GENOTYPE AND ENVIRONMENTAL DIFFERENCES IN FIBRE DIAMETER PROFILE CHARACTERISTICS AND THEIR RELATIONSHIP WITH STAPLE STRENGTH IN MERINO SHEEP

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SUMMARY
Fibre diameter profiles (FDPs) are a reflection of the way in which animals respond to their environment. These response patterns vary between sheep but it is not known to what extent these differences are genetically controlled. FDPs were generated from 40 Merino sheep consisting of two bloodlines (fine and medium) maintained in a Tablelands and a Mediterranean environment. The animals were progeny of two sires within each bloodline. The FDPs for each of these sheep were described using a number of characteristics. Environment, bloodline and sire group significantly influenced many of the FDP characteristics. These results suggest that there may be genetic differences in FDP characteristics at both the individual sheep and bloodline levels. Most of the FDP characteristics were correlated with staple strength (SS). Genetic differences in SS may be, at least in part, due to differences in environmental responsiveness and patterns of fibre diameter change.
Keywords: Fibre diameter profiles, staple strength, genotype, environment.

INTRODUCTION
Changes in nutrient supply and demand throughout the wool growth period create variation in fibre diameter along wool fibres. The way in which the fibre diameter of the wool changes over the year of wool growth, hereafter termed a fibre diameter profile (FDP), influences wool quality. The characteristics of this FDP have been shown to influence staple strength (SS) (Hansford and Kennedy 1988; Denney 1990; Peterson 1997) and the fibre length distribution of wool top (Hansford 1994; Hansford 1997). Previous research has demonstrated that the coefficient of variation in fibre diameter is negatively genetically related to SS (–0.46 to –0.86) (Greeff *et al.* 1995).

The way in which sheep interact with their environment varies between individual animals within and between mobs. FDPs can be used to examine these differences between sheep (Hansford 1994). Differences in the level of along staple variation in fibre diameter have been observed between individual sheep and sire groups (Denney 1990), selection lines (Jackson and Downes 1979) and bloodlines (Hansford 1994). The variation of fibre diameter along FDPs has been used as an indicator of their sensitivity to environmental change. This suggests that some sheep may be genetically predisposed to produce a certain type of FDP. For example, some sheep are more sensitive to the environment and will therefore have greater variation in fibre diameter along their staples. However, as yet no genetic parameters have been estimated for the FDP characteristics.

This study aims to examine the influence on FDP characteristics of environment and the relative performance of bloodlines and sires linked across environments. The influence of these differences on the relationship between the FDP characteristics and SS will also be examined.

MATERIALS AND METHODS

Wool samples. Wool staples were obtained from 40 Merino hogget ewes from the CSIRO Fine Wool Project (Purvis 1997). Twenty of these sheep were maintained in a Tablelands environment (mid-side samples collected from the Chiswick Research Station, Armidale, NSW) and 20 were maintained in a Mediterranean environment (CSIRO Yalanbee Field Station, Bakers Hill, WA). In both environments, there were two bloodlines of sheep (fine and medium) with the animals in each bloodline having one of two sires. For each bloodline the same sires were used in both environments. The animals were born in different years but were sampled at a similar age of 2 years.

Fibre diameter profiling. The greasy staples were washed, dried, wrapped in polyethylene cling wrap and segmented to yield a series of 2mm snippets for the entire length of the staple (Hansford *et al*. 1985). The mean fibre diameter and fibre diameter variation within each of these snippets was then measured using 500 counts by a Sirolan Laserscan. The fibre diameter measurements were plotted against their relative position in millimetres along the staple to generate the FDP.

The FDP for each sheep was described using a number of characteristics, which were selected to accommodate the shape of the profile. The FDPs grown in the Tableland environment were a generalised “M shaped” and the Mediterranean FDPs were “V shaped”. Three major points were identified in each of the profiles at which fibre diameter was recorded. These points were at the position of the minimum fibre diameter (Mindiam) in approximately the middle of the profile, the maximum fibre diameter (Maxdiam1) between the Mindiam and the tip of the profile and the maximum fibre diameter (Maxdiam2) between the Mindiam and the base of the profile. Using these three points, two rates of fibre diameter change were calculated. The first rate of change was calculated between the Maxdiam1 and the Mindiam (Roc1) and the second rate of change was calculated between the Mindiam and the Maxdiam2 (Roc2). These rates of change were calculated by fitting a linear regression to all points between the respective Max and Min. The along staple variation in fibre diameter (AstVAR), mean fibre diameter (Profmean) and the coefficient of variation of fibre diameter along the FDP (AstCV) were also calculated for each FDP.

Objective measurements of mean fibre diameter (MFD), coefficient of variation of diameter (CVMFD), SS and staple length (SL) were measured in mid-side samples by the Australian Wool Testing Authority.

Statistical analysis. Environment, bloodline, sire and their interactions were all fitted and analysed using least squares analysis of variance and the General Linear Model procedure in SAS (1990). The sire effect was fitted as a random effect and was nested within bloodline. Residual partial correlation coefficients were calculated between SS and all other characteristics. Step-wise multiple regression was used to estimate the amount of the variation in SS that was explained by the other characteristics. This regression analysis ignored differences between bloodlines and sires.

RESULTS AND DISCUSSION

The means for each characteristic are presented in Table 1. Mindiam, MFD and SS were significantly lower and the Roc1 and CVMFD were significantly higher in the Mediterranean environment ($P < 0.05$). AstVAR and AstCV were also higher and the Profmean lower in the Mediterranean environment ($P < 0.10$). Profmean, Mindiam, Maxdiam1, Maxdiam2, MFD and CVMFD were significantly different between bloodlines. For many of these characteristics there was a significant interaction between bloodline and environment. This indicates that the environment has a significant influence on the differences observed between genotypes.

Table 1. The mean levels and variation within each FDP and objectively measured wool quality characteristic for the Fine and Medium bloodlines within each environment

FDP	Tableland				Mediterranean			
Characteristics	Fine		Medium		Fine		Medium	
	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%
AstVAR (μm)	1.627	46.8	1.203	35.7	2.086	37.3	4.289	35.6
Profmean (μm)	18.40	7.0	20.29	5.2	16.47 [a]	5.3	19.58 [b]	8.3
AstCV (%)	6.8	26.8	5.3	16.1	8.6	19.2	10.4	16.3
Mindiam (μm)	16.77	9.5	18.94	5.1	14.27 [a]	4.8	16.58 [b]	8.5
Maxdiam1 (μm)	20.19	6.9	21.67	6.0	18.92 [a]	8.2	22.42 [b]	8.2
Maxdiam2 (μm)	19.90	7.6	21.81	5.5	18.35 [a]	7.1	22.67 [b]	8.5
Roc1 (μm/mm)	0.135	41.7	0.104	57.3	0.143	44.8	0.153	23.8
Roc2 (μm/mm)	0.186 [a]	37.9	0.125 [b]	41.9	0.089	27.4	0.111	32.8
MFD (μm)	18.55	5.5	20.72	5.5	16.82 [a]	4.1	19.06 [b]	7.6
CVMFD (%)	16.18	11.6	16.63	11.6	17.68 [a]	6.3	22.87 [b]	8.1
SS (N/ktex)	43.8	28.5	52.5	28.5	36.7	30.6	35.0	28.4
SL (mm)	86.4	8.8	100.5	8.8	77.7	15.5	94.9	8.9

Means within each environment for each FDP characteristic with different superscripts are significantly different ($P<0.05$)

Analysis over both environments indicated that Roc1 and SS were significantly different between sire groups. However, there were also significant interactions between sire groups and environment for AstVAR, AstCV and SL indicating that the differences between sires were also dependent on the environment. Examining the differences within each environment indicated that within the Tablelands environment sire significantly ($P < 0.05$) influenced AstVAR, Maxdiam1, MFD and CVMFD. In this environment the characteristics of Profmean, AstCV and SS were also close to being significantly different between sires at $P < 0.15$. In the Mediterranean environment AstVAR, AstCV, SS and SL were significantly ($P < 0.05$) different between sires within each bloodline.

Of the FDP characteristics, Profmean, Mindiam, Maxdiam1, Maxdiam2 and MFD were all positively correlated with SS (Table 2). AstCV, Roc1, Roc2 and CVMFD were all negatively correlated with SS. The correlations were generally higher in the Tablelands environment. This suggests that these characteristics are more closely related to SS in this environment.

Table 2. The residual correlations between SS and the FDP and wool quality characteristics

	Tablelands	Mediterranean		Tablelands	Mediterranean
AstVAR	-0.02	-0.09	Roc1	-0.63	-0.21
AstCV	-0.33	-0.34	Roc2	-0.30	-0.26
Profmean	0.76	0.40	MFD	0.67	0.40
Mindiam	0.82	0.54	CVMFD	-0.44	-0.56
Maxdiam1	0.62	0.17	SL	0.58	-0.39
Maxdiam2	0.78	0.39			

Using step-wise multiple regression, 85% of the variation in SS in the Tablelands environment was explained by Mindiam (59%), CVMFD (22%) and Roc2 (4%). In the Mediterranean environment SL (24%) and MFD (30%) explained 54% of the variation in SS. The other characteristics did not significantly improve the prediction of SS. This indicates that the FDP characteristics of Mindiam and Roc2 improved the prediction of SS in the Tablelands environment above that explained by mean fibre diameter and fibre diameter variation which are more easily measured wool quality characteristics. Although the FDP characteristics were correlated to SS in the Mediterranean environment they did not explain any more of the variation in SS than explained by MFD and SL.

The differences between bloodlines, sires and the variation between sheep all suggest that there may be genetic differences between sheep in the FDP characteristics and therefore sensitive to environmental change. This study has shown that these two genotypes of sheep react differently in each environment. The application of selection programs requires detailed genetic studies to evaluate the genetic characteristics of FDPs and suitable methods for measurement. These results have indicated that a larger study examining genetic aspects of FDP characteristics would be worthwhile.

ACKNOWLEDGEMENTS
The authors wish to thank the CSIRO Division of Animal Production at Armidale and Wool CRC for gratefully making the wool samples, equipment and technical advice available for this research.

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