
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

Wool growth responses of Romney rams selected for high or low wool strength to nutrient supplementation in winter

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ABSTRACT

Romney rams selected for high wool staple strength grew 25% more wool than rams selected for low staple strength when fed near maintenance rations during a 10 week winter experiment. Wool growth responses to supplements of energy (6% of diet as tallow), protein (9% of diet as bloodmeal) and methionine (1.2 g/d by intraperitoneal injection) were similar in the two staple strength selection lines. Tallow increased the estimated supply of metabolic energy by 53% but was without effect on wool growth. Bloodmeal increased dietary protein by 82%, dietary energy by 9% and sulphur supplies by 13% and produced 38% more wool. Methionine injections also increased sulphur supplies by 13% but had no effect on energy or protein supplies and the wool growth response (35%) was similar to that of bloodmeal. The finding that methionine supplies limited wool growth is consistent with other studies in sheep on low planes of nutrition.

A component of wool growth responses was an increase in minimum mean fibre diameter. It accounted for most differences in staple strength between treatments but comparison at the same minimum mean fibre diameter indicated that the methionine supplement increased staple strength through an additional mechanism. Staple strength responses to nutritional treatments were similar in the two staple strength selection lines.

It is concluded that the greater wool growth of the high staple strength selection line accounted for the majority of its staple strength advantage over the low strength line, and that there may be an effect of methionine on wool strength that is additional to its effect on fibre diameter. Because nutritional and genetic effects on staple strength were independent, they can be exploited concurrently to reduce the incidence of tender wools.

Keywords: Sheep, wool, growth, strength, nutrition, winter.

INTRODUCTION

The decline in wool growth in Romney sheep in winter (Story & Ross, 1960; Geenty *et al.*, 1984) results in production of the thinnest and weakest section of wool fibres at that time. Wool growth and strength can be increased by improving the level of winter feeding during winter (Monteath, 1971; Hawker & Thompson, 1987). However, responses to nutritional treatments are expected to be influenced by the types of nutrients supplied (Kempton, 1979; Reis, 1979) and by the genetic potential of the sheep. This report presents responses in Romney sheep selected for high and low wool staple strength to energy, protein and methionine supplements in winter.

MATERIALS AND METHODS

Forty rams aged 1.5 years from lines of Romney sheep selected for High (HSS) or Low (LSS) wool staple strength (Bray *et al.*, 1992) were compared at two levels each of dietary energy (LE, HE), dietary protein (LP, HP) and methionine (LM, HM) supply in a 2x2x2x2 factorial design. The animals had been reared on pasture and were introduced to the LELP diet and individual pens indoors over a 4 week period before a 10 week experimental period from 27 June to 22 August 1989 after which they returned to pasture.

The LELP diet was chaffed ryegrass hay (80%), crushed barley grain (17%) and minerals and vitamin mix (3%). Tallow was included in HE diets at the rate of 6% and blood meal was included in HP diets at 9% on a fresh weight basis, replacing hay and grain. All diets were fed at the same rate per unit of metabolic liveweight, with the rate adjusted weekly to maintain the mean liveweight of the LELP treatment group. They were fed once each day between 0800 and 0900 hours.

Methionine was injected into the peritoneal cavity at the rate equivalent to 1.2g/d in sterile saline (Barry, 1976) immediately before feeding each Monday, Wednesday and Friday during the treatment period.

The metabolisable energy content of diets was estimated using values from MAFF (1984) and Ulyatt *et al.* (1980). Nitrogen content of diets was measured by the Kjeldahl method and the sulphur content was determined turbidometricaly following nitric/perchloric acid digestion. Liveweights were measured immediately before sheep were fed. Wool was harvested from midside patches (8 x 8cm) at intervals of 4 weeks with a delay of 9 days after treatment initiation to allow time for fibre emergence above skin level. The wool was scoured and conditioned for calculation of wool growth per unit area of the midside patch and mean fibre diameter (airflow method). At shearing, 2 months after completion of treatments, midside samples of wool were extracted from the fleece for measurement of staple strength (Orwin *et al.*, 1988).

Blood samples were obtained by jugular venipuncture prior to the daily feed after 4 and 8 weeks treatment. Plasma

TABLE 1: Nutrient supply, liveweight gain and wool growth in High and Low wool strength rams receiving two levels of dietary energy, dietary protein or methionine; main effect means.

Treatment	Wool Strength		Energy		Protein		Methionine		S.E.D.
Level	LSS	HSS	LE	HE	LP	HP	LM	HM	(max.)
Daily nutrient supply									
Energy (MJME)	8.88	8.70	7.25	11.11**	8.39	9.19	8.74	8.84	0.21
Nitrogen (g)	19.0	18.8	19.2	18.4	13.4	24.4**	18.8	19.0	0.51
Sulphur (g)	2.43	2.41	2.45	2.38	2.27	2.57**	2.28	2.56**	0.06
Daily liveweight gain (g)	35	26	16	52**	18	43*	25	35	10
Daily wool growth (μg/mm²)	6.64	8.31	7.10	8.04	6.28	8.67**	6.35	8.59**	0.62

* difference between levels of treatment significant at 5% level
** difference between levels of treatment significant at 1% level

TABLE 2: Efficiency of wool growth expressed as wool growth rate (μg/mm²/d) at mean levels of nutrient supply; main effect means

Treatment	Wool Strength		Energy		Protein		Methionine		S.E.D.
(mean level of supply)	LSS	HSS	LE	HE	LP	HP	LM	HM	(max.)
Energy (8.8MJME/d)	6.90	8.05	8.01	6.68	6.52	8.44*	6.39	8.57**	2.60
Nitrogen (18.9g/d)	6.74	8.22	7.05	8.12	7.21	7.74	6.37	8.58**	3.02
Sulpher (2.42g/d)	6.75	8.21	7.03	8.15	6.65	8.30	6.69	8.26	0.89

*, ** as for Table 1

TABLE 3: Fibre diameter during the experiment and staple strength; main effect means

Treatment	Wool Strength		Energy		Protein		Methionine		S.E.D.
Level	LSS	HSS	LE	HE	LP	HP	LM	HM	(max.)
Fibre diameter (μm)									
Mean	29.4	33.1*	31.3	31.5	29.2	33.3	30.2	32.2	0.9
Minimum mean	25.7	29.4*	27.0	28.3	26.7	28.4	27.7	27.4	0.7
Staple Strength (N/ktex)	27.4	53.3**	37.3	44.9	37.1	43.6	37.5	43.1	4.3

*, ** as for Table 1

TABLE 4: Metabolite levels (mmol/l) in peripheral plasma; main effect means for data pooled from samples collected 0, 2 and 6 hours after feeding following 4 and 8 weeks of treatment

Treatment	Wool Strength		Energy		Protein		Methionine		S.E.D.
Level	LSS	HSS	LE	HE	LP	HP	LM	HM	(max.)
Glucose	3.45	3.38	3.42	3.42	3.33	3.51**	3.37	3.46	0.06
ß-hydroxybutyrate	0.45	0.43	0.45	0.44	0.42	0.47*	0.41	0.47*	0.03
Urea	5.25	5.45	5.26	5.49	3.99	6.71**	5.69	5.01**	0.21
Creatinine	108	105	107	106	112	101*	103	109*	5

*, ** as for Table 1

from them was stored frozen until analysed for glucose (hexokinase method, Boehringer Mannheim kit), urea (enzymatic UV method, Boehringer Mannheim kit), creatinine (colorimetric method, Boehringer Mannheim kit) and ß-hydroxybutyrate (Koch and Feldbreugge, 1987) using an Instrumentation Laboratory micro centrifugal analyser 'Multistat 3 plus'.

The data were analysed by analysis of variance and covariance using Genstat versions 4 and 5.

RESULTS

Dry matter intake was similar for all treatment groups. HE diets increased energy supply by 53% ($P<0.01$) over LE diets. HP diets increased nitrogen supply by 82% ($P<0.001$), energy supply by 9% ($P<0.05$) and sulphur supply by 13% ($P<0.01$) over LP diets. HM treatments increased sulphur supply by 13% ($P<0.01$) over LM treatments (Table 1).

Initial liveweights were similar for all treatments. Liveweight gain responses to energy and protein supplementation were significant (P<0.05) although small relative to increases in nutrient supply.

Wool grew 25% faster (NS) in HSS than in LSS rams, 38% faster (P<0.01) in HP than LP, and 35% faster (P<0.01) in HM than LM treatments. Energy, nitrogen and sulphur were utilised more efficiently for wool growth by HSS than by LSS rams but differences were not significant (Table 2). Rams on the HP diet used energy more efficiently (P<0.05) and HM rams used both energy and protein more efficiently (P<0.01) for wool growth. There were no significant treatment effects on the efficiency with which sulphur was used.

HSS rams had mean and minimum mean fibre diameters 3.7µm greater (P<0.01) than LSS rams (Table 3). Minimum mean fibre diameter for most rams occurred at the start of the experimental period. Across all treatments each 1µm increase in minimum mean fibre diameter was associated with an increase in staple strength of 4.8N/ktex. The largest treatment effect on staple strength was that of ram selection line with HSS rams having nearly double the staple strength of LSS rams. Sixty nine percent of this difference was accounted for by the difference in minimum mean fibre diameter between selection lines. When compared at the same minimum mean fibre diameter the difference in staple strength was reduced (LSS 32.3, HSS 48.4 N/ktex) and was not significant. The significance of the difference in staple strength between methionine treatments, on the other hand, was increased (LM 37.0, HM 43.7 N/ktex; P<0.05) by adjustment for differences in minimum mean fibre diameter. There were no major interactions between staple strength selection line and nutritional treatments for wool parameters.

Levels of glucose, ß-hydroxybutyrate, urea and creatinine in plasma were not significantly affected by wool strength selection line nor by energy supplementation (Table 4). Protein supplementation increased glucose, ß-hydroxybutyrate and urea levels and decreased creatinine levels (P<0.05) while methionine supplementation increased ß-hydroxybutyrate and creatinine levels and decreased urea levels (P<0.05).

DISCUSSION

Rams selected for high staple strength grew more wool than those selected for low staple strength, at the same level of energy, protein or sulphur supply. The HSS line also grew more wool when they grazed pasture in common mobs where food intake and diet selection by individual sheep were not controlled (Bray *et al.*, 1992). The increased wool growth was not associated with reduced body weight in this study nor in the report of Bray *et al.* (1992), indicating either that the amount of extra nutrients needed for the extra wool growth was small compared to amounts required for maintenance and growth of non-wool tissues, or that the HSS line utilised nutrients more efficiently. Results of this experiment indicate that at least part of the wool growth rate response was due to increased efficiency. Plasma levels of metabolites associated with energy and protein metabolism indicated no major differences between the two selection lines. Elevated plasma levels of insulin in HSS rams in two other studies (Dijkstra *et al.*, 1991; A.R. Bray, unpublished) could influence glucose and amino acid utilisation but they were not found in the present experiment (Bray *et al.*, 1990).

Given that High fleece weight Merino (Williams *et al.*, 1972) and Romney (Harris *et al.*, 1990) sheep exhibited greater responses to sulphur amino acid supplementation than those with a lower genetic potential for wool growth, it was expected that high staple strength rams in the present study would have greater wool growth responses to bloodmeal and methionine than did low staple strength rams. This was not the case. The two selection lines responded similarly to all three nutritional supplements.

A 53% increase in energy supplies had little influence on wool growth or plasma metabolite levels. It is possible that forms of energy other than tallow may have been more effective but the results obtained are consistent with previous reports in which other energy sources have been used (Kempton, 1979). The lack of interactions between level of energy and level of other nutrients for wool growth indicates that the low level of dietary energy supply (7.25 MJME/d) did not limit wool growth.

Inclusion of bloodmeal in the diet increased nitrogen intake by 82% and, given that over 60% of it escapes degradation in the rumen (National Research Council, 1985), it is expected to have increased the amount of amino acids absorbed and raised their levels in plasma to an even greater extent. Higher plasma amino acid levels could account for elevated plasma levels of urea in HP treatments. They could also increase gluconeogenesis and so explain the elevation of plasma levels of glucose in HP treatments. The extra amino acids available from the digestive tract may also have reduced the need for catabolism of tissue proteins and so reduced plasma levels of creatinine. The greater ß-hydroxybutyrate levels in the plasma of protein supplemented rams is consistent with the stimulation of lipolysis by protein supplements in animals at low energy intakes (Fattet *et al.*, 1984). In stimulating lipolysis bloodmeal may have enhanced energy supplies above that indicated by dietary energy levels. A wool growth response to increased amino acid supplies was expected (Kempton, 1979; Reis, 1979) and the greater minimum mean fibre diameter accounts for the increased staple strength in HP treatments.

Methionine supplementation resulted in similar increases in wool growth, fibre diameter and staple strength as seen in bloodmeal treatments, without increasing plasma glucose levels or, presumably, supplies of other amino acids. In contrast to bloodmeal it reduced plasma urea levels, possibly by increasing the efficiency with which other amino acids were used in protein synthesis. Also in contrast to bloodmeal, it increased plasma creatinine levels, indicating stimulation of tissue protein catabolism or reduced renal clearance. Like bloodmeal, it increased plasma ß-hydroxybutyrate levels and so may have increased energy supplies above that indicated by dietary energy levels. It is unlikely that the extra energy had any effect on wool growth considering the lack of response to tallow. The metabolic effects in common between bloodmeal and methionine do not appear to explain the similar wool growth responses to the two treatments.

The ability of methionine to stimulate wool growth to the levels seen in the bloodmeal treatment indicates that methionine was the limiting amino acid for wool growth, as seen in other studies with sheep on low planes of nutrition (Reis, 1979). This is highlighted by the marked increase in the efficiency with which energy and protein were utilised for wool growth in methionine supplemented rams in this study. Most of the staple strength responses to treatments were explained by changes in minimum mean fibre diameter. The influence of the nutritional supplements on staple strength may have been greater if the minimum mean fibre diameter had occurred later in the experimental period. Even so methionine treatment increased staple strength more than expected from its effect on fibre diameter. This suggests that it affected the composition of fibres to improve tenacity (breaking force per unit cross-sectional area). Lee *et al.* (1992) reported elemental contents of wool from the present experiment. They noted increased sulphur, phosphorus and zinc and decreased calcium concentrations in response to methionine treatment, particularly towards the end of the treatment period. In other experiments sulphur amino acid treatments have increased the level of high sulphur proteins (Reis, 1979) but evidence linking them to wool strength is by no means conclusive (Reis, 1992).

It is concluded that the greater wool growth of the high strength selection line is due to a greater efficiency of utilisation of nutrients for wool growth, and that greater wool growth accounts for most of the difference in wool staple strength between the High and Low strength lines. The importance of methionine for wool growth at low levels of nutrition was confirmed and this study suggests that methionine may affect staple strength through its influence on fibre composition. The independence of nutritional and genetic effects on wool strength means that they can be exploited concurrently to reduce the incidence of tender wools.

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