
VOLUME 62 2002

Responses to selection for wool staple strength in Romney sheep

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ABSTRACT

Wool staple strength was determined in 2120 Romney ewes from 12 sources and 242 Romney rams from 3 sources between 1986 and 1988. Positive, negative and random selection formed High Strength, Low Strength and Control lines, each with 80 ewes and 10 sires. Since 1989 ewe and ram replacements have been selected from within the lines and the number of breeding ewes per line increased to 100.

Staple strength was 25% greater in the High Strength line and 15% lower in the Low Strength line than in the Control line when fleeces of hoggets born in the selection lines from 1986 to 1989 were compared (P<0.01). Positively correlated with the staple strength response were responses in staple length, fibre diameter, clean fleece weight and fibre length after carding. The major effect to date of selection for increased staple strength has been to enhance wool growth, with the consequent increase in fibre diameter contributing to the improvement in staple strength. The increase in both the strength and length of staples will have contributed to the increase in fibre length after carding. These preliminary results demonstrate that direct selection for staple strength has been successful. The staple strength response and associated responses in wool production and wool characteristics were of benefit to both producers and processors.

Keywords Sheep production, genetic gain, single trait selection, wool strength, wool characteristics.

INTRODUCTION

The efficiency of wool processing and the quality of end products is reduced by fibre breakage. The entanglement of broken fibres in a growing fleece impedes drying of the fleece resulting in felting to form a cott that requires opening before processing. Moist fleece conditions also lead to discolouration of the fleece which limits end uses. Weak and tangled fibres are more likely to break during carding and short fibres tend to be lost during carding, combing and spinning so that wastage is higher. Yarns with short fibres are weaker and have more protruding fibre ends so they have restricted end uses. Weak or tender wools therefore attract lower prices.

Between 16 and 20% of fleece wool sold at auction in each of the 5 years prior to 1988/89 was assessed as tender by the New Zealand Wool Board (New Zealand Wool Board, 1989). The lower price paid for tender wool was calculated to reduce financial returns to producers by $100 million per year in 1989. This compares with an earlier estimate of $50 to 100 million by Ross (1982).These losses include discounts for associated faults, such as cotting and discolouration. While they overestimate the importance of tenderness *per se*, they indicate that directly and indirectly it causes substantial losses in revenue.

Fleece tenderness is caused by the synchronised thinning or, in extreme cases, shedding of fibres to create a weakness in the wool staple. In sheep breeds in which wool growth follows photoperiodic patterns, it occurs most commonly during winter when seasonal reductions in fibre growth are exacerbated by food restrictions and demand for nutrients from foetuses in pregnant ewes (see Bigham *et al.*, 1983 for a review). Bigham *et al.* (1983) proposed three options for overcoming fleece tenderness - improved feeding during winter, shearing close to the weak point and selection for improved wool strength. Orwin and Geenty set out to investigate the last option by establishing single trait selection lines (Orwin *et al.*, 1986). This paper reports performances during the first 4 years of selection, updating and expanding on the report of Rogers *et al.* (1990).

MATERIALS AND METHODS

Three lines of Romney sheep were established between 1986 and 1988 by screening 2120 ewes and 242 rams for wool staple strength. Positive, negative and random selection formed High Strength, Low Strength and Control lines respectively. Foundation stock of 80 ewes and 10 rams where chosen for each line. Ewes were obtained from 12 flocks at MAF Woodlands, Templeton, Rotomahana and Invermay Research Stations. The flocks had been established from a wide range of industry sources. Sires were selected from 242 rams in 3 of the same flocks. Equal numbers of animals from each source were selected for each selection line.

The selection lines were closed in 1989 at 100 ewes and 10 sire groups per line, with replacements selected on the same criteria as foundation stock. Ewe hoggets, ram hoggets and mature ewes were managed in separate mobs within which all 3 lines receive common treatment under commercial conditions.

Pedigree and production records have been maintained with emphasis on wool characteristics. Ewe and ram lambs have been shorn in January each year and greasy fleece weights recorded. Ewe and ram hoggets and breeding ewes have been shorn each November and greasy fleece weight (unskirted, belly excluded) recorded, and a midside fleece sample collected. Clean wool yield, average fibre diameter (airflow method), staple strength (Orwin *et al.*, 1988) and staple length were measured on each midside sample. Fibre length after carding (barbe; Orwin *et al.*, 1988) was measured on midside samples pooled within each sheep class (ram hogget, ewe hogget, breeding ewe) in each selection line. Wool bulk and colour were measured on core samples from bales of skirted fleece wool from each sheep class in each selection line.

Selection differentials were calculated as described by Baker *et al.* (1991) except that data from source flocks were used to calculate selection differentials for foundation animals. Where data were not available they were assigned a value of zero.

Results presented for ewes are from the mixed age breeding flock. In 1986 and 1987 it was composed of foundation ewes only with the addition in 1988 and 1989 of replacement ewes born in the selection lines. The data presented for ewes therefore largely reflect the performance of foundation ewes. Lamb and hogget results are from progeny born in the selection lines.

Means and standard deviations were calculated by analysis of variance of line means over the years 1986 to 1989 allowing for year effects.

RESULTS AND DISCUSSION

The mean mating weight of mixed age ewes was lowest for the Control line ($P<0.05$). This will have contributed to the lower ($P<0.05$) litter size which in turn will have contributed to the higher ($P<0.05$) mean birth weight recorded for the Control line relative to the other two lines (Table 1). These differences may have been influenced by variations in foundation ewes that were unrelated to the selection criteria and an imbalance in age structure between lines. Further data from progeny born in the selection lines are required to establish a causal relationship between selection for staple strength and body growth and reproduction.

TABLE 1 Mean values for live weight and reproduction parameters for 1986-1989.

	Selection line			
	Control	Low Strength	High Strength	L.S.D. (5%)
Liveweight (kg)				
Ewe[1] mating	53.2	54.8	54.9	1.2
Birth	4.32	4.20	4.16	0.13
Weaning	20.8	20.4	20.6	1.1
Reproduction				
Litter size[1]	1.54	1.63	1.67	0.10
Lamb survival (%)	76	81	79	5

[1] Ewes include foundation ewes and the first 2 crops of replacements bred in the selection lines

The High Strength selection line had the heaviest fleeces in ewes, lambs and hoggets, with Low Strength line fleeces lighter than or of similar weight to those of the Control line (Table 2). High Strength hoggets also had the highest, and Low Strength the lowest, fibre diameter, staple strength, staple length and barbe (selection line effects $P<0.05$; Table 2). It is noteworthy that differences occurred in both diameter and length components of fibre volume. The changes in fibre diameter will have contributed to the changes in staple strength (Orwin *et al.*, 1987) and differences in the length and strength of staples and fibre diameter will have influenced fibre length after carding (barbe) responses (Orwin *et al.*, 1988). Although the selection line effect on fibre length after carding was statistically significant ($P<0.05$) it was probably not of consequence to wool processors.

Clean wool yield, bulk and colour measurements were similar for all 3 selection lines.

Phenotypic trends in staple strength of hogget fleeces in Figure 1 illustrate the magnitude of environmental effects. There was a 3-fold variation in strength between years. Differences between ewes and rams within years reflect effects of separate management of the sex groups. In all years for both sex groups, the Low Strength line had lower strength and the High Strength line had greater strength than the Control line. Responses to selection were recorded in conditions that produced both high (60 N/ktex) and low (<30 N/ktex) staple strength in the Control line. The Low Strength line averaged 15% less, and the High Strength line 25% more than the Control line. This was equivalent to 0.41 and 0.78 of the Control standard deviation, respectively. Figure 2 shows that the staple strength response increased with selection pressure and supports earlier reports (Bigham *et al.*, 1983) that staple strength has moderate to high heritability relative to other quantitative productive traits.

TABLE 2 Mean values for wool production and wool characteristics for 1986-1989.

	Selection line			
	Control	Low Strength	High Strength	L.S.D. (5%)
Fleece weight (kg)				
Ewe[1], clean	2.64	2.65	2.79	0.11
Lamb, greasy	0.90	0.87	0.91	0.06
Hogget, clean	2.35	2.31	2.47	0.14
Hogget fleece characteristics				
Fibre diameter (μm)	33.4	32.4	34.3	0.8
Staple length (cm)	14.0	14.0	15.0	0.5
Staple strength (N/ktex)	36.7	31.1	45.8	6.6
Barbe (cm)	11.8	11.2	12.1	0.6
Yield (%)	72.8	72.3	73.5	1.5
Bulk (cm^3/g)	24.2	24.7	24.0	1.4
Brightness, CIE Y	63.3	63.3	62.8	0.5
Yellowness, CIE Y-Z	2.50	2.93	3.00	0.61

[1] Ewes include foundation ewes and the first 2 crops of replacements bred in the selection lines

FIGURE 1 Phenotypic trends in wool staple strength for ewe and ram hoggets in 3 lines; Control ■——■, Low Strength ▲- - -▲, High Strength ○- - -○.

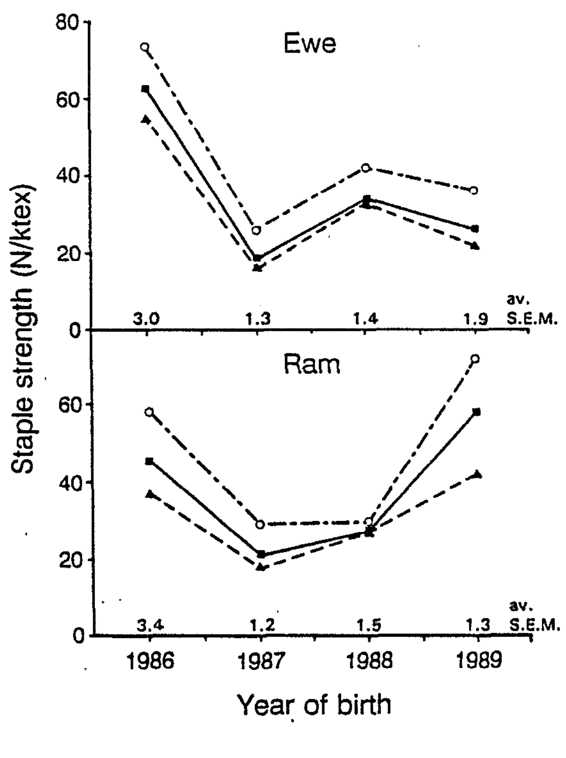
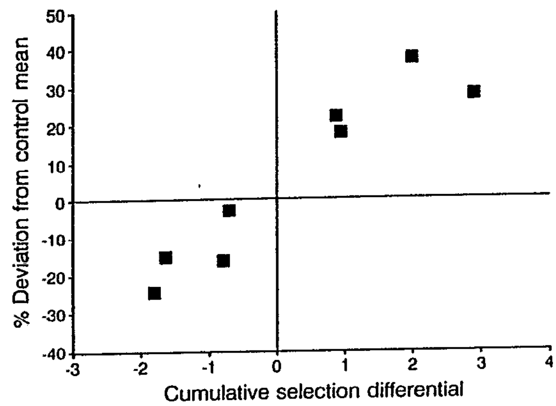
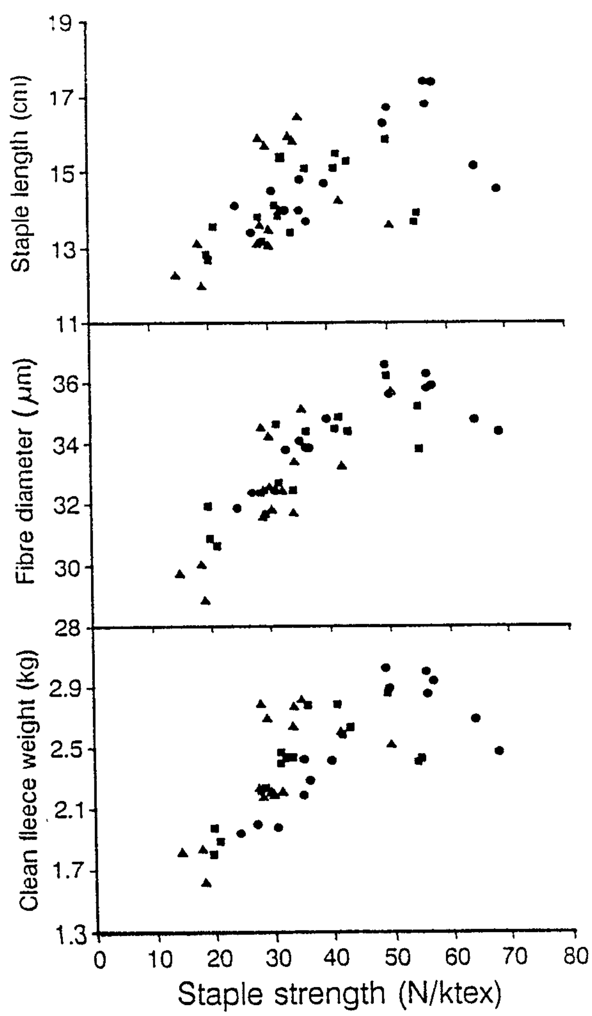


FIGURE 2 Relationship between responses to selection for and against wool staple strength and selection differential.



Positive correlations with hogget staple strength existed for fleece weight, fibre diameter and staple length (Figure 3). Similar correlated responses have been reported in Romney sheep selected for fleece weight (Hawker and Littlejohn, 1986; H.T. Blair, personal communication). These early results indicate positive economic implications of selection for increased staple strength. No major negative responses have been identified. The increases in staple strength and fleece weight are beneficial while that in fibre diameter should be seen as neutral (Maddever at al., 1991). Further information is needed to establish the relative merits of fleece weight and staple strength as selection criteria.

FIGURE 3 Phenotypic relationship of staple strength with staple length, fibre diameter and fleece weight at hogget shearing. Each point represents the mean for a sire group in Control (■), Low Strength (▲) and High Strength (●) lines.



It is concluded that the major effects of selection for staple strength apparent in the first 4 crops of progeny have been exerted through its influence on wool growth, with both fibre diameter and length growth components of fibre volume positively correlated to staple strength. The results demonstrate that direct selection for staple strength has been successful. The staple strength response and associated responses in wool production and wool characteristics were of benefit to producers and processors.

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