1987) and also lead to high K concentrations in plant tissue. This is the likely explanation of the high K and low Mg in our forages. Forage Ca contents in Experiments 1-4 were typical of wheats grown in south-eastern Australia, and were usually at or slightly above lamb growth requirements (Table 1). Forage Mg content was positively but poorly related to forage Ca content ($r^2=0.171$). The high K and low Na concentrations in the wheat forage are a cause for concern, because high K and low Na intakes result in a high K:Na ratio in rumen fluid, which in turn greatly reduces Mg absorption from the rumen (Martens et al., 1987; SCA, 1990; Berger, 1992). Although high forage K can often also reduce forage Na content (see SCA, 1990), there was no relationship between forage K and forage Na in Experiments 1-4. Martens et al. (1987) reported a 55% increase in Mg absorption when sheep consuming a low-Na diet were supplemented with Na into the rumen. It follows that in sheep consuming high-K forage, supplementation with Na could lower rumen K:Na ratio and increase Mg absorption. Our observed responses to Na could thus be due, at least in part, to an improvement in the Mg status of the animals. This aspect requires further investigation under field conditions in Australia.

In order to prevent grass tetany in beef cattle grazing winter wheat, Berger (1992) recommended that animals be supplemented with a 1:1 mix of NaCl:MgO. For lambs grazing wheat forage under Australian grazing conditions, our results suggest that a similar supplementation policy would be sensible. Given the cost of the supplements used in the present study (about 1 cent/sheep per day) and the value of the resultant extra liveweight gain (about A$1.60/kg), it would also be economically worthwhile.

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