Sampling Variation Over A Fleece For Mean Fibre Diameter, Standard Deviation Of Fibre Diameter And Mean Fibre Curvature.

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Summary

This paper is a preliminary report that estimates the levels of variance between strains of animals from the same management system, and between sites on animals for the fibre characteristics of Mean Fibre Diameter (MFD), Standard Deviation of Fibre Diameter (SDD) and Mean Fibre Curvature (MFC). The variation over a fleece for Mean Fibre Diameter showed the normal dorso-ventral and posterior-anterior trends. Very little is known about the variability of Mean Fibre Curvature and Standard Deviation of Fibre Diameter over animals. This paper examined the variability of MFD, SDD and MFC over 9 sites for 3 strains of sheep. Measurements were made on both the LASERSCAN and the OFDA100. The trends of all three measurements over the fleece were compared. Different sheep exhibited different ranges in measured wool characteristics over their fleeces.

As MFC is now creating a great deal of interest among wool producers, the use of MFC as a selection tool was discussed, with particular emphasis on site selection. Sites for sampling were chosen to measure the MFC of three strains of animals: Fine, Medium-Peppin and Broad wool merino strains.

Introduction

The variability in measured fleece traits across the body of an animal can influence the selection decisions made by wool producers. Marler (2001a, 2001b) demonstrated how measurement variability could result in inappropriate selections during culling by wool producers. Hansford *et al* (2002) has shown that the selection of animals is influenced by the method used for the testing of fleeces, while Turner *et al* (1953) demonstrated wool measurements vary over a fleece. These papers have concentrated on Mean Fibre Diameter (MFD) because this is the measurement of greatest commercial significance. Increased interest in the measurement of Mean Fibre Curvature (MFC) as an additional selection tool has necessitated that investigations be conducted into the variability of MFC over a fleece.

Materials And Methods

Fifty ewes were sampled randomly from each of three genetically dissimilar flocks of Merinos, born and pastured within the Trangie QPLU$ flock located in Central NSW (Taylor and Atkins 1997; Taylor and Atkins 2000; Fish 2002). The ewes were 15 months of age carrying 12 months of wool growth, and represented the control lines of Fine, Medium-Peppin (herein referred to as Medium) and Broad wool Merino strains, as outlined by Taylor and Atkins (1997).

Prior to shearing, 10cm^2 wool samples were removed from the 150 animals using fine gauge animal clippers. Wool was removed from each of nine sites on the left side of all 150 animals, as depicted in Figure 1.

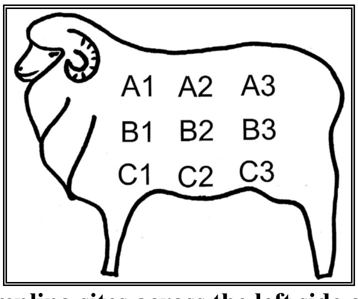

Figure 1: Sampling sites across the left side of the animal.

Each site sample was split into two sub-samples. Sub-samples were then aqueous scoured, dried and conditioned to comply with IWTO-52-96. Each sub-sample was tested once using the two measurement instruments of OFDA100 and LASERSCAN. Sub-samples were minicored once for each test. For each site two test specimens of 1000 counts were measured on LASERSCAN and two slides (i.e. test specimens) were measured on OFDA100. In the case of LASERSCAN, any one of a possible 10 LASERSCANs was used for the measurement of a test specimen, however, for OFDA100, any one of 2 OFDA100 instruments was utilised.

An analysis of variance was performed on the balanced datasets for each strain and instrument used. Variance components were estimated for each site. The variances reported in Tables 2, 3 and 4 include any between-instrument variances because the experimental design was not structured to allow removal of this component of variance.

Results and Discussion

Table 1 summaries the results for the three strains investigated. The three strains were found to be significantly different for both MFD and MFC. In general, the three strains measured slightly higher for MFD on OFDA100 than on LASERSCAN, however the reverse relationship occurred for MFC.

Table 1. Means for Mean Fibre Diameter (µm), Standard Deviation of the Fibre Diameter (µm), and Mean Fibre Curvature (deg/mm).

Parameter	LASERSCAN			OFDA100		
	Fine	Medium	Broad	Fine	Medium	Broad
MFD	19.1	20.0	23.2	19.4	20.3	23.3
SSD	3.7	4.4	4.7	3.8	4.4	4.7
MFC	107.6	88.7	79.6	103.6	85.3	74.5

Mean Fibre Diameter

Analysis of the MFD data showed an increase in the MFD from anterior to posterior positions along the bodies of the animals, for each of the three strains for both the instruments used for the measurement of fleece differences. MFD was also shown to decrease from the dorsal to ventral positions in most cases. Table 2 shows the average difference between each sampling site and the mean value of animals partitioned by strain and by instrument. Values are accompanied by an estimated variance component for each individual site.

Of the six possible statistical groupings (3 strains x 2 instruments), the midside (B2) was found to relate directly to the animal's mean in only one group (Medium measured on LASERSCAN). In the remaining groups, the midside was offset by either –0.2µm or –0.3µm. This result is not unexpected, and supports findings by Turner *et al* (1953), which showed that the midside does not always equal the mean fleece value for MFD.

Table 2. Differences between mean site MFD and mean strain MFD (µm) as measured by LASERSCAN and OFDA100, with the associated site variance estimate. (Note: shading has no statistical meaning, it is for ease of interpretation only.)

	LASERSCAN MFD						OFDA100 MFD					
	Fine		**Medium**		**Broad**		**Fine**		**Medium**		**Broad**	
Site	**x-Mean**	**Var**	**x-Mean**	**Var**	**x-Mean**	**Var**	**x-Mean**	**Var**	**x-Mean**	**Var**	**x-Mean**	**Var**
A1	-0.1	1.0	+0.2	1.7	+0.1	1.8	-0.1	1.2	+0.1	1.7	+0.1	1.8
A2	0.0	1.0	+0.5	1.9	+0.5	2.4	+0.1	1.4	+0.4	1.9	+0.4	2.3
A3	+0.4	1.1	+0.6	2.2	+0.8	2.7	+0.4	1.2	+0.5	2.2	+0.9	2.5
B1	-0.3	0.8	-0.3	1.0	-0.6	2.4	-0.4	0.8	-0.3	1.7	-0.6	1.5
B2	-0.2	0.8	0.0	1.5	-0.3	2.3	-0.2	1.0	-0.2	1.5	-0.3	2.1
B3	+0.3	1.1	+0.4	2.1	+0.8	2.6	+0.2	1.3	+0.4	2.0	+0.7	2.2
C1	-0.6	0.8	-0.7	1.4	-1.4	1.7	-0.7	0.9	-0.8	1.4	-0.9	1.8
C2	-0.2	0.9	-0.6	1.6	-0.8	2.1	-0.4	1.4	-0.6	1.5	-0.7	1.8
C3	+0.7	1.4	+0.3	2.0	+0.4	2.2	+0.5	1.3	+0.2	1.8	+0.6	2.1
Mean	19.1	1.0	20.0	1.7	23.2	2.2	19.4	1.2	20.3	1.7	23.3	2.0

Standard Deviation of Fibre Diameter

Analysis of the data for SDD shows that the trends in SDD across the bodies of the animals closely resembled the trends in MFD (Table 3). A small range in SDD, accompanied by very small estimated variance components showed that SDD is within 0.2µm of the mean SDD for animals across most sites.

The mean components of variance estimated for SDD were found to be similar for all strains and both instruments.

Table 3. Differences between mean site SDD and mean strain SDD (µm) as measured by LASERSCAN and OFDA100, with the associated site variance estimate.

	LASERSCAN SDD						OFDA100 SDD					
	Fine		Medium		Broad		Fine		Medium		Broad	
Site	x-Mean	Var	x-Mean	Var	x-Mean	Var	x-Mean	Var	x-Mean	Var	x-Mean	Var
A1	0.0	0.2	0.0	0.5	+0.1	0.4	0.0	0.2	0.0	0.3	+0.1	0.3
A2	0.0	0.3	+0.1	0.5	+0.3	0.4	+0.1	0.2	+0.2	0.3	+0.2	0.3
A3	0.0	0.2	+0.1	0.5	+0.1	0.5	+0.1	0.2	+0.3	0.4	+0.3	0.3
B1	-0.1	0.2	-0.1	0.4	-0.1	0.4	-0.1	0.2	0.0	0.2	-0.1	0.3
B2	-0.1	0.2	0.0	0.4	0.0	0.4	+0.1	0.2	+0.1	0.2	+0.1	0.3
B3	+0.1	0.3	+0.1	0.6	+0.2	0.4	+0.1	0.2	+0.2	0.3	+0.2	0.4
C1	-0.2	0.2	-0.3	0.3	-0.4	0.4	-0.1	0.2	-0.2	0.2	-0.3	0.4
C2	-0.1	0.2	-0.3	0.4	-0.3	0.3	-0.1	0.2	-0.2	0.2	-0.3	0.3
C3	+0.2	0.3	0.0	0.5	0.0	0.3	+0.2	0.2	0.0	0.3	0.0	0.2
Mean	3.7	0.2	4.4	0.5	4.7	0.4	3.8	0.2	4.4	0.3	4.7	0.3

Mean Fibre Curvature

Analysis of the MFC data showed trends in MFC were exhibited within strains and within instrument types (Table 4). There was a general trend for an increase in MFC from the dorsal to ventral positions. There was also an increase in MFC from anterior to posterior regions.

Previous reports (Fish *et al* 1999; Sumner & Upsdell 2001) showed MFC to decrease as MFD increases. This relationship was true for the dorso-ventral relationship between MFD and MFC. However, a contradictory relationship exists for the anterior-posterior trends, which showed an increase in both MFD and MFC.

Table 4. Differences between mean site MFC and mean strain MFC (deg/mm) as measured by LASERSCAN and OFDA100, with the associated site variance estimate.

	LASERSCAN MFC						OFDA100 MFC					
	Fine		Medium		Broad		Fine		Medium		Broad	
Site	x-Mean	Var	x-Mean	Var	x-Mean	Var	x-Mean	Var	x-Mean	Var	x-Mean	Var
A1	-3.8	180.7	-3.0	103.9	-3.4	123.5	-5.1	92.9	-3.6	38.2	-3.5	41.5
A2	+0.2	160.5	-0.5	149.0	-1.2	113.8	-0.5	96.5	-2.5	54.6	-0.9	59.5
A3	+1.0	155.2	-1.0	112.1	-0.4	155.0	+0.2	86.6	-1.0	47.0	-2.1	40.6
B1	-2.0	127.8	-2.7	107.4	-2.1	112.1	-1.0	92.2	-1.6	54.3	-1.5	39.3
B2	+0.8	208.8	+0.9	125.4	+0.9	99.5	+3.1	90.0	+1.6	45.5	+1.5	45.0
B3	+3.0	163.5	+2.6	122.6	+1.2	146.6	+3.5	101.6	+1.3	49.0	+1.1	39.1
C1	-2.6	150.4	-0.3	93.8	-1.4	131.2	-3.1	100.9	-1.2	57.7	+0.3	52.7
C2	-1.8	218.1	+0.8	101.7	+1.2	172.8	-1.2	117.6	+1.1	54.6	+1.2	47.4
C3	+5.6	224.7	+3.1	110.0	+4.9	133.6	+3.3	102.9	+3.7	59.5	+5.1	51.9
Mean	107.6	176.6	88.7	114.0	79.6	132.0	103.6	97.9	85.3	51.2	74.5	46.3

The estimated variance components in Table 4 are extremely large when their relationship to the mean was compared to similar relationships in Tables 2 and 3. In some cases, the estimated variance component was larger than the mean MFC value for that particular statistical group. Also, a difference existed between the variance components estimated for LASERSCAN and OFDA100 for all strains of animals. The use of ten LASERSCAN instruments, compared to two OFDA100 instruments would have contributed to this difference in variance. Since MFC measurement does not include a calibration procedure which would compensate for minor differences between instruments (within instrument-type) and for preparation effects, between instrument differences (i.e. within instrument type) would be expected to be far more significant than for calibrated measurements such as MFD.

Variation Between Sites

When selecting animals, it is customary for woolgrowers to choose one testing site only. For the purposes of this paper, the midside (B2) is used to demonstrate the differences between site and fleece values for MFD, SDD and MFC that would be expected if the midside (B2) site were used for testing (Table 5). It is important to remember that the variance estimates in Tables 2 to 4 are pooled estimates for each strain, and that the level of within site variance can vary for individual animals within a strain. Therefore, Table 5 demonstrates the difference from the mean values that needs to be accounted for if using the midside to estimate mean values of MFD, SDD or MFC for the strains of animals measured in this trial.

Table 5. Differences from mean fleece values for MFD (µm), SDD (µm) and MFC (deg/mm) when the B2 site is used for site sampling using either LASERSCAN or OFDA100.

	LASERSCAN			OFDA100		
	Fine	Medium	Broad	Fine	Medium	Broad
MFD	-0.2	0.0	-0.3	-0.2	-0.2	-0.3
SDD	-0.1	0.0	0.0	+0.1	+0.1	+0.1
MFC	+0.8	+0.9	+0.9	+3.1	+1.6	+1.5

Using the data outlined in this paper, sampling sites have been selected that generated results similar to the overall mean for MFD, SDD and MFC, partitioned by instrument and strain (Table 6). In most cases, three separate sites are closely related to the overall mean of the measurements for the three strains involved. This illustrates that if only one site is to be chosen for measurement purposes, then it needs to reflect the measurement components of greatest interest to the breeding or selection program to be implemented.

Table 6. Selected fleece testing sites which provided estimates closest to the mean value for the measurement of individual fleece components using either LASERSCAN or OFDA100.

	LASERSCAN			OFDA100		
	Fine	Medium	Broad	Fine	Medium	Broad
MFD	A2	B2	A1	B2	B2	A1
SDD	A1	B2	C3	A1	B1	C3
MFC	B1	C1	B2	A3	A3	C1

Concluding Remarks

As expected, MFD, SDD and MFC vary over an animal, between animals in a flock and between flocks. In general, MFC was shown to increase from the dorsal to ventral regions, and from the anterior to posterior regions. The variance estimates for MFC as a proportion of the range were substantially higher than for MFD and SDD. The high variance estimates for MFC are due not only to large within animal variations of MFC, but also to the large variance associated with the measurement. The MFC variation within an animal is not consistent between animals, or between strains.

Increased measurement accuracy may be achieved by measuring multiple sites as recommended by Turner *et al* (1953). Turner *et al* recommended that 3 sites along a diagonal plane be selected to reduce sampling variance due to MFD bias over animal's bodies. However, individual woolgrowers need to assess if the increase in costs associated with sampling more than one site can be justified by an increase in the testing accuracy achieved. For high value rams, the cost benefits may well be justified, but for flock partitioning purposes it may not. The ideal measurement regime for an individual woolgrower will depend greatly on what the grower is trying to achieve with the measurement.

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