PREDICTION OF VARIATION OF FIBER DIAMETER IN WOOL FLEECES

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Summary

Distribution of fiber diameter was determined for side, britch and core samples from 178 yearling finewool rams participating in the 1989 Wyoming and Texas Ram Performance Tests and 48 crossbred ewes. The coefficient of variation of diameter of the whole-fleece (140 or 150-d) core sample was shown to be poorly correlated (r = .15) with the difference in mean diameters between side and britch staples and moderately correlated (r = .45) to the coefficient of variation of diameter of the side sample. This suggests that the coefficient of variation of the side sample diameter is preferable to the difference in mean diameter between side and britch staples for estimating the variability of the whole fleece. However, coefficient of variation of the side sample does not indicate the "coarse edge" of fleeces which could be estimated from a histogram from the whole fleece. Both side diameter and britch diameter were highly correlated (r = .87 and .77, respectively) with core diameter but the britch diameter was approximately 3 microns coarser than the side and core diameters. One implication for ram testing and selection of stud rams is that the coefficient of variation of diameter of the whole fleece is not a sensitive indicator of objectionable coarse britch wool. When this information is required, a histogram from the whole fleece sample should be provided or wool from the britch should be measured directly. The fiber diameter and variability correlations established for 140 or 150-d ram fleeces, grown under performance test conditions were similar to those established for 12-mo ewe fleeces produced under range conditions.

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Introduction

Fiber diameter is an important price-determining characteristic of raw wool. For constant length distribution, diameter and variation in diameter govern the size (linear density) of yarn that can be spun from wool fibers (Turpie 1976, 1977, 1978; Turpie and Hunter, 1980). High levels of diameter variability reduce spinning performance, yarn uniformity and tensile properties through the influence on number of fibers in the yarn cross-section (Whiteley and Jackson, 1980). Consequently, fiber diameter and its variation play major roles in the processing and marketing of wool.

Variation of wool fiber diameter may be expressed as the standard deviation of the mean fiber diameter. However, coefficient of variation (CV) provides a more useful statistic for comparing fiber diameter variance of wool differing in mean diameter since it accounts for the increase in standard deviation which generally occurs with an increase in fiber diameter (David, 1975; Whiteley et. al., 1984). Sources of within-staple fiber diameter variability include: diameter differences along the length of individual fibers; and, diameter differences between fibers (Stobart et al., 1986).

The variation of fiber diameter between body regions has been estimated in previous studies. Dunlop and McMahon (1974) found the variation in fiber diameter between sites on the bodies of sheep accounted for only 6 to 12% of total variation in five Australian Merino strains. Stobart et al. (1986) found the variation in fiber diameter attributable to body region to be only 2 to 15% of the total variation.

The variation of wool fiber diameter measured on properly drawn and processed cores would appear to be the best sample for establishing the overall distribution of fiber diameter since the cores contain fibers from all regions of the fleece and in the correct proportions (Stobart et al., 1986). Core samples are considered to be

more representative than discrete samples taken from other parts of the fleece, such as side samples and britch samples, for describing mean fiber diameter and associated variability. However, side and britch samples are easier to obtain. It has been hypothesized that overall variation of fiber diameter in the fleece of a fine-wool sheep can be estimated by the difference in diameter between side and britch samples. The belief is that the greater the difference in diameter between these two locations, the higher will be the variation.

The britch wool of a fine-wool, Rambouillet type of sheep represents only a small portion of the whole fleece. Willingham et al. (1984) found that britch wool composed only 5.7% of the entire fleece, and although removal of the britch decreased the fiber diameter of the remaining fleece, this difference was negligible by the time the wool was converted to top. Since the britch constitutes only a small portion of the fleece, its contribution to variability of diameter of the whole fleece is expected to be proportionally low. However, britch wool can contain some exceptionally coarse, hairy fibers and can make a major contribution (together with lower leg wool) to the so-called "coarse edge" of a fleece. Whiteley and Thompson (1985) studied ways of estimating the "coarse edge" statistics in grease wool sale lots and concluded that the standard deviation and CV are sufficient for establishing "coarse edge" statistics. Jones (1985) disagrees with this view particularly when applied to single fleeces.

Although relatively few in number, rams play the major role in the genetic selection process in a flock (Botkin et al., 1988). Because of its importance in establishing price and value, mean fiber diameter is one of the several variables that have been routinely and objectively measured in ram performance tests (Lupton and Shelton, 1986).

For this study, fiber samples were measured from 178 rams on the 1989 Wyoming and Texas Ram Performance Tests. The objective of this study was to determine if the CV of the side sample diameter (Side CV) or the difference in diameter between wool from the side and britch regions could be used to predict the core CV (Core CV) which is frequently used as a measure of overall variation of wool fiber diameter in fleeces. The relationships of mean fiber diameter and CV between side, britch and core samples were also studied. The correlations between side, britch and core samples from 48 ewes having one year's wool growth were compared with similar correlations from the 78 Rambouillet rams on the Wyoming Ram Performance Test.

Table 1. Mean Fiber Diameter of Different Body Areas

Test Site	Body Area	Mean Fiber Diameter µ	Standard Deviation µ	Coefficient of Variation %
Wyoming				
(78 rams)	Side	24.47	4.24	17.30
	Britch	28.06	6.01	21.44
	Core	24.25	5.29	21.83
Texas				
(100 rams)	Side	22.98	4.43	19.28
	Britch	25.82	5.59	21.62
	Core	23.37	5.71	24.24
Wyoming				
(48 ewes)	Side	26.58	4.67	17.69
	Britch	29.18	5.92	20.36
	Core	25.58	5.37	21.02

Materials and Methods

Wyoming

Wool samples from the mid-side and britch areas of 78 yearling Rambouillet rams on the 1989 Wyoming Ram Performance Test and 48 two year old, 3-mo pregnant, cross-bred ewes were collected and characterized in terms of diameter and variability at the University of Wyoming's Animal Science Facilities in Laramie. Samples were taken from the rams at the end of a 150-d test period. Thirty-two, 13 mm core samples were removed from the 150-d fleeces after shearing, using a technique described by Johnson and Larsen (1978). Subsequently, the side and britch samples were washed in an aqueous solution of nonionic detergent at 50° C, air dried, while core samples were washed in similar manner, oven dried at 105° C and carded to further randomize the fibers. Fiber diameter measurements were conducted in accordance with American Society for Testing Materials (ASTM) Standard Test Method D2130 (ASTM, 1989A). Side and britch staples were sampled at the mid-point, whereas, sampling of the cores represented random sampling in terms of fiber position in staple and body. In the case of the ram staples, 400 fibers per sample were measured. Two hundred fibers were measured on the core samples. These numbers of individual fiber measurements provided confidence limit of the mean of less than one micron at the 95% probability level.

Table 2. Correlation Coefficients Between Various Measures of Fiber Diameter of Rams

Correlation	Wyoming	Texas
Side vs Britch	.81*	.80*
Side vs Core	.86*	.89*
Britch vs Core	.78*	.76*
(Mean Side & Britch) vs Core	.86*	.86*
(BD - SD) vs Core	.16	.20

* Significant (P< 01).

a (BD - SD) = Side and britch diameter difference.

Table 3. Correlation Coefficients Between Various Measures of CV and Mean Diameter of Rams

Correlation	Wyoming	Texas	Average
Side CV vs Britch CV	.63*	.43*	.53*
Side CV vs Core CV	.42*	.48*	.45*
Britch CV vs Core CV	.52*	.21	.37*
(Mean Side & Britch CV) vs Core CV	.53*	.37*	.45*
(Britch CV - Side CV) vs Core CV	.40*	.12	.26
(BD - SD)a vs Core CV	.16	.15	.16
(BD - SD)a vs Side CV	.02	.08	.05

* (P< .01).

a (BD - SD) = Side and britch diameter difference.

Texas

Wool samples from the mid-side and britch areas of 100 yearling Rambouillet rams on the Texas Ram Performance Test were removed on the 100th day of the 140-d test. The staples were subsequently characterized in terms of diameter and variability at the Texas Agricultural Experiment Station's Wool and Mohair Research Lab in San Angelo. Whole fleeces were shorn at the end of the test and core-sampled in an identical manner to the Wyoming ram fleeces. Mid-side and britch staples were subsampled using a two-bladed cutting device (Buckenham, 1986) producing snippets 1.8 mm in length. The staples were sampled at a point 3/10 of their length from the base corresponding to the mid-point of the 140-d staple. The degreased snippets were measured using a Peyer Texlab FDA200 System (Lynch and Michie, 1976). In each case, 1000 fibers were measured providing a mean diameter value having a confidence limit of approximately ± .4 microns at a 95% probability level.

Core samples removed from the whole fleeces were washed and dried in accordance with ASTM Standard Test Method D584 (1989B). The cleansed cores were carded prior to subsampling for diameter measurement. Snippets sampled from the card web were thus considered representative of the whole fleece in terms of average fiber diameter and variability.

Simple linear correlation analysis (Steel and Torrie, 1980) was used to establish relationships between the mean fiber diameters and variabilities measured on the samples taken from the body locations and the whole fleece core samples.

Results and Discussion

The mean fiber diameter, standard deviation and CV from the two locations are presented in table 1. The mean values of side and core diameters are similar, while the britch diameter is approximately 3 microns coarser at both sites. The coefficient of variation of the cores (Core CV) are higher than the side coefficient of variation (Side CV) and britch coefficient of variation (Britch CV) but the side samples are the most uniform (CV = 18). Core samples are expected to be the most variable because they contain fibers from all parts of the fleece and from all points along the staples which, under the condition of a performance test, vary significantly in diameter from tip to base (i.e., approx. 2 microns on average; Lupton and Shelton, 1986). Overall, the rams in the Texas test were finer than their counterparts in the Wyoming test. However, rams from the Wyoming test were less variable in all measurements than the rams from the Texas test.

Table 2 shows correlation coefficients (r values) between 3 measures of fiber diameter and also for the mean value of side and britch diameter versus core diameter and the difference between side and britch diameter and core diameter. All coefficients are high except the last one, suggesting that side, britch and mean of side and britch diameters are all good indicators of core diameter. However, side diameter produced the highest correlation with core diameter. The difference between britch and side diameter is not highly correlated with core diameter.

Correlation coefficients between side, britch and core CV's of diameter are shown in table 3. The r values between side CV and core CV for the two locations are moderately high (.42 and .48) while the correlations between side and britch diameter differences and core CV were low (.16 and .15). These results suggest that the side CV provides a better indication of core CV than side and britch diameter difference. However, the correlation is

Table 4. Correlation Coefficients Between Various Measures of Diameter of Wyoming Ewes and Rams

Correlation	Ewes	Rams
Side vs Britch	.89	.81
Side vs Core	.89	.86
Britch vs Core	.86	.78

All values (P< .01)

Table 5. Correlation Coefficients Between Various Measures of Fiber Diameter and CV of Wyoming Ewes and Rams

Correlation	Texas	Rams
Side CV vs Core CV	.62*	.42*
(BD - SD)[a] vs Side CV	.08	.02
(BD - SD)[a] vs Core CV	.02	.16

* (P< .01).

[a] (BD - SD) = Side and britch diameter difference.

only moderate, indicating that a mere 20% of the variability in core CV can be accounted for the by the variability in side CV. Thus, it appears that an *accurate* measure of core CV can be obtained only by measuring it directly. Further, this measurement is *not* highly correlated to side and britch diameter difference presumably because of the relative insensitivity of the CV to the presence of approx. 5% of the normally coarser britch wool. Thus, core CV cannot be relied upon as an accurate indicator of excessively coarser britch wool. When this information is required, therefore, it should be measured directly.

The correlation coefficients between the three measures of diameter for the Wyoming ewes and rams are shown in table 4. The correlations for the ewes and rams are all high with the ewe coefficients being consistently slightly higher. Again, the data indicate that side samples can be used with reasonable confidence to predict the overall fleece diameter whether the wool was produced in a test situation (ram data) or a full year's range environment (ewe data).

The data in table 5 show that the Side CV for the ewe wool is more highly correlated (r = .62) to Core CV than for the ram data wool (r = .42). Again, the side and britch diameter difference vs Core CV and Side CV correlation coefficients are low.

Conclusions

The best sample for establishing the overall distribution of fiber diameter in fleeces is considered to be a properly drawn and processed core. However, these data suggest when this is not possible, a side sample may be measured to provide a moderately accurate estimate (r for Side CV vs Core CV = .45) of the diameter variability of the whole fleece. Neither side and britch diameter difference (r = .15), nor side and britch coefficient of variation differences (r = .26) can be used to *accurately* predict the variability of diameter of a whole fleece (i.e., coefficient of variation of diameter of a core sample).

The fiber diameter of a side sample provides a good estimate (tables 1 & 2) of the mean diameter of a core sample from the whole fleece.

The fiber diameter and variability correlations established for 140 or 150-d ram fleeces grown under performance test conditions are similar to those established for 12-mo ewe fleeces produced under range conditions.

The coefficient of variation of fiber diameter of a whole fleece is too insensitive a statistic for indicating the presence of excessively coarse britch wool in a whole fleece. Direct access to the fiber diameter distribution, preferable from the whole fleece, is necessary to reveal this objectionable trait. Alternatively, when a more accurate estimate is required (e.g., in the selection of a fine-wool stud ram where a coarse britch is suspected) wool from the britch area should be measured directly.

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