

VARIATION IN FIBRE DIAMETER ALONG THE WOOL STAPLE IN SIRE PROGENY GROUPS

N.R. ADAMS and J.R. BRIEGEL

CSIRO Livestock Industries, Private Bag 5, Wembley WA 6913

SUMMARY

The development of the Optical Fibre Diameter Analyser (the OFDA2000) has greatly facilitated measurement of the variation in fibre diameter (FD) along the staple. This equipment was used to measure fibre diameter profiles on 680 midside wool samples from progeny groups of 17 rams in a sire evaluation test, to determine characteristics of the variation in FD along the staple (SDalong). The SDalong of clean vs greasy samples differed among sire progeny groups, so further analysis focused on clean samples. Over 90% of the variation in SDalong could be accounted for by 3 components; the overall change in diameter across the year (slope), and the maximum and minimum diameters. There were significant differences among progeny groups for SDalong and for all of its components. The average difference in FD between adjacent measurements along the staple differed among sires, but was not a significant component of SDalong. The SDalong was greater in animals with high fleece weight, indicating that sheep that grew more wool responded more to the seasonal variation in nutrition. The components of SDalong were also related to staple strength.

Keywords: Fleece weight, staple strength, responsiveness, sensitivity

INTRODUCTION

The variability in FD consists of two distinct components, variation along the fibre, and variations between fibres. The standard deviation in diameter between fibres (SDbetween) is highly heritable and closely related to staple strength (Howe et al. 1991). Variation along the fibre (SDalong) is affected mainly by changes in nutrition, but it also has a small genetic component (Yamin et al. 1999).

The availability of the OFDA2000 has enabled practical and cheap measurement of these characteristics. The SDalong may give useful insights into the way the animal responded to its environment throughout the year, but relationships between SDalong and other characteristics are still relatively unexplored. The present work uses genetically different groups run under identical management at a central sire test evaluation site to define relationships between SDalong and other fleece characteristics.

MATERIALS AND METHODS

Single staples were measured from midside wool samples collected from a flock of 682 male and female progeny from 17 rams, in groups between 26 and 45 offspring run at Brookton WA. The sheep were born in June 1999, and given a preliminary shearing in October. Midside wool samples were collected in August 2000 before the sheep were shorn in September. The mean clean fleece weight was 2.7 kg, the mean FD measured by a Laserscan machine was 18.5 μ m, and the mean SS measured on an AgriTest Staple-Breaker II was 42.9 N/ktex.

Measurement using an OFDA2000 were carried every 3.5 mm on greasy staples, which were then reread after washing 3 times in petroleum ether solvent and re-conditioned for 24 h at 20°C and 65% relative humidity. The OFDA grease correction factor was automatically subtracted from values measured on the greasy staple. The FD characteristics recorded included maximum diameter, minimum diameter, SDalong, SDbetween, and the proportion of fibres greater than 30 μ m. The average change in FD between successive measurements along each sample was also calculated (adjacent difference in FD).

All data were analysed by stepwise multiple regression using the general linear model of Systat (Wilkinson 1998). The proportion of variance accounted for in the various statistical relationships is indicated by the size of the adjusted multiple R^2 value.

To enable the changes to be appreciated visually, the data from each animal was standardized to the mean staple length for that progeny group, using a procedure developed by Mata and DeBoer (G. Mata, pers comm.). Standardized profiles for each progeny group presented in Figure 1 indicate that there was an overall decrease in FD throughout the year, with two troughs resulting from seasonal changes in quality and quantity of pasture. Animals grazed on dry pasture after shearing until an early break to the season, but had only short green feed during early winter.

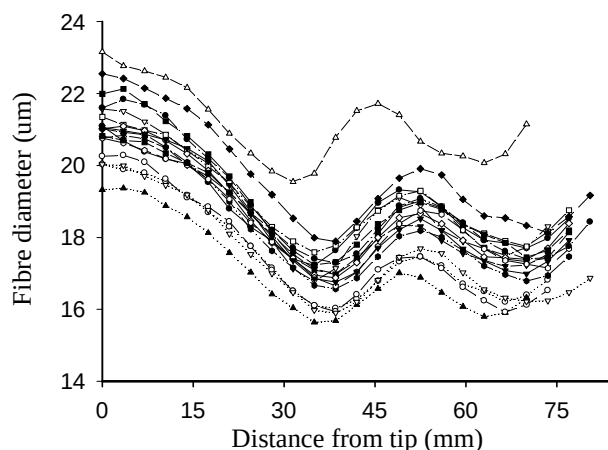


Figure 1. Mean profile of fibre diameter for each progeny group

RESULTS.

Effect of cleaning staples on the measured value of SDalong.

Ram progeny groups ranked differently for SDalong after samples were cleaned (Spearman 0.89; Figure 2a), whereas groups ranked similarly for mean FD measured on greasy or cleaned staples (Spearman rank correlation 0.98; Figure 2b). Across all samples, the greatest difference between the greasy and clean SDalong was seen in wools with a high staple length ($P < 0.001$), a high greasy SDalong ($P < 0.001$), and high SDbetween ($P < 0.01$). There was an additional effect of sire ($P < 0.001$), but no effect of mean FD. Because greasy samples were a less accurate reflection of differences in FD throughout the year, further analysis was limited to studies on clean samples.

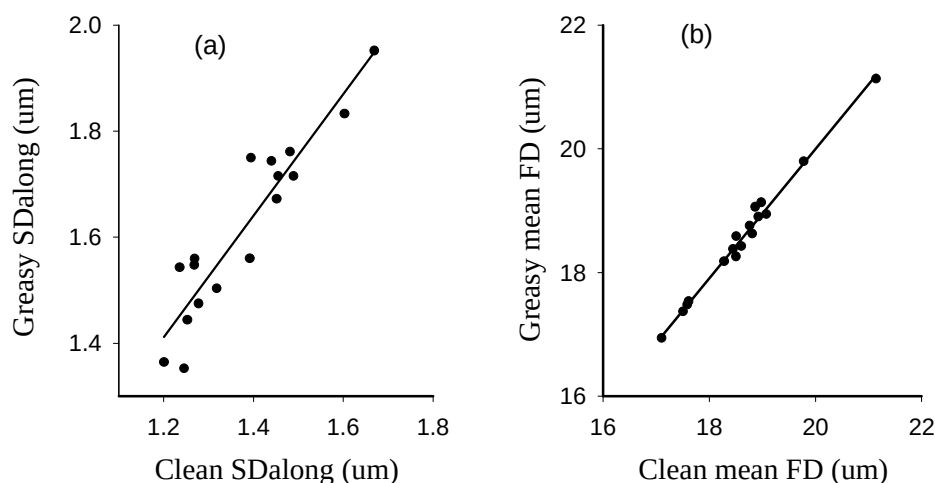


Figure 2. Mean values for (a) SDalong and (b) fibre diameter before (greasy) and after (clean) washing wool staples from 17 ram progeny groups

Components of SDalong

The SDalong can be conceptualized as consisting of the overall change in diameter through the year (the slope), and the range in diameters within the year (maximum and minimum diameters). These factors accounted for over 90% of the variance of SDalong (adjusted multiple R^2 of 0.92) in a multiple step-wise regression analysis. A further potential measure of variation, the average difference in

diameter between adjacent measurements (the adjacent difference) did not contribute significantly to the variation in SDalong in this analysis. Sire also added nothing to this analysis.

Using simple ANOVA, there were statistically significant differences among sires in SDalong ($P < 0.001$, $R^2 = 0.16$), arising out of differences among the sires in the components of SDalong. In individual one-way ANOVA, sires differed most in minimum diameter ($R^2 = 0.39$), followed by maximum diameter ($R^2 = 0.26$), mean adjacent difference ($R^2 = 0.13$), and slope ($R^2 = 0.10$).

Relationship between SDalong and other fleece characteristics

Individual regressions indicated that across all samples, SDalong was significantly ($P < 0.001$) greater in animals with high clean fleece weight, low yield, low curvature, low staple strength, a high proportion of breaks in the base of the staple, and a high proportion of fibres with a diameter $>30 \mu\text{m}$. SDalong was not related to the proportion of fine fibres ($<15 \mu\text{m}$). Many of these factors were related to each other, but multiple stepwise regression equation indicated that all of these factors were independently related to SDalong. If the proportion of broad fibres was removed from the analysis, SDalong was significantly greater in wools with a high SDbetween ($P < 0.01$).

The components of SDalong that most affected fleece weight were examined by stepwise regression. Clean fleece weight was greater in animals with a greater maximum diameter ($P < 0.001$), a lower slope ($P < 0.01$) and greater minimum diameter ($P < 0.01$). A lower adjacent difference was also associated with a higher fleece weight ($P < 0.01$), but this probably reflected its relationship to staple length because it was rejected by the analysis when staple length was included ($P < 0.001$). SDbetween was not related to fleece weight. The position of break (POB) in the staple occurred later in sheep with a high SDalong, but POB itself was not related to fleece weight.

Both SDalong and SDbetween contributed approximately equally to variation in staple strength, although the total adjusted multiple R^2 was only 0.07. Replacing SDalong with all of its components increased the R^2 to 0.38. The major contributors to the relationship with staple strength were minimum diameter and SDbetween, with smaller but still significant ($P < 0.001$) contributions from slope and adjacent difference. The maximum diameter was not significantly related to staple strength in this analysis.

The overall SDalong was not related to staple length, so the raw values were not adjusted to a constant length. However, the rate of change in FD was related to the length of staple over which the change occurred. Longer staples had a lesser slope ($P < 0.001$) and a lower adjacent difference ($P < 0.001$). The SDbetween was greater in wools with a higher mean FD ($P < 0.001$), but SDalong was not significantly related to the mean FD.

DISCUSSION

Cleaning made a significant difference to the ranking of sire progeny groups for SDalong (Figure 2). Cleaning removes more material from the base of the staple than the tip (Baxter 2001a), and this may differ among sire groups. Baxter (2001b) reported similar effects to the present study when comparing clean and greasy estimates of FD and SDalong from groups of sheep run under different management conditions. The present study used clean staples to enhance the accuracy of estimates of changes in wool growth throughout the year.

The SDalong reflects changes in wool growth rate, and so may be useful to indicate differences in the way groups of sheep respond to changes in pasture quality and quantity (Adams and Briegel 2002). Change in biological systems (for example, in enzyme kinetics) is usually described in terms of the magnitude of the change, and the rate at which it occurs. In physiology, these parameters are usually referred to as responsiveness and sensitivity (Cronjé 2000). The present study shows that measurements of responsiveness (slope, maximum and minimum diameter) accounted for over 90% of the total SDalong, while a measure of sensitivity, the mean difference between adjacent readings, made no independent contribution. Thus, the SDalong indicates the responsiveness, but not the sensitivity, of FD to nutritional change.

Although it was not included in SDalong, the sensitivity to nutritional change (the adjacent difference) was also biologically significant. The adjacent difference contributed independently to the prediction

of staple strength, supporting the observation that sheep selected for low staple strength have greater short-term differences in FD after nutritional change (Adams *et al.* 1997). However, the adjacent difference was not related independently to many other characteristics in the present study.

The present observations explain some of the anomalies in reported relationships between the overall variation in FD (the CV_{fd}) and fleece weight. Both SD_{along} and SD_{between} contribute to CV_{fd}, but only the SD_{along} was related to fleece weight, while the SD_{between} was not. Therefore, seasonal climates where SD_{along} is large relative to SD_{between} could be expected to have a stronger relationship between CV_{fd} and fleece weight. Thus, Cloete *et al.* (1997) observed a significant positive relationship between CV_{fd} and fleece weight in South Africa, whereas a slight negative relationship was recorded in fine wool sheep in Armidale NSW (Purvis and Swan 1997).

The profiles illustrated in Figure 1 can be analysed in a number of ways. For example, Brown *et al.* (2000) estimated additional characteristics, including the position of minimum diameter and the rate of change in diameter between minimum and maximum diameter, to better understand relationships with staple strength. However, the present study shows that rates of change in diameter make relatively little contribution to staple strength, compared with the overall magnitude of change. deJong *et al.* (1985) reported that staple strength is a complex measurement depending on the total mass of wool in the staple, the minimum diameter along the staple, and interactions among the fibres as the staple comes to tension. Attempts to predict staple strength from fibre diameter profile information alone will always suffer difficulty.

In conclusion, the SD_{along} indicates the responsiveness, but not the sensitivity, of the FD to nutritional change. Although the heritability of SD_{along} is low (Yamin *et al.* 1999), and sire group accounted for only 16% of the variation of SD_{along} in the present study, some breeders aim to reduce the nutritional variation in fibre diameter throughout the year. SD_{along} is a useful integrated measure of this characteristic. However, SD_{along} is likely to be of most benefit in assisting flock managers to recognize the nutritional status of their sheep and adjust grazing pressures accordingly (Peterson *et al.* 2000a) or to predict of fibre length in wool top after processing (Peterson *et al.* 2000b).

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Email: Norm.Adams@csiro.au