

RELATIONSHIPS BETWEEN STAPLE STRENGTH AND FIBRE DIAMETER CHANGES IN MERINO SHEEP SELECTIVELY BRED FOR EITHER HIGH OR LOW CLEAN FLEECE WEIGHT

M.A. FRIEND, G.E. ROBARDS and J. P. KENNEDY

Dept of Wool and Animal Science, University of New South Wales, Sydney, N.S.W. 2052

SUMMARY

Twenty Merino wethers, 10 from each of genetically high and low wool producing selection lines, were subjected to 1 of 3 nutritional regimes. A control group was fed a pelleted 75/25 lucerne chaff/oats control ration to maintain liveweight. The other 2 groups were fed this ration for the first 14 weeks of the experiment, offered a maintenance level of either a high or low protein ration for the next 12 weeks, then had the rations reversed in the last 12 weeks of the experiment. Sheep from the genetically high wool producing line offered the control ration followed by the low protein then the high protein ration had a lower staple strength ($P < 0.05$) than their counterparts in the other groups. Staple strength of sheep from the genetically low wool producing selection line was unaffected by nutritional treatment. Staple strength was positively correlated with diameter change and rate of change between the first and second periods, while it was negatively correlated with diameter change and rate of change between the second and third periods. *Keywords:* staple strength, fibre diameter change, selection lines

INTRODUCTION

After fibre diameter staple strength is one of the major determinants of the price received for wool at auction. Traditionally, price penalties have been imposed on wools with staple strength less than 30N/ktex; however, price penalties are now being imposed on wools above this limit to the extent that 25% of all Australian Merino wool is penalised for low staple strength (Adams 1994). As finer wools have a tendency to be weaker than stronger wools (Baker *et al.* 1993), consumer demand for lighter weight fabrics made from finer wools is making it increasingly important to isolate the causes of wool tenderness and sheep with genetically higher staple strength. Management strategies and breeding programmes can then be implemented to improve staple strength.

Staples do not always break at the point of minimum fibre diameter, and minimum fibre diameter accounts for only 20-40% of the variation in staple strength (Hunter *et al.* 1983; Hansford and Kennedy 1990). Hansford and Kennedy (1990) observed a greater correlation between staple strength and the rate of change of fibre diameter than any other measured characteristic. Reductions in fibre diameter and rapid changes in fibre diameter can be induced by pregnancy, lactation, nutritional change, disease, season or any stress event. The objective of this study was to examine how changes in the crude protein intake, and the timing of these changes, affected the staple strength of Merino wethers sampled from 2 flocks selectively bred for either high or low clean fleece weight per head.

MATERIALS AND METHODS

Twenty 4-year old Merino wethers from NSW Agriculture's Fleece Plus (FI+) and Fleece Minus (FI-) selection flocks were housed in individual pens at UNSW's Sheep Unit at Little Bay, Sydney, where they were subjected to 1 of 3 nutritional treatments. After an acclimatisation period of 9 weeks when the sheep were fed a maintenance level of a pelleted 75/25 lucerne chaff/oats grain ration, they were randomly allocated on the basis of stratified fleece-free live weight to 1 of 3 groups. Group 1 (Control, 2 FI+ and 2 FI-) was fed the control ration throughout the experiment. During the successive periods 1, 2 and 3, group 2 (CHL, 4 FI+ and 4 FI-) was fed the control, high and low protein rations, and group 3 (CLH, 4 FI+ and 4 FI-) was fed the control, low and high protein rations. The rations were:

Control [C]: a pelleted 75/25 lucerne chaff/oats ration (10.1 MJ Metabolisable Energy (ME)/kg Dry Matter (DM), 2.45% Nitrogen (N)).

High protein [H]: a 50/37.5/12.5 formaldehyde-treated canola meal/lucerne chaff/oats ration (11.7 MJ ME/kgDM, 4.45%N).

Low protein [L]: a 85/15oaten chaff/oats ration (9.3 MJ ME/kgDM, 0.86%N).

Sheep were offered a maintenance level of each ration. Each of the 3 periods in the experiment consisted of a 6 week adjustment phase followed by a measurement phase of 8 weeks in period 1 and 6 weeks in periods 2 and 3.

Dyebanding, staple strength and fibre diameter measurements

Sheep were shorn on 10 August 1993, 1 day prior to the start of the experiment. A dyeband was applied on 11 August 1993 on the left **midside**. Subsequent dyebands were applied at the end of each adjustment and measurement phase. At the end of the experiment on 4 May 1994, all sheep were returned to the control ration until shearing on 25 May 1994. Dyebanded staples were removed immediately prior to shearing. Fleece weights were recorded and a **midside** fleece sample taken at shearing.

Staple strength was measured on 10 dyebanded staples from each sheep. Linear density (ktex) of staples was calculated by multiplying staple thickness by 3.2. Staple thickness was measured at tip, middle and base using compressed air **callipers** (Mitutoyo, Japan). Breaking force for each staple was measured in Newtons using an Agriteste staple breaker (Agriteste Pty. Ltd, Ryde, NSW). Staple strength was calculated as the force required to break each staple divided by the average linear density. Point of break (POB) was recorded by visual examination of the broken dyebanded staples.

Fibre diameter was measured at weekly intervals over the last 2 weeks of each measurement phase and over the entire adjustment phase of periods 2 and 3 using the modified autoradiographic technique described by Friend and Robards (1995). A total of 30 fibres was measured for each sheep using image analysis equipment (Video Trace, Leading Edge Technologies, Marion, S.A.).

Two changes in diameter were calculated as the difference of the mean diameters in periods 1 and 2, and the difference of the mean diameters in periods 2 and 3. Two regression coefficients of change in diameter over time were calculated over the adjustment phases of periods 2 and 3.

Statistical analysis

Data were analysed using the General Linear Models procedure of SAS (SAS Institute 1985). Correlations between staple strength and the 2 changes in fibre diameter and the regression coefficients were calculated. Correlation coefficients were calculated taking into account flock and treatment effects.

RESULTS

Staple strength

Due to a large standard error (3.0N/ktex) there was no significant effect of flock on staple strength even though FI+ wethers had a staple strength of 47.7N/ktex compared with 42.8N/ktex for FI- wethers. Treatment effects however, were significant at the 5% level. For FI+ wethers, the staple strength of both the C ($56.5 \pm 6.3\text{N/ktex}$) and CHL ($51.4 \pm 4.4\text{N/ktex}$) groups was significantly greater than the CLH group was ($35.3 \pm 4.4\text{N/ktex}$), however there was no significant difference between the C and CHL groups. Within the FI- flock, there were no significant differences due to nutritional treatments.

Fibre diameter

FI+ sheep had a greater ($P < 0.05$) fibre diameter in each of the 3 measurement phases of the experiment than FI- sheep. Sheep consuming the high protein ration had a greater fibre diameter than sheep consuming either the low protein or control ration in any period (Table 1). The treatment x flock interaction was not significant for fibre diameter.

Table 1. LSMEANS (\pm SE) for fibre diameter (pm) for each treatment group in the measurement phase of each period

Period	Control	CHL	CLH
1 ^A	20.7 \pm 0.77	21.0 \pm 0.55	22.3 \pm 0.55
2	21.7 ^a \pm 0.81	25.3 ^b \pm 0.57	21.2 ^a \pm 0.57
3	21.5 ^a \pm 1.03	21.0 ^a \pm 0.73	25.9 ^b \pm 0.73

^A Means in the same row with different superscripts differ significantly ($P < 0.05$).

Fibre diameter changes and regression coefficients

Over both periods sheep consuming the high protein ration had the greatest changes and rates of change of diameter (Table 2). Diameter change and rate of change did not differ between CHL and CLH groups

when each was introduced to the high protein ration. Sheep in the CHL group had a greater negative diameter change and rate of change when introduced to the low protein ration than CLH sheep when introduced to the low protein ration.

Table 2. LSMEANS (\pm SE) for change in diameter (μm) between the measurement phase of periods 1 and 2 (FDC 1) and 2 and 3 (FDC 2), and regression coefficients ($\mu\text{m}/\text{wk}$) of diameter change over time in the adjustment phase of period 2 (Regr. 1) and period 3 (Regr. 2) for each subgroup

	FI+C	FI+CHL	FI+CLH	FI-C	FI-CHL	FI-CLH
FDC 1	1.1 ^{ca} (0.69)	6.1 ^{a***} (0.49)	-0.5 ^{bd} (0.49)	1.0 ^{cd} (0.69)	2.4 ^{c***} (0.49)	-1.6 ^{b**} (0.49)
FDC 2	-0.2 ^d (0.86)	-6.0 ^{***} (0.62)	6.1 ^{b***} (0.62)	-0.3 ^{de} (0.88)	-2.6 ^{c***} (0.62)	3.3 ^{c***} (0.62)
Regr. 1	0.05 ^{bc} (0.110)	0.82 ^{a***} (0.078)	-0.01 ^c (0.078)	0.19 ^{bc} (0.110)	0.31 ^{b**} (0.078)	-0.07 ^c (0.078)
Regr. 2	-0.03 ^c (0.189)	-0.61 ^{a***} (0.134)	1.06 ^{b***} (0.134)	0.10 ^e (0.189)	-0.37 ^{ac*} (0.134)	0.68 ^{b***} (0.134)

^a Means in the same row with different superscripts differ significantly ($P < 0.05$).

* Mean differs significantly from zero at $P < 0.05$.

** Mean differs significantly from zero at $P < 0.01$.

*** Mean differs significantly from zero at $P < 0.001$.

Correlations of derived characters with staple strength

Both change in diameter and rate of change between periods 1 and 2 were significantly positively correlated with staple strength. In contrast, both change in diameter and rate of change between periods 2 and 3 were significantly negatively correlated with staple strength (Table 3).

Table 3. Correlation coefficients between staple strength and derived rates of change or change in fibre diameter (FD) over the periods of ration change in the experiment

Correlation between SS and..	Correlation coefficient	Correlation between SS and..	Correlation coefficient
Regression 1	0.45*	FD change 1-2	0.56*
Regression 2	-0.57**	FD change 2-3	-0.56**

** $P < 0.01$, * $P < 0.05$.

DISCUSSION

Sheep in the CHL and CLH groups were subjected to rapid increases and decreases in the crude protein content of their diets. Sheep selectively bred for high clean fleece weight (FI+) offered the CLH nutritional regime produced wool with a lower staple strength compared with, FI+ sheep maintained on a constant diet, whereas FI+ sheep offered the CHL nutritional regime produced wool which did not differ in staple strength from that of FI+ sheep maintained on a constant diet. The staple strength of sheep which had been selectively bred for low clean fleece weight (FI-) was unaffected by any of the nutritional regimes imposed.

There were significant positive correlations (Table 2) between staple strength and both change in diameter and rate of change between periods 1 and 2, while the correlation was negative between staple strength and change and rate of change in diameter between periods 2 and 3. Interpretation of this result is difficult as negative diameter changes and rates of change contribute to the correlation by having values less than smaller absolute diameter changes and rates of change. When rates of change were expressed in absolute terms, no significant correlations with staple strength were obtained. Clearer interpretation of the results can be gained by comparison of diameter changes only. Diameter changes in FI+ sheep in the CHL and CLH groups were not significantly different when each group was introduced to the high protein ration (periods 2 and 3 respectively). When each of these groups was introduced to the low protein ration (periods 3 and 2 respectively), FI+ sheep in the CHL group had a greater diameter change (negative) than the CLH group. FI+ sheep in the CHL group therefore exhibited large positive and negative changes in diameter, but this did not have a deleterious effect on staple strength. In contrast, FI+ sheep in the CLH group exhibited a non-significant negative change in fibre diameter followed by a large positive change in diameter of the same

magnitude as that exhibited by FI+ sheep in the CHL group. In this case FI+ sheep in the CLH group produced wool of lower staple strength than wool from FI+ sheep in the C or CHL groups. In this experiment large changes in diameter *per se* did not have a deleterious effect on staple strength. Hansford and Kennedy (1990) reported a negative correlation between staple strength and rate of change of fibre diameter; however none of their treatment groups were similar to the CHL group. It therefore appears that previous nutritional history is important in affecting staple strength changes resulting from diet changes. It is concluded that large diameter changes, while they may be associated with reductions in staple strength in some cases, are not necessarily a cause of reduced staple strength.

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REFERENCES

- ADAMS, N.R. (1994). *Proc. Aust. Soc. Anim. Prod.* 20: 46.
- BAKER, S.K., BARTON, J. and PURSER, D.B. (1993). In "Improving Sheep Management to Improve Wool Production and Marketability", (Ed R.J. Sluiter) pp.7-20 (W.A. Dept Agriculture: Perth).
- FRIEND, M.A. and ROBARDS, G.E. (1995). *Proc. N.Z. Soc. Anim. Prod.* 55: 28-30.
- HANSFORD, K.A. and KENNEDY, J.P. (1990). *Proc. 8th Int. Conf. Wool Textile Res.*, Christchurch 1: 590-8.
- HUNTER, L., LEEUWNER, W., SMUTS, S. and STRYDOM, M.A. (1983). SAWTRI Technical Report No. 514 (The South African Wool and Textile Research Institution: Port Elizabeth).
- SAS INSTITUTE INC. (1985). SAS Users Guide: Statistics. Version 5 Edition, p.433.