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## Comparison of methods for measuring fibre diameter of Romney wool

D.R. SCOBIE, N.C. MERRICK AND D.J. SAVILLE

AgResearch, P.O. Box 60, Lincoln, 8152, New Zealand.

### ABSTRACT

Wool from lines of Romney sheep selected on the basis of staple strength was measured for mean fibre diameter using both the airflow apparatus and an Optical Fibre Diameter Analyser (OFDA). For wool from "low strength" and "control" selection lines, airflow measurements tended to be upwardly biased in relation to the OFDA measurements, while for wool from the "high strength" line the airflow measurements tended to be downwardly biased. Two sources of bias are known in the literature, medullation and standard deviation. In this work the latter seemed to be more important, which may be a consequence of the relatively low level of medullation present in these wools (8.6 %). For research work the OFDA is put forward as the preferred instrument.

**Keywords:** wool; medullation; fibre diameter; standard deviation.

### INTRODUCTION

The average diameter of wool fibres determines their end-use and therefore their value. There are a number of techniques available to estimate average fibre diameter, the projection microscope method (IWTO, 1966) being the reference or benchmark procedure. Due to the number of person-hours which go into a projection microscope measurement and the associated high cost, other techniques have been developed. Andrews *et al.* (1987) compared five different methods including the projection microscope and examined the biases of each relative to the others. While they acknowledged projection microscope as the base-line, they concluded that despite the biases exhibited by other methods, projection microscope was the least preferred because of the cost.

The 'Airflow' method (IWTO, 1989) is a commonly used technique, where the resistance to the flow of air through a known mass of wool is measured. Assuming that the density of wool is constant, then the resistance to the flow of air is proportional to the surface area of the fibres. If the cross-section of the fibres is assumed to be circular, the surface area is proportional to their average diameter.

Technological advances have led to the development of the Optical Fibre Diameter Analyser (OFDA), which produces a frequency distribution for fibre diameter from video images, and is essentially a mechanised projection microscope. Indeed, measurements of fibre diameter made on OFDA show reasonable agreement with other methods (Baxter *et al.*, 1991; Baxter *et al.*, 1992). The advantage of the OFDA machine is that it gathers data much faster and therefore at lower cost.

In general, there is reasonable agreement between the methods, but Edmunds (1993) reviewed some of the problems associated with airflow estimates. For example, medullated wools tend to measure finer by airflow than projection microscope (IWTO, 1989), because the medulla is much less dense than keratin and the constant density assumption is therefore violated. Also, wools which have an anomalously high or low standard deviation of fibre diameter will be biased upwards or

downwards respectively when diameter is estimated by airflow. Robinet and Franck (1959) recognised a consistent downward bias when measuring diameter of lambswool by airflow, the cause of which is yet to be resolved.

It is generally regarded that between animals within a breed, those with greater fibre diameter tend to be more highly medullated (Krishnarao *et al.*, 1960; Ince and Ryder, 1984). Based on airflow measurements, Bray *et al.* (1992) reported a 2  $\mu\text{m}$  difference in average fibre diameter between wool from lines of Romney sheep selected for increased and decreased staple strength. Unexpectedly, the level of medullation was lower in the line selected for increased strength, which had the higher fibre diameter (Scobie, unpublished). This led to the hypothesis that the differences in medullation between the flocks may explain some of the difference in airflow estimates of diameter. The following experiment was conducted to compare airflow and OFDA methods for wool from these lines of sheep, and to determine whether airflow is a satisfactory technique in this context.

### METHODS

Ewes ( $n = 200$ ) from the three selection lines born in August/September 1990 were shorn as lambs in January 1991 and run as one flock until November 1991 when a midside wool sample was collected. Two subsamples were washed and conditioned at 20°C and 65% R.H. Diameter was measured on one subsample using the airflow apparatus and the other using an OFDA. The proportion of medullation was estimated using a WRONZ Medullameter (Lappage and Bedford, 1983). The resulting data were statistically analysed using analysis of variance, regression and analysis of covariance.

### RESULTS

The average diameter from airflow and OFDA, the standard deviation between fibres within a sample from OFDA and the average proportion of medullation for the selection

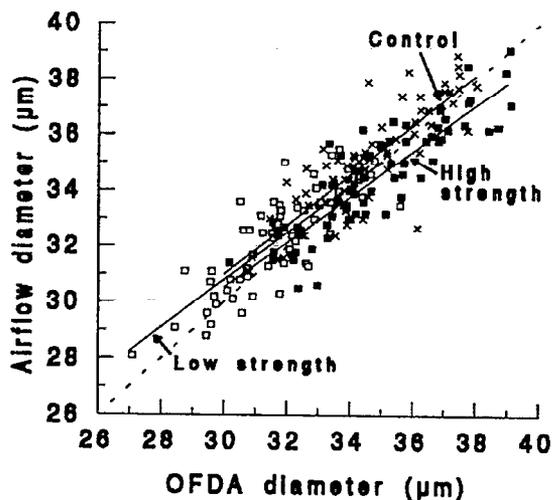
**TABLE 1:** Group mean diameter by airflow and OFDA, and within sheep standard deviation by OFDA, proportion of medullation and covariate adjusted airflow.

Selection Line	n	Mean fibre diameter ( $\mu\text{m}$ )		Standard deviation of fibre diameter by OFDA ( $\mu\text{m}$ )	Proportion of medullation (%)	Covariate adjusted airflow ( $\mu\text{m}$ )
		Airflow	OFDA			
Low strength	69	32.4	31.8	9.0	8.6	34.0
Control	69	35.0	34.5	9.0	8.6	34.4
High Strength	62	34.7	35.1	7.9	6.5	33.6
Between Sheep standard deviation		1.9	1.9	0.8	3.5	1.0
LSD (5%) between lines		0.7	0.6	0.3	1.4	0.4

lines are displayed in Table 1. If for arguments sake we treat OFDA as the reference method, the airflow diameters tend to be upwardly biased for the low strength and control lines, and downwardly biased for the high strength line. This is the converse of what we would expect from the differences in medullation, but ties in with what we would expect from the differences in standard deviation.

When airflow was plotted against OFDA for each selection line, the fitted lines were found to be parallel (Figure 1). When the airflow group means were adjusted by covariance to a common OFDA value, the high strength group had a significantly lower mean airflow diameter than the control group ( $P < 0.001$ ), the low strength group being intermediate (Table 1). In addition, the average slope of the fitted lines (0.85) was significantly less than 1 ( $P < 0.001$ ), giving further cause for concern.

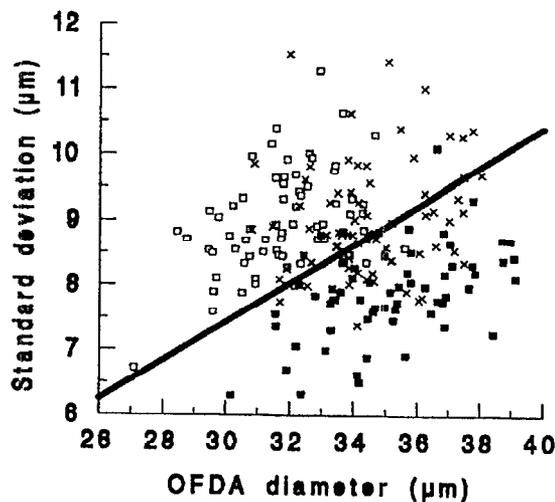
**FIGURE 1:** The relationship between average fibre diameter measured by OFDA and Airflow for the low strength ( $\square$ ), control (x) and high strength ( $\blacksquare$ ) selection lines. The dotted line represents the ideal relationship.



The variability of fibre diameter within fleece samples (standard deviation from OFDA) was significantly lower in the high strength group than in the other two groups ( $P < 0.001$ ), despite the fact that group mean fibre diameter was higher than in the low strength group. Figure 2 shows the standard deviation of fibre diameter plotted against average fibre diameter (from OFDA). This demonstrates different relationships existing within the three groups, the fibre diameter of the low strength group being lower with respect to the control whilst standard deviation was very similar. On the

other hand, the high strength group had a lowered standard deviation across a similar range of fibre diameters to that of the control.

**FIGURE 2:** The relationship between average diameter and standard deviation of diameter for individual wool samples. The equation for the solid line was provided by Edmunds (1993) for "normal" New Zealand raw wools, and clearly separates the low ( $\square$ ), and high ( $\blacksquare$ ) strength selection lines (randomly selected control (x)).



## DISCUSSION

In the experiment reported here there were small but important differences between the airflow and OFDA methods, with airflow biasing the average diameter of the high strength line downwards and the low strength and control upwards (Figure 1). These biases are more consistent with the reported biases due to differences in standard deviation of fibre diameter, than those due to differences in medullation (Edmunds, 1993).

It is evident that the wools from the selection lines are anomalous with respect to standard deviation. Edmunds (1993) gave the following relationship between fibre diameter ( $\mu\text{m}$ ) and the standard deviation of fibre diameter ( $\mu\text{m}$ ) of "normal" raw wool:

$$\text{Standard deviation} = (0.298 \times \text{Mean}) - 1.511$$

This function has been added to Figure 2, to demonstrate the fact that the low strength group have a mean standard deviation of fibre diameter ( $9.0 \mu\text{m}$ ) greater than "normal" wool of a similar diameter ( $8.0 \mu\text{m}$  from Edmunds (1993)

equation). The reverse is true for the high strength group (7.9  $\mu\text{m}$  vs. 9.0  $\mu\text{m}$ ), whereas the control group have a relatively "normal" standard deviation relative to wool of similar diameter (9.0 vs 8.8). It is tempting to speculate that wool with low staple strength may have an inherently more variable fibre diameter, perhaps signifying a number of thin or weak points in the fibre. However, from the present experiment it is impossible to determine how much of the total variability is due to between fibre variation, and how much is due to variation along individual fibres. Wool with a high standard deviation of fibre diameter may also be more likely to contain medullated fibres. It is encouraging that the latest version of software for OFDA contains a module for along fibre diameter measurements, with a further module for the measurement of medullation being likely in the near future, to enable these aspects to be further investigated.

Clearly the airflow method is biased with respect to measurements made on OFDA for these experimental wools. Since part of the objective of any selection experiment is to examine the correlated changes, it would seem unwise to monitor these with methods which may moderate or exaggerate them. OFDA would appear to be the preferred method for research purposes given that it provides mean, standard deviation and frequency distribution of fibre diameter in a price competitive manner.

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