

THE DIRECT PARTITIONING OF VARIATION IN FIBRE DIAMETER IN TENDER WOOL^{**}

A.H. MCKINLEY*, P.A. IRVINE , E.M. ROBERTS
and M.W. ANDREWS**

Summary

Direct estimates of variance components for tender wools are presented for variation in fibre diameter between and along wool fibres. These were made by measuring the diameter at dye-banded points at different growth levels within single staples. The study was made on tender wool from pregnant and lactating Peppin Merino ewes run as one flock under field conditions. Thirty four per cent of the total variation was observed along single fibres, and 34% between fibres. Variation among sheep accounted for 9%, and the remaining 23% was attributed to interaction and error.

I. INTRODUCTION

Fibre diameter influences spinning performance and fabric properties and for this reason is important in wool marketing and growing. Variation in diameter along fibres weakens them and contributes to fibre breakage and waste during processing. This variation is largely nutritional in origin, and can be controlled by the grower. In this paper direct estimates are given of the variation in diameter at corresponding growth levels on single fibres within staples for tender wools, where the variation is expected to be greater. A study of sound wool produced under constant nutrition is in progress.

II. PREVIOUS WORK

The literature has been reviewed by Quinnell, Whiteley and Roberts (1973). They presented estimates of variance components, and included theoretical predictions for variation along single fibres since no actual estimates had been made. Sumner and Revfeim (1973) presented estimates made in New Zealand Romney hoggets. Their estimates of between- and along-fibre variation were made from diameters measured at random points along single fibres. Dunlop and McMahon (1973) derived estimates for Merinos from skin and fibre cross-sections and by other means. They used indirect methods to estimate variation along fibres and realised that this variation may be seriously underestimated. Otherwise, their estimates broadly agreed with those of Quinnell, Whiteley and Roberts (1973).

III. MATERIALS AND METHODS

Five ewes were selected at random from a medium Peppin Merino flock used in a grazing experiment at Illabo in the Southern N.S.W. wheat-sheep belt. The ewes were three and one-half years old at the beginning of the experiment in March 1970. They were joined in

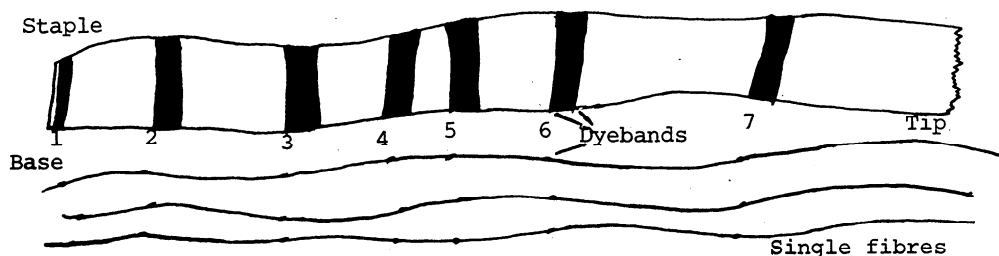
* University of New South Wales, School of Wool & Pastoral Sciences, Kensington, N.S.W. 2033.

** C.S.I.R.O. Division of Textile Physics, Ryde, N.S.W. 2112.

February 1970, and shorn in March. They lambed in August and their lambs were weaned in early December. Dry matter availability and liveweights declined from October until the end of the experiment, although some green feed followed late summer rains. The ewes were finally shorn in May 1971. The ewes were stocked at ten/ha on a subterranean clover (*Trifolium subterraneum* L.) pasture dominated by barley grass (*Hordeum leporinum* Link), which had been treated with superphosphate at 250 kg/ha. All of the five ewes had a lamb, but only three raised a lamb to weaning.

The sheep were dyebanded as described by Chapman and Wheeler (1963) on the midside throughout the year at nine convenient and known times except that the ewes were not disturbed before or during the lambling period. The wool was dyed at skin level with Durafur Black R (ICI/ANZ PTY.LTD.). Williams and Chapman (1966) found that the dye penetrates only about 50 μm down the follicle to the level of the sebaceous gland. Therefore the bottom of each dyeband on single fibres should mark points generated at approximately the same time (Figure 1). Measurements of diameter made at the base of dyemarks on the fibres should therefore enable variation among fibres and along fibres to be directly partitioned at those points, even though the length growth-rates may differ or differential fibre movement might occur in the staple. Variation between bands was taken as the measure of variation along the fibre.

FIGURE 1
Dyemarked fibres drawn from a dyebanded wool staple



The midside samples were removed using Oster clippers with a no. 40 (fine) head. One staple was plucked at random from each of the five mid-side samples and single whole fibres drawn at random from the base of each staple. The two bands nearest to the tip could not always be distinguished and were omitted from the analysis. The seven remaining bands cover the period from 23 June 1970 (late pregnancy) to 30 April 1971. Ten fibres each marked with seven bands were selected from each staple. The fibres were degreased in petroleum ether and held in a bath of paraffin oil on a microscope stage especially developed for the purpose and to be described elsewhere. The standard error of the measurement system was $\pm 0.26 \mu\text{m}$. Two measurements of fibre diameter each averaged over a short length and 122 μm apart were made at the base of each dyemark on each of the fibres. There were therefore five staples, 10 fibres within each staple, 7 bands per fibre and two adjacent readings per band: 700 readings in all. The experimental design was balanced and enabled unbiased estimates of least-square means and variance components to be made. A completely random statistical model was assumed in the results presented.

IV. RESULTS

The base of each staple dyeband was sharply defined, indicating a lack of relative fibre movement subsequent to dyebanding. The staple growth-rate was estimated from the banding dates and the distance between the bases of adjacent dyebands and ranged from 200 to 280 μm per day. All factors and interactions were statistically significant. ($P < 0.01$). The least-squares mean was 22.76 μm and the standard deviation per observation (i.e., the square root of the error mean square) was 1.32 μm . The deviations of the staples about the general mean ranged from -2.04 μm to 2.43 μm . The deviations of dyebands from the general mean ranged from -4.73 μm (a tender region at band 3) to 3.0 μm (sound regions at bands 6 and 7). The fibres within staples ranged from -8.66 μm below to 5.04 μm above the general mean. The main interest in this analysis is in the components of variation for fibre diameter and these are presented in table 1. A model with fixed banding times was also fitted and gave similar-results.

TABLE 1

Variance components. for fibre diameter derived from tender wool

Source	Variance component		
	μm^2	%	S.E. (μm^2)
Between staples (i.e. between sheep)	2.05	9.0	1.78
Between fibres within staples	7.67	33.7	1.67
Between bands along fibres	7.75	34.0	4.05
(Staples x Bands) interaction	1.47	6.4	0.49
(Fibres x Bands within staples) interaction	2.12	9.3	0.26
Between duplicate readings within bands (Error residual)	1.74	7.6	0.13
	22.80	100.0	

V. DISCUSSION

As only one staple was measured per sheep, the variation over the body is confounded with variation among sheep. The variation among sheep is lower than reported by Quinnell, Whiteley and Roberts (1973) and by Dunlop and McMahon (1973) since only five medium Peppin Merino ewes were measured. However, the proportion of the total was similar to their lowest estimates. Dunlop and McMahon (1973) suggest that their estimates of variation between fibres may be slightly inflated by (nutritional level x fibre) interaction. This is estimated by the (fibre x bands) interaction component and is small (table 1). They claim that their estimate of variation along fibres may be seriously under-estimated due to differential fibre growth rates and relative fibre movement prior to sampling. These sources of error are minimised in the present experiment on the dyemarked fibres and allow a direct estimate of variation along the fibre to be made, and it can be seen from table 1 that the estimate is similar in magnitude to the between-fibre variation for these particular fleeces. This similarity is in agreement with the theoretical predictions of Quinnell, Whiteley and Roberts (1973) for tender wools, and with the findings of Sumner and Revfeim (1973) in Romneys, although the nutritional history of their sheep was not stated. However, the latter authors found that in tender Romney wool, the within-fibre variation could be up to four times the

between-fibre variation. The small (staples x bands) interaction term in the present analysis shows that the sheep did not differ greatly among themselves in diameter changes along fibres in response to nutritional and other stresses. The lower proportions for estimates of between- and along-fibre variance components in the present study are due to the small interaction terms being partitioned from them.

VI. CONCLUSIONS

The variation between fibres and along fibres within the staple has been directly partitioned in tender wools from sheep run together under field conditions. The variation along fibres was found to be similar to the variation between fibres in the wools studied and confirms the findings and predictions of others for tender wools. The interaction terms were found to be small. The fact that most of the variation in fibre diameter occurs within the staple and much of it along single fibres reinforces the conclusions of Roberts (1931) and Smith (1956) that traditional wool classing and mill sorting have minimal effect on the control of variation in diameter for processing. On the other hand, if a grower can eliminate tenderness, the processing quality of his clip will improve. As the sale of wool becomes more firmly based on measurement of diameter and other fibre properties, a proper premium may be paid for sound wool.

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