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## Effect of selection for greasy fleece weight on the components of fleece weight in New Zealand Romney sheep

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### ABSTRACT

Variation in the clean fleece weight (W) between ewe hoggets born in 1988 from the Massey University fleece weight selected (FW) and control (C) flocks was related to variation in four components: predicted skin surface area (S), mean number of fibres (follicles) per unit area of skin (N), mean fibre cross-sectional area (A) and mean staple length (L). Mean W ( $\pm$ se) was 3.34 and  $2.48 \pm 0.07$  kg for the FW and C lines, respectively. Of the components, L (147 and  $126 \pm 3.1$  mm;  $P < 0.001$ ), N (29.6 and  $27.0 \pm 0.83$  fibres/mm<sup>2</sup>;  $P < 0.05$ ) and A (1096 and  $1002 \pm 28.0$   $\mu$ m<sup>2</sup>;  $P < 0.05$ ) were significantly greater in the FW line (n=27) when compared to the C line (n=22).

The difference in W between the two lines was apportioned into contributions from the various components using the percentage deviation technique. The influence of combined components, wool weight per unit area (N x A x L), fibre volume (A x L) and total number of fibres (S x N) on W was also examined. The most important contributor to the difference in W between lines was L with A and N being less important; the contribution of S was relatively small. Wool weight per unit area had far more influence on between line differences in W than wool growing surface area (S) and fibre volume was more important than the total fibre number.

Attempts were also made to assess the relative importance of the components of fleece weight between sheep within each line. The standardized partial regression coefficients of log transformed values of each component on W were; for the selected line, L = 0.26, A = 0.36, N = 0.16, S = 0.38; for the control line, L = 0.08, A = 0.58, N = 0.45, S = 0.53. High values of S relative to the other components of W suggest that the size of animal is more important in determining the phenotypic differences in fleece weight within the line than the genetic differences between lines.

**Keywords:** fleece weight; follicles; staple length; Romney; selection; sheep.

### INTRODUCTION

Variation in the fleece weight of sheep can conceptually be considered as the effect of a number of components combined multiplicatively (Turner, 1958). The two major components are the wool production per unit area of skin and wool-growing surface area. Wool production per unit area of skin can in turn be described as a function of follicle or fibre density (N), mean fibre cross-sectional area (A) and mean staple length (L). The wool-growing surface area is determined by the skin surface area (S). Thus the clean fleece weight (W) can be considered as:

$$W = S \cdot N \cdot A \cdot L \cdot K,$$

where K is a constant which reflects the specific gravity of the wool (Q) and errors in estimates.

Studies on the relationship between clean fleece weight and its components have been reported for various strains of Merino sheep by many authors including Schinckel (1956, 1957), Turner (1956, 1958), Young and Chapman (1958), Dun (1958), Hancock (1976) and Mortimer and Atkins (1993). Components of wool weight per unit skin area have been calculated by Henderson and Hayman (1960) for New Zealand Romney lambs and by Doney (1963) for Scottish Blackface sheep.

The main aim of the present study was to establish which of the possible pathways of response were the most important in leading to the increase in fleece weight of sheep in the Massey

University fleece weight selection line (Blair *et al.*, 1984, 1985). Since there are no published reports of the relative importance of the various components to variation in fleece weight between sheep within a New Zealand Romney flock, attempts were also made to assess the importance of the components within the fleece weight selected line and the control line.

### MATERIALS AND METHODS

#### Animals

Fleece weight selected (FW) and control (C) lines of Romney sheep were established by random allocation from a common base population in 1956 and subsequently have been subjected to single-trait selection on hogget greasy fleece weight or have been randomly selected. Details of these two lines have been described by Blair *et al.*, (1984, 1985). The measurements used in this study were made only on ewe hoggets (27 for FW line and 22 for C line) born in August-September 1988.

#### Data

In October 1989, the hoggets were shorn. Individual greasy fleece weights, were recorded. A mid-side sample of wool was also collected for staple length, airflow fibre diameter and clean wool content measurements. A few days after shearing, two skin samples were removed from the right mid-

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side of each animal by means of a 1 cm diameter trephine. After shearing, hogget live weights were recorded.

Histological sections from the wax-embedded skin samples were used for assessing the follicle density. Primary (P) and secondary (S) follicle counts were made on ten 1 mm<sup>2</sup> fields per sample. These counts were then used to calculate the density of primary ( $n_p$ ) and secondary follicles per mm<sup>2</sup> ( $n_s$ ) using the correction factor of 0.75 to adjust for skin shrinkage in histological processing (Maddocks and Jackson, 1988). The number of fibres per unit area (N) was assumed equal to the total number of follicles per unit area.

The skin surface area (S) was derived from body weight (B) of animals using the equation of Lines and Peirce (1931):  $S = 0.0909 B^{0.67}$ .

Mean fibre cross-sectional area (A) was estimated from airflow estimates of mean fibre diameter (D):  $A = \pi D^2/4$ .

### Statistical methods

The percentage deviation technique described by Turner and Young (1969) was used for assessing the relative importance of the components to differences in fleece weight between the selected and control lines. The line means were estimated using General Linear Model Procedure (SAS, 1990). The least squares means of the control line were taken as the base. The corresponding mean values in the selected line were used to derive the percentage deviations from the base. The model used was as follows:

$$W_p = \sum C_{ip}$$

where  $W_p$  is a percentage change in clean fleece weight and  $\sum C_{ip}$  is the sum of the percentage changes in the corresponding components.

Many methods have been used for within-line analyses. None are completely satisfactory for the type of data normally available. The combination of inter-related components, multiplicative relationships and varying accuracy of the measurements used places great limitations on the reliability of results. For the results presented, the data were log-transformed so that relationships became additive rather than multiplicative (Henderson and Hayman 1960) and standard partial regression coefficients were generated to assess the relative influence of each component on W within each line. Simple correlations were generated among components. The results are presented in a path-analysis format.

## RESULTS AND DISCUSSION

### Components of variation in differences between lines

Table 1 presents the mean values for clean fleece weight (W) and its various components in each line. There were marked responses in W and L, with the FW line being significantly higher ( $P < 0.001$ ) than the C line. The components of N and A were also greater ( $P < 0.05$ ) in the FW line than the C line. The increase in N was due largely to more secondary follicles. This sample of the two lines was not significantly different in S although other studies, based on more animals, have found the FW hoggets to be slightly heavier than C hoggets (Blair 1986).

The differences in combined components between two lines were also examined (Table 1). Wool weight per unit area (N

**TABLE 1:** Mean values ( $\pm$  standard errors) of clean fleece weight and its components for ewes in fleece weight selected (FW) and control (C) lines.

Parameters	FW	C	Level of significance
W (kg)	3.34 $\pm$ 0.07	2.48 $\pm$ 0.08	***
S (m <sup>2</sup> )	0.99 $\pm$ 0.01	0.96 $\pm$ 0.02	NS
$n_p$ (primary follicles/mm <sup>2</sup> )	4.24 $\pm$ 0.12	4.15 $\pm$ 0.13	NS
$n_s$ (secondary follicles/mm <sup>2</sup> )	25.3 $\pm$ 0.69	22.8 $\pm$ 0.76	*
$n_s/n_p$ ratio	6.04 $\pm$ 0.02	5.49 $\pm$ 0.02	***
N (fibres/mm <sup>2</sup> )	29.6 $\pm$ 0.79	27.0 $\pm$ 0.87	*
A ( $\mu^2$ )	1096 $\pm$ 26.6	1002 $\pm$ 29.4	*
L (mm)	147 $\pm$ 3.32	126 $\pm$ 3.68	***
N x A x L x Q (mg)	6.64 $\pm$ 0.26	4.75 $\pm$ 0.28	***
A x L (mm <sup>3</sup> )	0.16 $\pm$ 0.01	0.13 $\pm$ 0.01	***
S x N (million)	29.4 $\pm$ 0.85	25.7 $\pm$ 0.94	**

N x A x L x Q = wool weight per unit area, where Q = specific gravity of wool (1.4) (Van Wyk and Nel, 1940);

A x L = the volume per fibre;

S x N = total number of fibres (or follicles).

NS = not significant; \*  $P < 0.05$ ; \*\*  $P < 0.01$ ; \*\*\*  $P < 0.001$ .

x A x L), fibre volume (A x L) and total number of fibres (S x N) were greater ( $P < 0.001$ ) in the FW line than the C line.

The relative contribution of the individual and combined components to response in fleece weight are shown in Table 2. The component which made the greatest contribution to the response in W was the staple length. The contributions of N and A were about equally important. The high positive genetic correlation (0.8) between greasy fleece weight and fibre diameter (Blair, 1981) leads to the expectation that the contribution of A would be larger but the negative genetic correlation of A with N (Davis and McGuirk, 1987) probably reduced its effect. Similarly, the response in N may have also been limited by this negative correlation with A. The contribution of S to between-line differences in W was relatively small.

**TABLE 2:** Percentage deviation of selection line from control line in clean fleece weight and its individual components.

Components	Percentage deviation	Percentage of W
W	34.7	100
S	3.1	8.9
N	9.6	27.7
A	9.4	27.1
L	16.4	47.2
Combined components		
N x A x L	39.8	
A x L	23.1	
S x N	14.4	

For explanation of symbols see footnote of Table 1.

Percentage deviation calculated from means of Table 1.

On the basis of the genetic parameters for Merino sheep, Davis and McGuirk (1987) predicted that selection for clean fleece weight would induce a response through changes in L, A and N and that there would be little change in S. The present data shows the same effect from selection of Romney hoggets on greasy fleece weight. The most comparable data from another

flock are those of Barlow (1974). The Merino flock he studied had been selected solely for clean fleece weight. The contributions of the components to the increase in W were very similar to those found in the present study. In the Romneys the response in L appears somewhat greater than those in N and A while L contributed less than N and A in the Merinos.

For the combined components, the majority of the response in W was achieved through increased wool weight per unit area. The fibre volume made a greater contribution than total fibre number. These results agree with those reported by Brown *et al.*, (1966) and Turner *et al.*, (1968), but in their Merino data, A appeared more important than L in contributing to fibre volume.

Despite the great differences in the mean value of N between Merino and Romney sheep the contribution of this component to the increase in W was fairly similar. This implies that the degree of genetic variation in N is similar for the two breeds even though the genetic level is very different. The increase in N was due to increase in the number of secondary follicles. Even though there is evidence of genetic variation in primary follicle numbers within Romney and Merino flocks (Meikle, 1987), change in this trait has not been a significant component of the response to selection for fleece weight.

### Components of the variation between sheep within lines

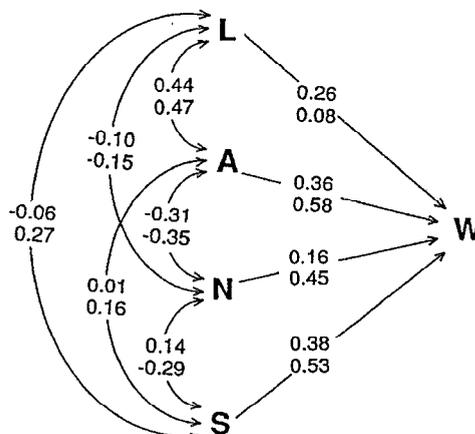
The contribution of components to differences in fleece weight between ewes within each line was assessed using multiple regression analysis on the log-transformed data. Figure 1 presents the simple correlations between components and the standardized partial regression coefficients in a path diagram form. The path coefficients indicate that the size of animal could be more important in determining the phenotypic differences in fleece weight within each line than the genetic differences between lines.

The correlation coefficients derived from FW line data did not differ significantly from those derived from C line. The correlation coefficients between N and W were not significantly different from zero in either line (i.e. they were lower than 0.37 and 0.41 for the FW and C lines, respectively). Using Merino data, Turner (1956) obtained a negative correlation between N and A of similar magnitude to those found within both the FW and C lines (just non-significant in the present data). The correlations between L and A were 0.44 and 0.47 ( $P < 0.05$ ) within selected and control lines, respectively. Turner (1958) found that there was no correlation between A and L in a medium-wool Merino flock, but there was a strong positive correlation in a strong-wool Merino flock.

### CONCLUSIONS

The results presented indicate that selection for high greasy fleece weight in this Romney flock increased all of the components of clean fleece weight. The gains in fleece weight are mainly contributed by L with A and N slightly less important. The contribution of S appeared relatively small. This suggest that, in Romneys, L could be a useful indirect selection criterion for increasing fleece weight.

**FIGURE 1.** Path diagrams of the interrelations of components and clean fleece weight (W); upper figure FW line; lower C; single-headed straight arrows represent the standardized partial regression coefficients; double-headed curved arrows represent the simple correlations between components; values lower than 0.37 (FW) and 0.41 (C) are non-significant.



Most estimates of the heritability of staple length from Romney data are relatively high (eg. 0.51, Newman, 1988). Together with high estimates for the genetic correlation with fleece weight (eg. 0.49-0.78, Newman, 1988), these also supports the usefulness of selecting for staple length as a method of increasing fleece weight. Fibre diameter (D) is likely to become coarser but the genetic correlation between L and D for Romneys tends to be lower than that for fleece weight and D. However, Bigham *et al.*, (1983) have reported a high negative genetic correlation (-0.67) between L and loose wool bulk and this could lead to an undesirable consequence.

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