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HORMONAL AND WOOL FIBRE RESPONSES TO MAINTENANCE OR SUB-MAINTENANCE FEEDING IN MERINO SHEEP WITH DIFFERENT STAPLE STRENGTH

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SUMMARY

This study examined whether sheep that produce sound wool have an ability to partition more nutrients to wool, during periods of under-nutrition. Groups of 12 low and 12 high staple strength sheep (SS) were fed to maintain or to lose 8% of liveweight over a 67-day period, fasted for 3-days and then re-fed above maintenance for 70 days. The SS groups had similar clean fleece weights, mean fibre diameters, SS, and staple lengths. Sub-maintenance feeding reduced fibre diameter at the point of break by 1.2 μm and SS by 16.1 N/ktex, compared to maintenance fed sheep. Over both feeding periods, cortisol and thyroxine concentrations were higher in the high SS group, while insulin concentration tended to be lower. It is concluded that SS groups differed in a number of metabolic hormones.

Keywords: staple strength; short term fast; wool growth; fibre diameter; metabolic hormones

INTRODUCTION

Much of southern Australia has a Mediterranean climate with mild wet winters and dry hot summers. Annual pastures are a feature of this environment and are characterised by large seasonal fluctuations in feed quantity and quality leading to large seasonal amplitudes in liveweight, wool growth and reduced staple strength (SS) (Schlink *et al*. 1999). SS strength is the second most important determinant of the value of raw wool, after fibre diameter.

In this study, we used wethers selected for divergence in SS (Howe *et al*. 1991) to investigate the relationship between nutritional stress, wool growth and SS. The wethers were fed at or below maintenance, to examine responses to their nutritional environment. They were then subjected to a short term fast, and after the fast, fed above maintenance for the remainder of the experiment. The present study also examined hormonal differences between sheep to see whether sheep with a tendency to produce wools with a higher SS have changes in partitioning nutrients to wool, or in their metabolic hormones.

MATERIALS AND METHODS

Twenty-four wethers (12 low and 12 high SS), initial liveweight of 62.7 kg, were selected from flocks used to establish the genetic parameters of wool SS (Howe *et al*. 1991). The low and high SS groups averaged 18.4 and 34.0 N/ktex, respectively, based on two previous annual shearings at the Great Southern Agricultural Research Institute, Katanning, Western Australia. The sheep were grazed at Bakers Hill (Latitude 31°46', Longitude 116°27') for 9 months then transferred to the animal house in Perth.

During days 0 to 67, each staple strength group was divided into two sub-groups (n=6) fed either to liveweight maintenance or 8% loss of starting liveweight over that period. All sheep were fed a diet of 78% oaten hay, 20% oaten grain and 2% mineral mix (Siromin®) (diets were estimated to contain 9.5 MJ ME/kg DM and 9.5% crude protein), to achieve the desired liveweight changes. All sheep were weighed at weekly intervals before feeding, and feeding rates adjusted to achieve the specified liveweight outcomes. At completion of the 3-day fast on days 68 to 70, all sheep were fed 1430 g DM/day for 11 weeks and then released to the field for four months. Mid-side wool samples were collected at shearing.

Wool was clipped from mid-side patches of approximately 100 cm^2 at 14-day intervals from day 7 of the experiment. Dye-bands were placed on the wool at 35-day intervals from day 7. Mid-side, patch and dye-banded wool samples were processed as described by Schlink *et al*. (1998).

Indwelling jugular catheters were inserted 24 h before the initiation of blood sampling. Blood was collected every 20 min for 10 h on day 64 (3 days before fasting) and again 13 days after re-feeding (day 83). During the fast, blood samples were collected every hour for 10 h starting at 0800 h. Blood was collected into heparinised tubes, centrifuged and plasma stored at -20^{o}C until assayed. Plasma cortisol concentrations were measured using the radio-immunoassay (Atkinson and Adams 1988). Plasma insulin, insulin-like growth factor 1 (IGF1), and growth hormone were measured by radio-immunoassay (Adams *et al*. 1996). Plasma concentrations of total thyroxine and tri-iodothyronine were measured using kits (Gammacoat, Baxter Healthcare Corp., Cambridge MA, USA).

Statistical analyses were carried out by univariate or repeated measures analysis of variance as appropriate. The pre-fast (day 64) and post-fast (day 83) plasma samples were compared by repeated measures analysis of variance.

RESULTS

Dietary regimes reduced SS (36.2 and 20.2 N/ktex, maintenance and sub-maintenance fed groups respectively, P=0.005), while the between SS groups approached statistical significance (23.8 and 32.5 N/ktex, low and high SS groups respectively, P=0.096). Sub-maintenance feeding for 67 days significantly reduced staple length without significantly affecting other fleece parameters. SS group had no significant effects on fibre diameter at the point of break or incidence of shed fibres at the point of break. Sub-maintenance feeding reduced fibre diameter at the point of break to 15.3 and 14.2 μm for maintenance and sub-maintenance fed groups, respectively (P<0.05), but did not significantly effect the rate of fibre shedding (3.1 and 3.3 % shed fibres for maintenance and sub-maintenance fed groups, respectively P>0.05).

The SS groups had similar clean fleece weights, mean fibre diameters and staple lengths. SS group had no significant effect on patch wool growth or patch fibre diameter (Figure 1). Sub-maintenance feeding significantly reduced wool growth and fibre diameter on patch wool harvest days 63 and 77 compared with maintenance fed sheep (P<0.05). However, there were no significant differences between dietary regimes in wool growth or fibre diameter at the completion of 70 days of re-feeding.

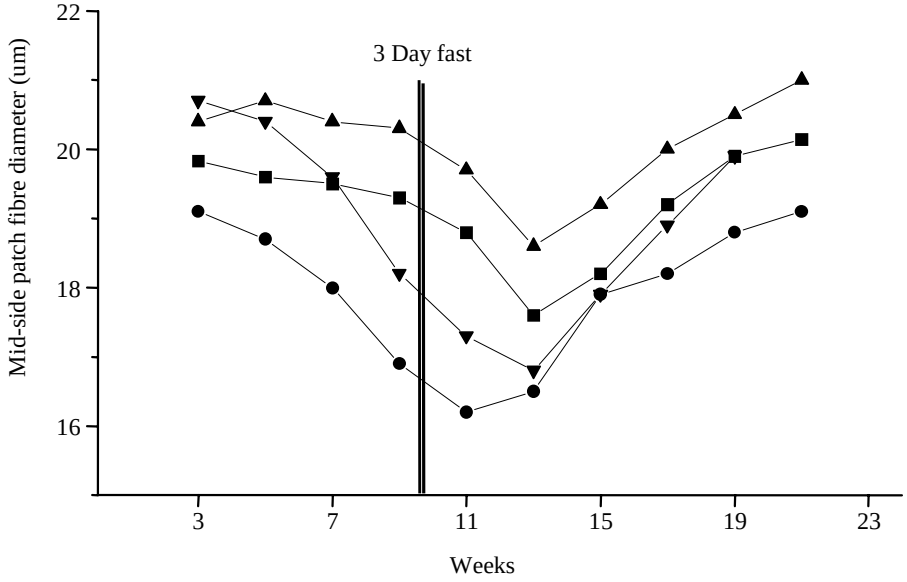

Figure 1. Mid-side patch fibre diameter in low and high staple strength sheep on maintenance (M) or sub-maintenance (SM) diets until day 67, all sheep were placed on 3-day fast until day 70, and re-fed for 11 weeks (■ low SS, M; ● low SS, SM; ▲ high SS, M; ▼ high SS, SM)

Feeding level before or after the fast did not affect concentrations of cortisol in plasma (Tables 1 and 2), but concentrations increased substantially during the fast (P<0.01). Overall plasma cortisol was greater in the high SS group (Table 2). There was no interaction between SS group and feeding treatment.

Sheep fed at maintenance had higher concentrations of both thyroxine and tri-iodothyronine than wethers fed sub-maintenance rations (Table 1). After re-feeding, plasma thyroxine did not change, while mean plasma concentrations of tri-iodothyronine decreased (Table 2). Overall plasma concentrations of thyroxine were higher in the high SS group (Table 2), but plasma concentrations of tri-iodothyronine were similar. There was a significant interaction between diet and SS group in plasma thyroxine concentration but not for plasma tri-iodothyronine concentrations.

Table 1. Plasma concentrations of hormones in low and high staple strength sheep on maintenance (M) or sub-maintenance (SM) diets before the period of fasting (day 64)

	Low SS		High SS			P values		
	Diet		Diet		s.e.m.	Diet	SS	Diet x
	M	SM	M	SM				SS
Cortisol (nmol/l)	9.7	7.4	13.5	8.8	1.9	0.11	0.21	0.53
Thyroxine (nmol/l)	61	64	84	62	4	0.04	0.07	0.02
Tri-iodothyronine (nmol/l)	11.4	10.9	13.4	10.8	0.7	0.04	0.19	0.14
Insulin (ng/ml)	0.77	0.63	0.66	0.50	0.7	0.04	0.11	0.90
GrowthHormone (ng/ml)	7.2	9.8	8.3	10.6	1.8	0.24	0.64	0.91
IGF1 (ng/ml)	239	291	236	211	24	0.56	0.10	0.12

Plasma concentrations of growth hormone were not significantly different between maintenance and sub-maintenance groups on day 64 (Table 1), but declined substantially after re-feeding on day 83 (Table 2). There was no difference between the SS groups in plasma concentrations of growth hormone at any level of feeding or sampling time.

Table 2. Main effects of feed intake and staple strength group on plasma concentrations of hormones in sheep fed at or below maintenance (day 64) and 9 days after re-feeding above maintenance (day 83).

	Feeding level		Staple strength			P values	
	Day 64	Day 83	Low	High	s.e.m	Feed	SS
Cortisol (nmol/l)	9.9	7.7	6.9	10.5	1.4	0.30	0.04
Thyroxine (nmol/l)	68	69	63	74	3	0.67	0.03
Tri-iodothyronine (nmol/l)	11.7	9.8	10.3	11.2	0.6	0.02	0.14
Insulin (ng/ml)	0.64	0.61	0.70	0.55	0.04	0.42	0.07
Growth hormone (ng/ml)	9.0	5.1	6.6	7.5	1.0	0.01	0.52
IGF-1 (ng/ml)	244	265	270	239	21	0.18	0.18

Plasma concentrations of insulin were lower ($P < 0.05$) in animals fed below maintenance than in those fed at maintenance (Table 1), but were not increased significantly by re-feeding (Table 2). High SS sheep tended to have lower plasma insulin concentrations (Table 2). No significant effects of diet or SS group were observed on plasma concentrations of IGF1 (Tables 1 and 2).

DISCUSSION

Reductions in fibre diameter and SS associated with sub-maintenance feeding compared with maintenance feeding are in agreement with those observed by Thompson and Hynd (1998) in weaner sheep. However, the 1.1 μm difference in fibre diameter with sub-maintenance feeding compared to maintenance feeding at the point of break is smaller than the approximately 3 μm predicted from the SS results for weaner sheep. The results clearly show opportunities to improve SS by maintaining liveweight to retain/increase SS, supporting the role of supplementary feeding for the maintenance of SS during seasonal decline (Gherardi *et al*. 1996). The SS outcomes in this study were more closely associated with feeding level than with previous SS outcomes for these sheep. The SS difference between SS groups was 8.7 N/ktex compared to the 16.1 N/ktex achieved with nutritional manipulation.

Thwaites (1972) increased the incidence of shed fibres by administering cortisol to sheep fed below maintenance. However, the increase in plasma cortisol during fasting in the present study produced only low levels of shed fibres at the point of break. The concentrations of cortisol we observed were similar to those induced by injection with 120 mg / day of cortisol acetate for 3-days (Schlink *et al.* 2002). In that study, treatment with cortisol for 3 days also produced non-significant changes in shed fibres, with no significant decrease in SS. We conclude that the 3-day fast does not significantly affect fibre diameter, shed fibre numbers or SS.

This study shows that sheep with different SS may differ in their metabolism. The high SS group had greater plasma concentrations of thyroxine and cortisol, and tended to have lower concentrations of insulin than the low SS group. The variety of hormonal differences between SS groups indicates that the difference was not determined by any particular hormone, but that the groups differed in their nutrient metabolism, and that this resulted in differences in many of the hormones measured. Adams *et al*. (2000) suggested that metabolic hormone differences between mature sheep that differed in SS was likely to be due to differences in body composition that developed as the sheep aged. Young sheep with divergent SS and no differences in body composition did not have significant differences in circulation metabolic hormone concentrations.

In conclusion, we found that a 3-day fast did not affect wool fibre diameter or fibre shedding, and is therefore expected to have little effect on SS in maintenance or sub-maintenance fed sheep. Thus routine movement of sheep for livestock management purposes should not have a significant impact on SS. SS background of the sheep did not affect SS response to a short-term fast or to changes in their nutritional status. A similar situation applied to the hormonal responses of the SS groups to the short-term fast. However, there appeared to be a metabolic difference between the low and high SS groups, resulting in differences between the two SS groups in the plasma concentration of a number of metabolic hormones. The hormonal data suggest that the SS strength sheep may be more metabolically active.

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