RELATIONSHIP BETWEEN FELTABILITY AND OTHER GREASY WOOL TRAITS AND THE ASSOCIATION WITH THE PROCESSING CHARACTERISTICS OF FINE/SUPERFINE MERINO WOOL

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INTRODUCTION

The feltability of wool is a property that can influence processing efficiency and product quality. Felting is undesirable in knitted and woven products because it is associated with poor fibre alignment and shrinkage in the finished product. Shrinkage changes the appearance and physical properties of the fabric produced from fine/superfine wool. The woven or knitted structure becomes less visible, the fabrics thickens and becomes less elastic and less air permeable (Kenyon *et al.,* 1999).

The characteristics of wool cuticle scales can contribute to the propensity for wool to felt (Makinson, 1964). That study suggested that the geometrical attributes of each wool scale contribute to the degree of movement of the fibres in the tip-to-root compared to movement in the root-to-tip direction. To reduce the extent of fibre movement, and hence create a non-shrink product, wool can be chemically treated (Chen *et al.,* 2000), usually by chlorination. Although highly successful in shrink-proofing the fibre, this process is highly detrimental to the fibre. For example, shrink-proofing reduces the affinity of the fibre to take up dye. Also, shrink proofing results in environmentally damaging residues that create a further expense to the wool industry.

Felt ball diameter is related to the propensity for wool to felt (Kenyon *et al.,* 1999). Fine/superfine wools have a high propensity to felt (Greeff and Schlink, 2001), yet it is these wools which are used to produce worsted apparel garments where shrinkage is particularly undesirable. The selective breeding of sheep for a low propensity to felt has the potential to increase the processing efficiency and product quality of wool (Greeff and Schlink, 2001). In this paper, the sources of variation in the propensity for fine/superfine wool to felt are examined along with the relationships between felt ball diameter, greasy wool traits and those traits which are important in early stage processing.

MATERIALS AND METHODS

Sheep. A subset of the CSIRO Fine Wool Project Flock, born in 1994, were used in this trial. The design and management of this flock has been described by Swan *et al.* (2000). Mid-side samples were taken from 269 randomly selected, 33 month old ewes for fleece measurements.

Processing batches. Single-sire batches, representing 11 bloodlines, were formed at shearing. That is, each processing batch represented a single sire. There were 1-4 sires per bloodline and a total of 35 processing batches. The batches were processed in replicate (A and B) (Purvis and

Swan 1998) and processing characteristics measured included romaine (ROM), hauteur (HAUT) and coefficient of variation of hauteur (CVH).

Wool measurements. The wool traits measured included mean fibre diameter (MFD), coefficient of variation of fibre diameter (CVFD), fibre curvature (FC), standard deviation of curvature (SDFC), manually measured crimp frequency (CF), staple length (SL), staple strength (SS), percentage of mid staple breaks (MIDBRK) and clean scoured yield (CSY). Felt ball diameter (FBD) was determined on cleaned, carded wool by a modified Aachen felt test (Kenyon and Wickham, 1999). The diameter of the ball was determined using computer aided image analysis at nine different places with the values being averaged. A subjectively assessed crevice factor (CRF), scored on a scale of 1 (small crevice) to 6 (large crevice) was recorded on each ball. This assessment was based on the width and depth of a crevice rather than the extent of cracking across the ball.

Statistical analysis. The data were initially analysed by least-squares analysis of variance to determine the significance of fixed effects. These included bloodline, processing batch, processing batch replicate, day of felt ball measurement and day of formation of felt ball. Variance components were estimated from a sire model using ASREML (Gilmour *et al.,* 2001). Genetic and phenotypic correlations were estimated from a series of bivariate analyses using the appropriate fixed effect model for each trait. Heritability (h^2_S) was calculated as four times the ratio of the sire component of variation to the total variation. The traits analysed were FBD, CRF, MFD, CVFD, FC, SDFC, CF, SL, SS, MIDBRK and CSY.

Correlations between FBD and the top characteristics (ROM, HAUT and CVH) were determined from the estimated sire means for each trait.

RESULTS AND DISCUSSION

The means and phenotypic variances for wool traits and felting characteristics are shown in Table 1. The mean FBD of wool with a MFD of 17.8 μm was 21.4 mm. This is lower than the mean FBD of 25.3 mm for 21.1μm wool estimated on medium wool sheep by Greeff and Schlink (2001) and substantially lower than FBDs found in wools covering a wide range of micron categories (Elliot and Lohrey, 1983). In the current study a higher coefficient of variation of mean FBD (6.6%) was found in comparison to Greeff and Schlink (2001) (4.6%).

The mean of subjectively assessed CRF was 2.90 (Table 1). The assessment of CRF had a coefficient of variation of 33.43%

The significant fixed effects for FBD were bloodline, day of felt ball measurement and day of formation of felt ball. The proportion of variation due to sire was 0.18 for FBD and 0.19 for CRF (Table 1). In comparison, Kenyon *et al.* (1999) found no significant difference between two sire groups (P = 0.38) of progeny bred from Merino x Romney rams and straight-bred Romney ewes.

The proportion of variation contributed by bloodline to FBD and CRF is 0.14 and 0.37 respectively.

Table 1. Means, phenotypic variances (V_P), the proportion of total variation due to bloodline (V_L/V_T) and the proportion of genetic variation due to sire (h^2_S) (± standard errors) for wool traits, including felt ball characteristics

Trait	Mean	V_P	V_L/V_T	h^2_S
FBD (mm)	21.4	1.1	0.14	0.18(0.12)
CRF (score 1-6)	2.9	0.9	0.37	0.19(0.19)
MFD (µm)	17.8	1.3	0.35	0.52(0.16)
CV FD (%)	16.9	4.2	0.19	0.37(0.20)
FC (°/mm)	137.9	406.8	0.57	0.56(0.18)
SDFC	102.4	65.7	0.51	0.47(0.11)
CF (crimps/cm)	7.1	2.5	0.76	0.12(0.13)
SL (mm)	78.4	102.8	0.49	0.22(0.23)
SS (N/ktex)	41.3	105.9	0.11	0.71(0.17)
MIDBRK (%)	89.8	248.4	0.01	0.41(0.17)
CSY (%)	76.9	22.1	0.13	0.41(0.13)

Table 2 shows that CRF is strongly correlated with FBD. This indicates that large crevices are more prevalent in large felt balls. The phenotypic correlations between MFD, CVFD, FC, SDFC, CF and MIDBRK with FBD are all negligible to low. The trend of the phenotypic correlations established in this study were similar to those found by Greeff and Schlink (2001). A low phenotypic correlation was found between FBD and CF (0.14). By contrast, Elliot and Lohrey (1983) state that variation in feltability is *highly* dependent on crimp, with the more highly-crimped wools having a lower propensity to felt than wools with lower crimp frequency.

Table 2. Phenotypic and genetic correlations (± standard errors) between FBD and other wool traits

Trait	r_P ± s.e	r_g ± s.e
CRF (score 1-6)	0.57(0.03)	0.98(0.18)
MFD (µm)	0.18(0.05)	0.43(0.34)
CVFD (%)	0.00(0.05)	0.25(0.39)
FC (°/mm)	0.16(0.05)	0.53(0.57)
SDFC	0.15(0.05)	0.57(0.32)
CF (crimps/cm)	0.14(0.04)	0.32(0.52)
SL (mm)	-0.07(0.05)	-0.09(0.45)
SS (N/ktex)	-0.01(0.05)	0.10(0.36)
MIDBRK (%)	0.08(0.05)	0.34(0.33)
CSY (%)	-0.21(0.05)	-0.80(0.22)

There was a moderate negative genetic correlation between FBD and CSY. Zahn and Blackenburg (1962) suggested that the wax content of the fibre might be lower thus allowing weathering and deformation of the scale structure at the fibre ends. This results in decreased felting.

Correlations between FBD and processing traits are outlined in Table 3. A moderate, positive association was found between HAUT and FBD. This is consistent with a hypothesis that a lower propensity to felt will be associated with longer tops. The positive association between ROM, CVH and FBD is unexpected and requires further investigation. The explanation may lie in the partial-correlations between FBD and other raw wool traits such as CF, FC, SL and MFD.

Table 3. Correlations between felt ball diameter and processing traits

Trait	r
ROM (%)	0.25
HAUT (mm)	0.20
CVH (%)	0.15

CONCLUSION

The relationships between feltability in fine/superfine wool sheep and greasy wool traits (MFD, CVFD, FC, SDFC, CF, MIDBRK and CSY) were relatively weak. The correlations between FBD and characteristics important to processing (ROM, HAUT and CVH) were also small. There are suggestions in these findings that breeding programs focused on reducing MFD, may show correlated increases in propensity to felt. However, it must be clearly stated, that the proportion of variation in a trait due to bloodline and sire quoted in this paper, is based on a small sample of sheep. Research is continuing with measurement of more animals as well as comparing the performance of superfine wool with other natural fibres.

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