Variation in fibre diameter profile characteristics between wool staples in Merino sheep

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Summary

Two experiments were conducted to examine the variation in fibre diameter profile (FDP) characteristics between staples. The mean values of all the FDP characteristics were not significantly ($P > 0.05$) different between staples prepared using the same and different staple preparation techniques. The residual correlation coefficient's between staples prepared using the same staple preparation technique for all FDP characteristics ranged from $r = 0.60$ to 0.96. The correlation coefficients between staples prepared using different staple preparation techniques ranged from $r = 0.37$ to 0.97. These results indicate that it may not be sufficient to segment a single staple for estimation of certain FDP characteristics to examine differences between individual animals. One staple is sufficient to estimate the average FDP of a group of animals. FDPs generated using different staple preparation techniques can be accurately compared for most FDP characteristics.

Introduction

Fibre diameter profiles (FDPs) are generated to examine the way in which fibre diameter changes throughout the wool growth period. FDPs are measured by segmenting an entire staple into a series of consecutive 2mm snippets. The fibre diameter is then measured in each of these snippets, producing a pattern of fibre diameter change along that staple. The characteristics of this FDP are associated with staple strength and explain (10 to 20%) greater variation in staple strength than the more easily measured mid-side characteristics of mean fibre diameter, coefficient of variation of fibre diameter and staple length (Brown *et al.* 1999; Brown 2000).

Most wool traits exhibit systematic trends over the body of sheep (Cottle 1991) and these trends have an influence on wool sampling techniques. It is generally agreed that the mid-side region is a good representation of the average over the fleece.

A number of studies have examined the level of variation in fibre diameter over sheep. Quinnell *et al.* (1973) observed that only 4% of the variation in fibre diameter within a mob was due to variation between staples within sites. Peterson (1997) also observed that variation between staples was small (0.88μm) compared to the variation in fibre diameter between fibres (7.93μm).

Denney (1990) observed that the variation in fibre diameter along the staple, measured as along-staple variance in fibre diameter, from the mid-side sample is representative of the variation in the whole fleece (9 sites covering should, mid-side and rump). Furthermore, Denney (1990) and Jackson and Downes (1979) found that their FDP measurement technique for measuring along-staple variance in fibre diameter was highly repeatable between duplicate (adjacent) staples sampled from the right mid-side of the same animal. However, the technique used in both these studies only segmented the staple into 10 segments to generate the FDP. There have been no studies investigating the variation in a range of FDP characteristics from a full FDP measured from staples randomly selected within a mid-side region.

Hansford (1992) found similar patterns of fibre diameter change throughout the year (FDPs) from eight sites covering the shoulder, mid-side, breech and withers of the sheep. However there were no statistical comparisons of FDP characteristics from these sites.

This study aims to examine the repeatability of FDP characteristics between two staples randomly selected from a mid-side sample. The influence of two staple preparation techniques on the FDP characteristics will also be evaluated.

Materials and Methods

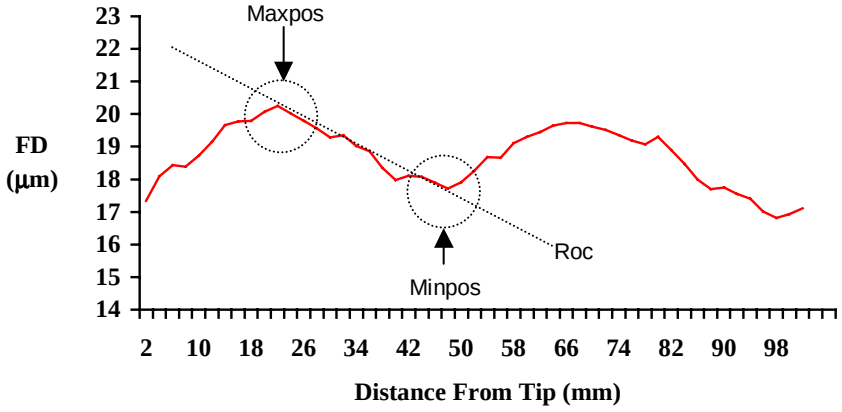
Experiment 1

Mid-side samples were collected from 31 fine wool Merino ewes. These 2 year old sheep were maintained at CSIRO "Chiswick" research station (Armidale NSW) and were representative of 9 bloodlines (2 to 4 sheep per bloodline) from the Fine Wool Project (Purvis 1997).

Two greasy staples randomly selected from each mid-side sample were wrapped in cling wrap and segmented using the CSIRO Wool Staple Segmenter, to yield a series of 2mm snippets along the entire length of the staple. Each snippet was washed by two rinses in Perchloroethylene (distributed by ICI chemicals), dried by the Sirolan air blast and the mean fibre diameter measured using the Sirolan Laserscan (Charlton 1995) utilising 500 counts per snippet. The fibre diameter measurements were plotted against their relative position in millimeters along the staple to generate the full FDP.

The FDP characteristics calculated were the minimum (Min), maximum (Max), range between the maximum and minimum (Diff), variance along the staple (AstVAR), mean (Profmean) and coefficient of variation (AstCV) of fibre diameter along each FDP. The position of the minimum (Minpos) and the maximum (Maxpos) fibre diameter points, in millimeters and the rate of fibre diameter change (Roc) between these points (calculated by fitting a linear regression) were also calculated for each FDP (Figure 1).

Figure 1 An illustration of the positions of maximum and minimum fibre diameter and the rate of fibre diameter change in an example FDP



Least squares multivariate analysis of variance of the FDP characteristics was conducted using the General Linear Model procedure in SAS (1990). Bloodline and sheep within bloodline were fitted as fixed and random effects respectively. Residual partial correlation coefficients were calculated to compare the FDP characteristics from each staple.

Experiment 2

Mid-side samples were obtained from 10 Merino ewe hoggets derived from the same flock as the ewes in experiment 1. These 10 sheep were all from the same bloodline. Two greasy staples were randomly selected from each mid-side sample. The first staple was used to generate a FDP as described in experiment 1, this being referred to as technique 1. The second staple was prepared according to technique 2. For this, the greasy staple was held at both ends with surgical clamps and washed twice for 5 minutes in hexane with gentle agitation aiming to maintain staple integrity. The staple was left overnight to dry, wrapped in cling wrap and segmented to yield a series of 2mm snippets for the entire length of the staple. The FDP was constructed as per technique 1.

The FDPs for each sheep were described using the same characteristics described for experiment 1. The FDPs were a generalised "M shape" and a number of possible rates of fibre diameter change were apparent. Based on the average of all animals within the group the rate of change between the minimum fibre diameter in the middle of the FDP and the maximum fibre diameter towards the base was the most important. As a result this is the rate of fibre diameter change that is reported.

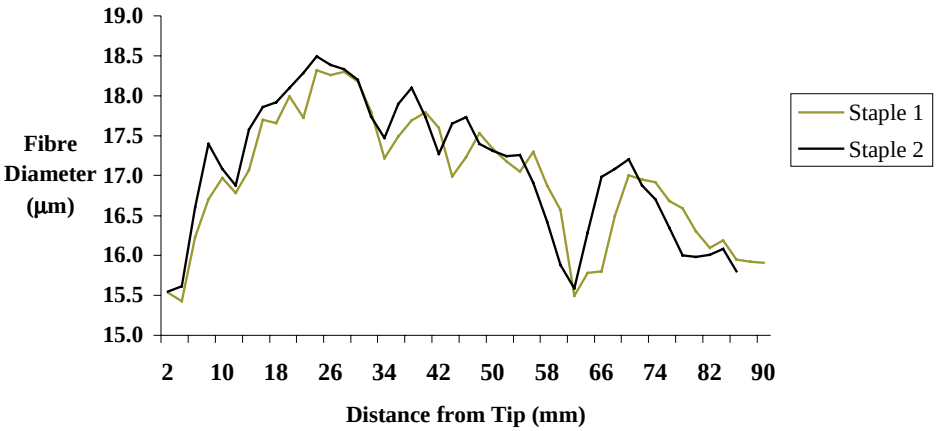
Least squares analysis of variance of the FDP characteristics was conducted using the General Linear Model procedure in SAS (1990). Sire and management groups were fitted as random effects. Residual partial correlation coefficients were estimated between the FDP characteristics calculated from the FDPs generated using the two staple preparation techniques.

Results

Experiment 1

The actual fibre diameter values which make up the FDPs were not significantly different ($P<0.01$) and highly correlated ($r = 0.88$, $P < 0.01$) between staples. Figure 2 further illustrates how closely the FDPs are related within a mid-side sample.

Figure 2 An example of the close relationship between the FDPs measured from two staples randomly selected from a mid-side sample



The mean values for all FDP characteristics were not significantly different ($P > 0.05$) between staples (Table 1). Correlations in excess of 0.90 were observed between staples for Max, Min, AstVAR, Profmean and AstCV ($r > 0.90$). The correlations for Diff and Maxpos were high ($r > 0.80$) while the correlations for the Minpos and Roc were moderate ($r = 0.55$ to 0.69).

Table 1. The least square means, standard errors (s.e.) and residual correlations between staples for each FDP characteristics

	Max	Min	Diff	AstVAR	Profmean	AstCV	Maxpos	Minpos	Roc
Staple 1	19.34[a]	16.56[a]	3.33[a]	0.88[a]	18.30[a]	4.89[a]	26.17[a]	49.43[a]	0.07[a]
Staple 2	19.81[a]	16.57[a]	3.20[a]	0.83[a]	18.25[a]	4.75[a]	30.01[a]	58.82[a]	0.06[a]
s.e.	0.42	0.06	0.07	0.02	0.04	0.06	1.57	4.68	0.01
Residual Correlations	0.94*	0.90*	0.80*	0.94*	0.96*	0.93*	0.82*	0.69*	0.60*

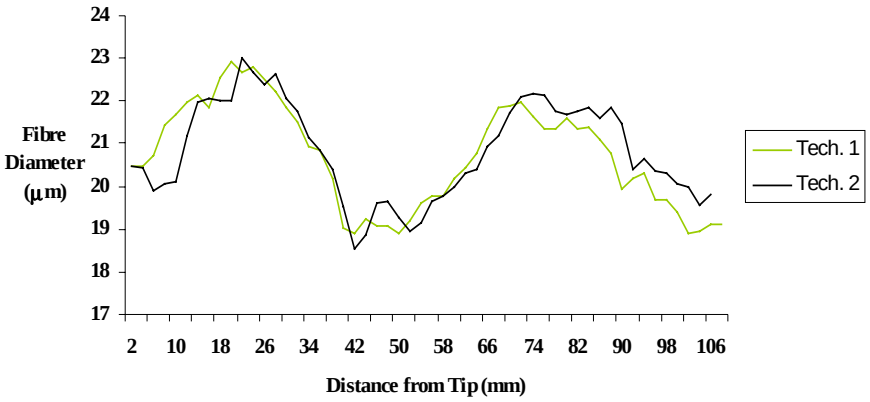
* Correlation significant (P<0.05)

Least squares means within each column with different superscripts differ at P < 0.05

Experiment 2

The actual fibre diameter values which make up the FDP measurements were not significantly different (P<0.01) and highly correlated (r = 0.84, P < 0.0001) between staples from the two preparation techniques. This high correlation can be observed in Figure 3 which illustrates the FDPs prepared using each staple preparation techniques.

Figure 3 An example of the close relationship between the FDP from the same sheep produced using each staple preparation technique



The least squares means (Table 2) for all the FDP characteristics were also not significantly different (P > 0.05) between the FDPs measured using the two preparation techniques. The residual correlations (Table 2) between the two staples for Max, Min, Diff and Profmean were high (r > 0.80) while the correlations for Astvar, AstCV, Minpos and Maxpos were moderate to high (r = 0.61 to 0.73). The correlation between staples for the Roc was low (r = 0.37).

Table 2. Least squares means, standard errors (s.e.) and residual partial coefficients for each FDP characteristic between the staples prepared using the two staple preparation techniques

	Max	Min	Diff	AstVAR	Profmean	AstCV	Maxpos	Minpos	Roc
Staple 1	21.76[a]	18.05[a]	3.71[a]	0.98[a]	20.05[a]	4.94[a]	50.43[a]	71.11[a]	0.14[a]
Staple 2	21.81[a]	17.79[a]	4.02[a]	1.16[a]	20.00[a]	5.32[a]	50.03[a]	73.51[a]	0.13[a]
s.e.	0.25	0.40	0.23	0.12	0.25	0.28	1.61	1.73	0.01
Residual Correlations	0.83*	0.97*	0.93*	0.65*	0.94*	0.73*	0.63*	0.61*	0.37

* Correlation significant (P<0.05)

Least squares means within each column with different superscripts differ at P < 0.05

Discussion

The results have demonstrated that the variation in the FDP characteristics between staples prepared in the same way is small, generally in the order of 10 to 20%. The most acceptable number of staples required to be sampled will depend on which FDP characteristics are to be calculated and the intended use of the FDP characteristics generated. If actual individual animal figures for the absolute fibre diameter values and along-staple variation in fibre diameter were required to compare animals within groups only one staple would be required. However if the positions and maximum and minimum fibre diameter and the rates of fibre diameter change were of interest more than one staple should be measured for each individual. Only one staple needs to be sampled to estimate mean group values for any of the FDP characteristics examined in this study.

The technique used to prepare staples for FDP measurement will influence the amount of time required and therefore the cost of measuring a FDP. The two staple preparation techniques examined in this study did not influence the mean group values of any of the FDP characteristics that were estimated. However, staple preparation did have a large influence on the rankings of the animals for the positions and maximum and minimum fibre diameter and the rates of fibre diameter change. Therefore for accurate comparisons of the rankings of sheep on all FDP characteristics the FDPs should be generated using the same staple preparation technique.

The correlations for the rates of fibre diameter change between staples in experiment 1 were moderate and the correlations between staple preparation techniques in experiment 2 were markedly different from the other FDP characteristics. The calculation of the rate of fibre diameter change using linear regression is very sensitive to small changes in the millimeter and fibre diameter values at the extremities of the data. Neter and Wasserman (1974), Belsley et al. (1980) and Fox (1991) have discussed this principle, referred to as leverage. Therefore small differences between staples in the position of the maximum and minimum and their fibre diameter value can have a large influence on the rate of fibre diameter change calculated. These principles can explain the discrepancy between the results observed for the rates of fibre diameter change compared to the other FDP characteristics. These results also suggest the need for a more robust or alternative method for estimating the rate of fibre diameter change within a FDP.

These results further indicate the need for automated measurement of FDPs. The OFDA 2000 (Brims *et al* 1999) may facilitate financially viable repeated measurements of FDPs for individual animals where more accurate estimates for the positions and maximum and minimum fibre diameter and the rates of fibre diameter change are required. However the relationships between the OFDA 2000 measured rates of fibre diameter change and the actual rates of fibre diameter change in the standard FDP are yet to be determined.

Conclusion

There is only small variation in the FDP characteristics between staples and as a result it is concluded that one staple needs to be measured from the mid-side sample to gain an accurate estimation of the FDP characteristics. While the technique used to prepare the wool prior to measurement of the FDP does not significantly influence the mean values of the FDP characteristics, the rankings of the animals on the positions of the maximum and minimum fibre diameter and the rates of fibre diameter change may be different. The intended use and type of FDP characteristics generated should influence the way in which staples are selected and prepared.

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References

Belsley, D.A., Kuh, E. and Welsch, R.E. (1980). 'Regression diagnostics: Identifying data and sources of collinearity', (Wiley, New York).

Brims, M.A., Peterson, A.D. and Gherardi, S.G. (1999). Introducing the OFDA2000 - For rapid measurement of diameter profile on greasy wool staples. In "International Wool Textile Organisation Meeting", Report No. RWG 04, South Africa.

Brown, D.J., Crook, B.J. and Purvis, I.W. (1999). Genotype and environmental differences in fibre diameter profile characteristics and their relationship with staple strength in Merino sheep. *Proceedings of the Association for the Advancement of Animal Breeding and Genetics* **13,** 274-277.

Brown, D.J. (2000) The estimation and utilisation of variation in fibre diameter profile characteristics between sheep, Post-Graduate Doctoral Thesis, The University of New England, Armidale, Australia, Submitted.

Charlton, D. (1995). Sirolan-Laserscan - A review of its development, performance and application. *Wool Technology and Sheep Breeding* **43,** 212-228.

Cottle, D. J. (1991). 'The Australian Sheep and Wool Handbook', (Inkata Press, Sydney).

Denney, G. D. (1990). Phenotypic variance of fibre diameter along wool staples and its relationship with other raw wool characters. *Australian Journal of Experimental Agriculture* **30,** 463-467.

Fox, J. (1991). 'Regression diagnostics', (Sage, Newbury Park, California).

Hansford, K. A. (1992). Fibre diameter distribution: Implications for wool production. *Wool Technology and Sheep Breeding* **40,** 2-9.

Jackson, N. and Downes, A.M. (1979). The fibre diameter profile of wool staples from individual sheep. *Australian Journal of Agricultural Research* **30,**163-171.

Neter, J. and Wasserman, W. (1974). 'Applied linear statistical models: Regression, analysis of variance and experimental designs.', (R.D. Irwin: Honewood, USA).

Purvis, I. P. (1997). Breeding for improved productivity and wool quality in fine wool Merinos. *Proceedings of the Association for the Advancement of Animal Breeding and Genetics* **12**, 697 - 700.

SAS (1990). 'SAS/STAT User's Guide.', Version 6, Fourth edition, (Cary, N.C.: SAS Institute).