ASSOCIATION OF FIBRE DIAMETER WITH WOOL COLOUR IN A SOUTH AUSTRALIAN SELECTION FLOCK

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SUMMARY

Bulk colour and its photostability are recognised limitations of wool relative to competing fibres and form part of the research program of the CRC for Sheep Industry Innovation. This paper shows effects of the association between fibre diameter and wool colour traits (greasy yellowness score, clean brightness and clean yellowness) and how adjustment for this association can change dam line and sire differences. The 323 wool samples used in this study were from yearling progeny of ewes from the South Australian Selection Demonstration Flocks (SDF) and 6 industry representative Merino sires. Progeny of dams from the Fine Wool (FW) component flock is separated in the analysis from that of dams from the other flocks involved (SD). Clean wool yellowness (Y-Z) ranged between 8.1 and 11.3. The mean fibre diameter of the progeny of the FW ewes was 16.0µm while for the SD ewes it was 17.6µm. Sire and dam line (FW and SD), when fitted in the analysis together with rearing type and day of birth, were significant for greasy visual yellowness and the clean colour traits ($P<0.01$). When mean fibre diameter, standard deviation of diameter and coarse fibre deviation were added as covariates this removed the dam line effect ($P>0.29$) for the clean colour traits; while for greasy visual yellowness it remained significant ($P<0.0001$). Furthermore, the differences in clean colour between the progeny groups of the rams were also reduced. Therefore, it is important to take into account the association of fibre diameter when assessing differences in clean colour.

INTRODUCTION

Whiteness and photostability of colour after processing are limitations of wool relative to other apparel fibres (Millington *et al.* 2008). Despite its importance to the textile industry, routine measurement of clean colour for greasy wool sale lot tests in Australia has had poor adoption. Similarly, when colour is considered in sheep selection it is usually limited to assessments of the visual appearance of the greasy wool (Brown 2006). Clean wool yellowness is highly heritable in Merino sheep (James *et al.* 1990). However, strong positive genetic correlations exist between Y-Z and mean fibre diameter (Hebart and Brien 2009; Smith and Purvis 2009). Millington *et al.* (2008) suggest that surface area and optical differences between fine and coarse fibres influence clean colour. Also, fibre medullation can result in a whiter fibre appearance due to the diffraction caused by this hollow component (IWTO 1998).

This paper examines the association between fibre diameter and wool colour traits (greasy yellowness, clean brightness and Y-Z) in terms of dam line and sire differences involving progeny of ewes from the South Australian Selection Demonstration Flocks.

MATERIALS AND METHODS

Location and wool. The 323 yearling ewes born in 2007 and not previously shorn as lambs were located at Turretfield Research Centre. The yearlings were the progeny of 6 industry representative Merino sires used via artificial insemination across ewes of component flocks from the SARDI's South Australian Selection Demonstration Flocks (AWI 2007). The animals were run as a single mob and progeny of ewes from the Fine Wool Flock component (FW) represented 41% of the total and each sire was represented by 10 – 23 individuals. Progeny of ewes from the other 5 component flocks from the Selection Demonstration Flocks together (SD) involved 28 – 36 animals per sire. The wool came from the rump region on the sheep and was collected from shorn fleeces.

Assessments and measurements. Each wool sample was subdivided to provide 40g for the AWTA Ltd tests of washing yield and clean colour and a 40g replicate sample for the OFDA100 test (IWTO 1998; 2000) and the remainder was used to make visual greasy wool assessments (AWI/MLA 2007). The AWTA Ltd tests provided a washing yield and tristimulus values X (red), Y (green) and Z (blue) for each sample (IWTO 2003). Clean yellowness is derived by Y-Z (higher value is more yellow) while brightness Y (higher indicates brighter or more intensity of reflection). A single slide with an average of 25,878 fibre snippets was tested by OFDA100 to measure the diameter and medullation variables (IWTO-57-98). The Visual Sheep Scores guide (AWI/MLA 2007) was used to score greasy yellowness (VC), fleece rot, dust penetration, crimp definition (CD), staple weathering, and staple structure. Crimp frequency was taken at the staple base and the average staple length based on 5 staples.

Statistical analysis. The data were analysed using procedures in SAS version 9.1. Regression analysis using the stepwise option with P=0.10 selected only mean fibre diameter (MFD) and VC as traits associated with Y-Z. As there was a limited range in Y-Z and some of the visual and medullation traits also had limited levels, a discriminant analysis was undertaken with 3 classes for Y-Z (<9.0; 9.0 – 9.9 and ≥10.0). GLM Model 1 involved Dam line (either FW or SD); Sire (1 to 6); Rearing type (1, single born or multiple born and single reared; 2, multiple born and reared) as the main effects and the first order interactions; and date of birth (day 13 – 26) was fitted as the covariate. GLM Model 2 involved simultaneously adding MFD, SDFD and CE (based on the discriminant analysis for Y-Z) as additional covariates to Model 1 (Table 1).

RESULTS AND DISCUSSION

The discriminant analysis selected the traits in Table 1 as associated with Y-Z class. MFD had the major effect while CVD, CF, CE and O had smaller significant effects. Figure 1 shows the relationship between MFD and Y-Z for all data. The correlation between the OFDA100 measures (Step 1-5) and Y-Z class was r = 0.71 (Table 1) while the regression shown in Figure 1 has a correlation of r = 0.67; which are higher than other reported phenotypic correlations (Smith *et al.* 2007) due to the added diameter components and perhaps also the large sample size (mean of 25,878 fibre snippets).

Table 1. Traits affecting fibre clean yellowness (Y-Z)

Step	Trait	Partial r^2	Probability >F
1	Mean fibre diameter (MFD)	0.385	<0.0001
2	Comfort factor (CF)	0.032	0.0052
3	Coarsest 5% of fibres deviation (CE)	0.033	0.0048
4	Coefficient of variation of diameter (CVD)	0.036	0.0031
5	Objectionable medullated fibres/10K (O)	0.023	0.0258
6	Greasy visual colour (VC)	0.019	0.0532
7	Crimp definition (CD)	0.017	0.0716

In GLM Model 1, Sire and Dam line were significant (P<0.01) for VC and clean colour X, Y, Z and Y-Z, and the diameter variables MFD, SDFD and CE. In Model 2 the covariates for diameter were significant for all of the clean colour variables (MFD, *P*<0.0001; SD, *P*<0.05; CE, *P*<0.01), improving model r^2 and completely removing the effect of Dam line (Table 2), but these covariates were not important for VC. The effect of Sire in GLM Model 2 remained significant (*P*<0.001) for VC, X, Y and Z but became non-significant for Y-Z (*P*=0.076). Sire*Dam line interactions were significant (*P*<0.05) for Z and Y-Z in Model 1 and 2 (Table 3).

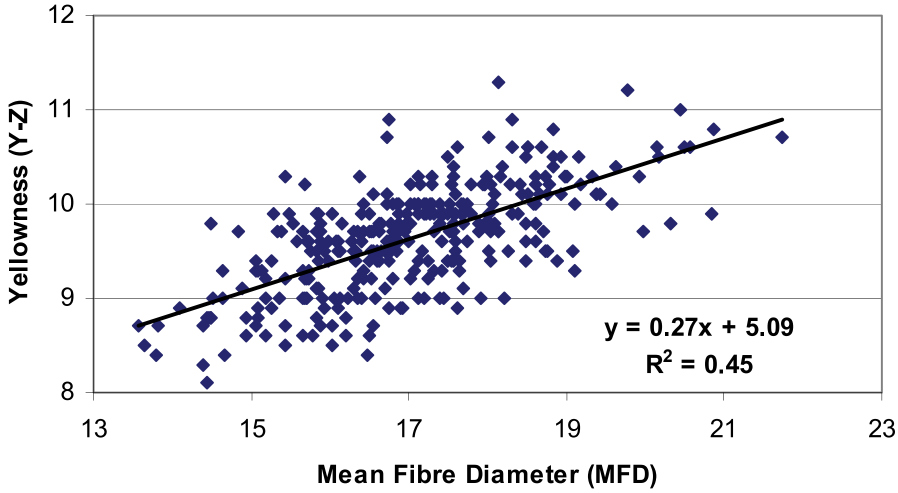

Figure 1: Relationship between mean fibre diameter (MFD) and yellowness (Y-Z)

A significant effect of Rearing Type (RT) occurred for X and Y (*P*<0.05) using Model 1 (lambs reared as multiples having lower values than singles) was removed in Model 2. RT also affected SDFD (*P*=0.022) and CE (*P*=0.007), the lambs reared as multiples had higher mean values than singles (3.94 v. 3.82µm and 7.42 v. 7.15µm; respectively), but not MFD. This result may reflect nutritional restriction on secondary follicle maturation for multiple born/reared lambs allowing more of the diameter variability associated with primary follicles to persist in the subsequent lamb/yearling fleece (Schinckel 1958). Sire*RT or Dam*RT interactions were not significant except Sire*RT for MFD in Model 1 (*P*=0.048); likely due to sampling. Day of birth as covariate, being restricted by artificial insemination to a range of 11 days, was non-significant.

Table 2 shows the GLM means for VC, Y and Y-Z and the associated difference in MFD, SDFD and CE of the progeny of SD and FW dam lines using Model 1 and in parenthesis the means from Model 2. Adjustment of the data for fibre diameter (MFD, SDFD and CE) reduced the difference between FW and SD dam lines for clean colour (Y and Y-Z) but not greasy colour (VC). Table 3 shows the sire mean values for VC and Y and the Sire*Dam line means for Y-Z from Model 1 and Model 1. Differences between the sire progeny groups for clean colour (Y and Y-Z) were reduced after adjustment for fibre diameter in Model 2.

Table 2. GLM means from Model 1 and Model 2 (in parenthesis)

Dam line		MFD	SDFD	CE	VC	Y	Y-Z
SD		17.6 a	4.10 a	7.75 a	2.07 a	72.2 a	9.81 a
	(Model 2)				(2.09 a)	(72.5 a)	(9.65 a)
FW		16.0 b	3.65 b	6.82 b	1.64 b	72.8 b	9.37 b
	(Model 2)				(1.61 b)	(72.2 a)	(9.64 a)

Means in columns with a different letter (a,b) are different at the 95% confidence level (*P*<0.05)

Table 3. Means for sire or sire within dam line for Model 1 and Model 2 (in parenthesis)

Sire	VC		Y		Dam	Y-Z	
Model	1	2	1	2	line	1	2
1	2.08 bc		73.3 d		SD	9.73	(9.55)
		(2.06 bc)		(73.1 d)	FW	9.05	(9.45)
2	1.82 b		71.7 ab		SD	9.89	(9.62)
		(1.84 b)		(71.8 a)	FW	9.50	(9.64)
3	1.81 b		72.3 bc		SD	10.03	(9.82)
		(1.82 b)		(72.3 abc)	FW	9.35	(9.59)
4	2.10 c		71.4 a		SD	9.95	(9.65)
		(2.11 c)		(71.6 a)	FW	9.83	(9.96)
5	1.82 b		73.3 d		SD	9.62	(9.64)
		(1.80 b)		(72.8 bcd)	FW	9.10	(9.56)
6	1.49 a		72.8 cd		SD	9.63	(9.60)
		(1.48 a)		(72.6 cd)	FW	9.37	(9.65)
Range	0.61	0.62	1.9	1.5		0.99	0.51

Means in the VC and Y columns with a different letter (a,b,c,d) are different ($P<0.05$)

CONCLUSION

The basis of the relationship between fibre diameter and clean colour could involve several factors (e.g. surface area and optical properties; fibre structure and composition, fibre and staple density, follicle type ratio, wax and suint ratio and composition) that either affect the colour measurement or susceptibility of the fibre to yellowing. Whatever the cause it is clear that fibre diameter should be taken into account when considering clean colour differences.

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