# GENETIC VARIATION OF MERINO WOOL FELTING

**J.C. Greeff[1] and A.C. Schlink[2]**

[1] Great Southern Agricultural Research Institute, 10 Dore Street, Katanning 6317, Australia
[2] CSIRO Livestock Industries, Private Bag 5, Wembley, WA 6913, Australia

## INTRODUCTION

Felting of wool is a major problem in the manufacture of knitted and woven products, as it is related to yarn shrinkage, which is a critical problem of the finished product. Felting is a unique property of animal fibres and a desirable characteristic in the making of felted products. However, felting is a particular problem with fine wools. Non-shrink woollen products are currently produced using chemical treatments during processing. Chlorination is the first step and it degrades the fibre surface. Fibres are then coated with polymers to cover degraded scale structures and/or to bond fibres together to prevent felt shrinkage. This process minimises frictional effects on wool fibre surfaces, limits relative motion of fibres in all directions, and increases hydrophilic properties of the fibre surface (Chen *et al.,* 2000). Although these processes have been highly successful in shrink-proofing wool, they are expensive and detrimental to the fibre. Furthermore, the chlorination process is environmentally unfriendly and there are difficulties with residue disposal.

Greeff and Schlink (2001) have shown that felting is a heritable trait, which implies that altering the ability of wool to felt through breeding may make a considerable contribution to wool's processing properties and will enhance wool's clean and green image. However, felting is strongly influenced by fibre curvature, fibre diameter (Scheepers and Slinger, 1968 ; Hunter *et al*., 1982 ; Kenyon *et al.,* 1999 ; Veldsman and Kritzinger, 1960) and clean yield (Schlink *et al*., 2000). Lipson and Rothery (1975) showed that Merino wool has a significantly higher felting ability than Polwarth wool in spite of the fact that there were no differences in fibre surface friction, scale frequency or elastic properties between the breeds. They did note significant differences between the breeds in "swellings and necks" at intervals along the fibres, but conclusions were not clear because these wools differed in micron and curvature was not recorded. The OFDA2000 (Brims, 1997) has algorithms to measure variability and unevenness traits along the fibre which may be used to identify samples that may cause spinning problems. The objective of this study was to identify whether these along fibre variability traits influence felting and whether they are heritable.

## MATERIAL AND METHODS

**Data.** The data were from a resource flock held at Katanning in Western Australia (Lewer *et al*., 1992). Greasy fleece weight (GFW) were collected on 2013 hogget animals born in 1999 and 2000 at shearing and that were the progeny of 80 sires. Midside wool samples were collected and processed according to Greeff and Schlink (2001) for average fibre diameter (AFD), standard deviation of fibre diameter (SDFD), coefficient of variation of fibre diameter (CV), curvature (Curv) and standard deviation of curvature (SDCurv) using an OFDA100 and staple strength (SS) and staple length (SL) using ATLAS.

Samples of scoured, hand-carded wool were measured for feltball density (Kenyon and Wickham, 1999) and along fibre variation using OFDA2000. The along fibre parameters measured on 0.2 mm sections of fibres at 2 µm intervals were used to determined mean along FD (MeanDA), standard deviation of MeanDA (SDMeanDA), minimum fibre (MinDA), standard deviation of MinFD (SDMinDA), standard deviation of fibre diameter along the 0.2mm segments of fibre (SDDA), and proportion of protrusions along the fibre (Blob) (Brims, 1997).

Full pedigree records were available for all animals as well as birth date, sex (male or female), birth type (single or multiple) and age of dam (2 to 6 years).

**Model of analysis.** Statistical analyses were carried out with ASREML (Gilmour, 1999) using an animal model. All models included flock, year of birth, birth type, sex and age of dam as fixed effects and day of lambing as a linear covariate. A stepwise regression procedure was carried out to determine which of the fibre traits had a significant relationship with felt density.

## RESULTS AND DISCUSSION

The number of records, means and standard deviations of the different traits, linear regression coefficients and their F-values are shown in Table 1.

**Table 1. Number of records, sires, means, standard deviations, linear regression coefficients and F-values of regression coefficients of the wool and fibre traits**

| Trait | Number of progeny with records | Number of sires | Mean | SD | Regression coefficients (± se) | F-value |
|---|---|---|---|---|---|---|
| Felt density ($g/cm^3$) | 2009 | 80 | 0.135 | 0.008 | | |
| AFD (µm) | 2013 | 80 | 19.48 | 1.61 | -0.07 ± 0.02 | 178.3 |
| SDFD (µm) | 2013 | 80 | 4.37 | 0.66 | --- | NS[a] |
| SL(mm) | 2007 | 80 | 105.00 | 9.80 | --- | NS |
| Yld (%) | 2013 | 80 | 70.40 | 4.70 | 0.01 ± 0.003 | 14.6 |
| CFW (kg) | 2008 | 80 | 3.16 | 0.50 | --- | NS |
| SS (N/ktex) | 2007 | 80 | 32.40 | 9.11 | --- | NS |
| CV (%) | 2013 | 80 | 22.50 | 3.16 | --- | NS |
| Curv (deg/mm) | 2013 | 80 | 88.12 | 10.50 | -0.04 ± 0.003 | 800.8 |
| SDCurv (deg/mm) | 2013 | 80 | 66.90 | 6.49 | 0.02 ± 0.004 | 75.2 |
| MeanDA (µm) | 2013 | 80 | 19.23 | 1.55 | -1.20 ± 0.65 | 73.5 |
| SDMeanDA (µm) | 2013 | 80 | 4.18 | 0.75 | -0.80 ± 0.35 | 15.0 |
| MinDA (µm) | 2013 | 80 | 18.10 | 1.46 | 1.07 ± 0.66 | 18.1 |
| SDMinDA (µm) | 2013 | 80 | 3.89 | 0.72 | 0.93 ± 0.36 | 6.1 |
| SDDA (µm) | 2013 | 80 | 0.87 | 0.09 | 0.15 ± 0.81 | 131.2 |
| Blob (%) | 2013 | 80 | 1.08 | 0.14 | -2.07 ± 0.17 | 216.0 |

[a] NS = non significant (P>0.05)

The data shows that felt density is a complex trait and that it is significantly ($P<0.001$) influenced by Curv, SDCurv, Yld, AFD, MeanDA, MinDA, SDMeanDA, SDMinDA, SDDA and Blob. This confirms previously published relationships between felting and AFD, Curv and Yld (Veldsman and Kritzinger, 1960 ; Kenyon *et al*., 1999 ; Schlink *et al*., 2000).

No previously published values are available of the relationship of felt density with proportion of blobs and SDDA. Both SDDA and blob percentage were highly significantly ($P<0.001$) related to felt density. A high SDDA, which implies higher variation along the fibre segment, indicates higher felt density whereas high blob values indicates lower felt density.

A high heritability of 0.62 was estimated for felt density of wool. However, as it is strongly affected by the other fibre traits, which are also highly heritable, adjustment of the heritability of felt density for those significant traits in Table 1 resulted in a moderate heritability estimate of 0.38. This indicates that felt density has a heritable component that is independent of the other wool and fibre traits and should respond to selection.

**Table 2. Heritability of felt density and wool traits and the genetic and phenotypic correlations between felt density and the wool and fibre traits**

| Trait | Heritability ± se | $r_p$ | $r_g$ ± se |
|---|---|---|---|
| Felt density ($g/cm^3$) | 0.62 ± 0.07[a] | --- | --- |
| Felt density ($g/cm^3$) | 0.38 ± 0.07[b] | --- | --- |
| AFD (µm) | 0.66 ± 0.08 | 0.25 | 0.36 ± 0.08 |
| SDFD (µm) | 0.57 ± 0.07 | 0.04 | -0.00 ± 0.09 |
| SL(mm) | 0.59 ± 0.08 | 0.00 | 0.05 ± 0.10 |
| Yield (%) | 0.54 ± 0.07 | -0.26 | -0.34 ± 0.09 |
| CFW (kg) | 0.40 ± 0.07 | -0.12 | -0.11 ± 0.11 |
| SS (N/ktex) | 0.32 ± 0.07 | 0.12 | 0.32 ± 0.11 |
| CV (%) | 0.61 ± 0.07 | -0.08 | -0.22 ± 0.03 |
| Curv (deg/mm) | 0.57 ± 0.07 | 0.44 | 0.67 ± 0.06 |
| SDCurv (deg/mm) | 0.35 ± 0.07 | 0.30 | 0.62 ± 0.08 |
| MeanDA | 0.74 ± 0.07 | 0.26 | 0.27 ± 0.08 |
| SdMeanDA | 0.61 ± 0.07 | -0.00 | -0.08 ± 0.09 |
| MinDA | 0.74 ± 0.07 | 0.23 | 0.25± 0.08 |
| SdMinDA | 0.60 ± 0.07 | -0.02 | -0.11 ± 0.10 |
| SDDA | 0.49 ± 0.07 | 0.48 | 0.53 ± 0.08 |
| Blob (%) | 0.12 ± 0.05 | 0.31 | 0.15 ± 0.15 |

[a] Unadjusted for significant fibre traits (see Table 1)
[b] Adjusted for significant fibre traits (see Table 1)

The heritability estimates of the normal wool traits (CFW, AFD, SS, CV, Yld, Curv and SDCurv) are all within expectation. MeanDA and MinDA and their respective standard deviations were higher than AFD and SDFD. The phenotypic and genetic correlations of felt density with AFD, Yld, Curv and SDCurv confirms our previously published estimates (Greeff and Schlink, 2001), while the genetic and phenotypic correlations of felt density with MeanDA and MinDA is slightly less (0.27 and 0.25 respectively) than with AFD.

Blob percentage was lowly heritable (0.12) and was phenotypically moderately correlated to felt density but was not strongly correlated genetically with felt density. SDDA had a moderately high heritability (0.49) and it was also phenotypically and genetically moderately strongly correlated with felt density. However, both SDDA and blob percentage had a relatively low coefficient of variation (10 and 13 per cent respectively).

## CONCLUSION

The results show that felt density is a complex trait that is strongly correlated to fibre curvature, average fibre diameter, blob percentage and variation of fibre diameter along the fibre. The results have confirmed that felting, independent of the other wool traits, has a heritable component trait that implies selection for reduced wool felting should be possible. More work needs to be carried out to establish lines of wool with predictable felting properties. Once high and low felting wools can be confidently identified, then the role of these wool characteristics in wool processing and fabric outcomes needs to be evaluated.

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