
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

Effects of sire and body site on wool colour measurements in Romney x Perendale progeny

T. WULIJI, K.G. DODDS, R.N. ANDREWS, P.R. TURNER AND R. WHEELER

AgResearch, Invermay Agricultural Centre, Private Bag 50034, Mosgiel.

ABSTRACT

Six Romney rams were selected, three for “Bright” and three for “Yellow” wool, using estimates of breeding values for base wool colour. Six hundred Perendale ewes were randomly allocated to these rams in a single sire groups and joined for one mating cycle. Female progeny (n=280) were identified and grazed in one mob until weaning then split into two, one on Invermay and the other on Woodlands. Shoulder wool strip samples were collected at 3, 9, 12 months of age, two-tooth and as 2 year old ewes. The wool characteristics of yield, fibre diameter, resistance to compression and tristimulus colours were measured. No significant sire effect was found for tristimulus Y values at any sampling interval. A significant ($P<0.05$) tristimulus Y-Z difference was found for two tooth fleeces in progeny of Yellow sires compared with Bright (5.3 vs. 4.4 SED 0.4). Belly and back site wool was significantly ($P<0.05$) more yellow (Y-Z 7.8 and 6.1) than other body sites, belly wool was also lower ($P<0.05$) for brightness (Y 47.9) than other sites. The most significant source of variation in tristimulus Y and Y-Z values was contributed by body regions of fleece, emphasising the importance of effective skirting of fleeces.

Keywords: crossbred; sheep; fleece; belly; yellowness; discolouration.

INTRODUCTION

The colour of wool is important as it limits the range of dyeing and the light shade options available for end products. Yellowness was associated with poor processing and dyeing performance in both woollen and worsted yarn manufacturing (Rottenbury, 1984). Diversification in the end uses of crossbred wool in worsted or semi-worsted products, rather than traditional carpeting, has promoted a greater interest in wool colour. Yellowness in New Zealand crossbred wool is the major cause of increasing price discounts. The New Zealand Wool Board analysis of wool auction data over the past years has indicated a gradual but important increase in relative economic value for brightness and a discount for yellowness (Maddever *et al*., 1991). Yellowing in wool varies with season and time of shearing (Sumner *et al*., 1992; Reid *et al*., 1993). Greasy wool yellowness has been noted in the literature as being of medium to high heritability (James *et al*., 1983) whereas the heritability for the colour of the scoured wool heritability is low and the relationship between greasy and scoured wool yellowness is inconsistent (Whiteley *et al*., 1980). Major sources of discolouration are environmental and seasonal effects, while variation between body fleece regions may also make a significant contribution.

The colour of wool can be described objectively by measuring the Commission Internationale de I’Eclairange (CIE) tristimulus values X,Y,Z (Edmunds, 1977). The test for yellowness in sale lots is reasonably well correlated with tops (Thompson, 1988), and the scoured wool test is a broad predictor of dyeability in woollen products. This project investigated the effects of sire, body region, farm location and sampling time on colour values of Romney x Perendale ewe crossbred ewe wool collected during 1990 to 1992.

MATERIALS AND METHODS

Animal selection

Six 2-tooth high fleece weight Romney rams from the Mt Linton Station, Ohai, Southland were selected from 300 ram hoggets for progeny test mating in 1990. Midside fleece samples taken from these rams had been recorded for fleece weight at shearing in 1989 and midside fleece samples were tested for yield, fibre diameter, bulk, staple length and wool colour (Tristimulus X, Y, Z; Y-Z). Breeding values were estimated for brightness and yellowness. Three sires were chosen for wool brightness (Tristimulus Y value: 61, 63 and 62; Tristimulus Y-Z value: 1.1, 1.1 and 1.1 respectively) and another three for wool yellowness (Tristimulus Y-Z value: 10.3, 8.7 and 8.1; Tristimulus Y-Z value: 10.3, 8.7, and 8.1 respectively). Their progeny were grouped to provide “bright” and “yellow” wool lines.

Six hundred Perendale mixed-age ewes were randomly allocated in groups of 100 to each of the rams and joined for one cycle (17 days) in single sire mating groups on the Invermay farm in April 1990. Ewe lambs were identified to sire, ear tagged at docking, weaned at 12 weeks of age (n=250) and grazed together until lamb shearing at 4 months of age (January 1991).

Management and measurements

After being shorn as lamb shearing the animals were randomly subdivided into two groups within each sire line. One of these remained on the AgResearch Invermay farm near Dunedin, while the other was transferred to the Woodlands Research Station near Invercargill for grazing until 2-tooth shearing (March 1992). After 2-tooth shearing the Woodlands group was transferred to the AgResearch Gore Station for grazing until 2 year old shearing (December 1992). There is a local climatic difference, with rainfall higher at Gore and Woodlands (1041 mm annum^{-1}) than at Invermay farm (687 mm annum^{-1}), and it is slightly colder at Woodlands than Invermay.

The animals were recorded for live weight at weaning, shearing (lamb, hogget in September 1991, and 2-tooth) and at the first wool sampling (March 1991). Greasy fleece weights (excluding belly wool) as lamb (LFW), hogget (HFW), 2-tooth (TFW) and 2 year old ewe (EFW) were recorded. Mean fibre diameter (MFD) and resistance to compression (RtC) were determined for hogget wool samples. A shoulder strip wool sample (8cm wide) was clipped on each animal from the top of the shoulder diagonally to mid belly at three monthly intervals (starting from March 1991) adjacent to each earlier strip so that the first strip represents three months wool (I), the second strip represents six months wool (II) and third strip represents nine months growth (as hogget, (III). Further strips were collected from 2-tooth (IV) and 2 year old ewes (V). In addition, four ewe hoggets (two per farm) from each sire were wool sampled from six positions namely neck, shoulder, midside, breech, belly and back at hogget and 2-tooth shearing.

Wool samples from different seasons and fleece parts were measured for yield (%), and tristimulus X, Y (brightness), Z and Y-Z (yellowness) values measured using a HunterLab (Labscan) spectrophotometer with a 4g subsample (NZS 8707:1984). A 2.5g subsample was tested for RtC (Resistant to compression tester, Agritest Ltd) and MFD (Sonic Fineness Tester, CSIRO).

Statistical analysis

The measurements at each sampling were analysed by least squares methods. The models included location (except for weaning weight and LFW), sire group and sire. For yellowness and tristimulus Y the models also included the location by sire group interaction as in some cases this was significant. Selection group was tested using the sire mean square. Correlations between the same type of measurement at different times were calculated after first adjusting for location.

Yield, yellowness and brightness of the patches taken from different positions on the animal were analysed using residual maximum likelihood. (REML) with the MIXED procedure in SAS (SAS 1992). The model included location, sire group, time, patch site, time by location and time by patch site interactions as fixed effects, and sire and animal as random effects. Location by patch site interaction was also included as a fixed effect in the model for yield.

RESULTS

Liveweight, fleece weight and fleece characters:

The animals grazed at Invermay achieved a significantly ($P<0.001$) higher liveweight than the Woodlands group in March, June and September 1991, but this had reversed by the 2-tooth weighing in March 1992, (Table 1). There was no difference between sire groups for liveweight. Animals at Woodlands clipped significantly less wool than their Invermay counterparts for HFW and TFW, while the reverse occurred at two year old ewe shearing; with no difference between sire groups for any of these measurements (Table 2). MFD and RtC were not different for sire groups but were significantly ($P<0.001$) higher at Invermay than Woodlands.

Yield gradually declined from period I to III (September) when the fleece was longest, but was higher again for 2-tooth fleeces (Table 3). The lower yields also corresponded to the lower fleece growth seasons. There was no difference between sire groups for any interval, but yields at Invermay were significantly ($P<0.05$) higher than those at Woodlands for intervals I, IV and V, but lower for interval III (September).

Sire group differences for brightness and yellowness were consistent with their subgroups, however these dif-

TABLE 1: Least squares means for liveweight (kg) by sire groups and locations

Group	Subgroup	No	WWT	Mar 91	June 91	Sept 91	Mar 92
Sire	Bright	120	21.2	27.9	33.4	37.6	55.8
	Yellow	130	21.0	26.9	32.2	37.0	54.5
	SED	0.6	0.5	0.5	0.4	0.5	
Location	Invermay	127	21.1	28.0	36.2	41.0	54.0
	Woodlands	123	-	26.8	29.3	33.6	56.2
SED				0.4**	0.4***	0.4***	0.6***

**: P<0.01; ***: P< 0.001.

TABLE 2: Least squares means for greasy fleece weights (kg), fibre diameter (µm) and resistance to compression (kPa) values for sire groups and locations

Group	Subgroup	LFW	HFW	TFW	EFW	MFD	RtC
Sire	Bright	1.10	2.27	2.22	2.56	32.8	9.99
	Yellow	1.16	2.31	2.27	2.53	33.4	9.84
	SED	0.04	0.09	0.06	0.08	0.7	0.42
Location	Invermay	1.13	2.75	2.42	2.31	33.6	10.25
	Woodlands	-	1.82	2.07	2.77	32.6	9.58
	SED		0.04***	0.03***	0.06***	0.2**	0.11**

**: P<0.01; ***: P<0.001.

TABLE 3: Least squares means for yield at each sampling, by sire group and location

Group	Subgroup	I[1]	II	III	IV	V
Sire	Bright	71.9	68.8	63.1	76.0	71.0
	Yellow	71.7	69.5	63.8	76.9	70.9
	SED	1.0	0.8	1.0	0.7	0.2
Location	Invermay	73.6	69.2	59.4[2]	77.7	73.6
	Woodlands	69.9	69.1	67.5	75.3	68.3
	SED	0.3**	0.4	0.6***	0.3***	0.5**

[1] Intervals were I: Jan-Mar 1991, II: Mar-Jun 1991, III: Jun-Sep1991, IV: Sep 1991 - Mar 1992, V: Mar-Dec 1992; [2]: strip samples were clipped under wet conditions and/or stored improperly at Invermay for interval III; **:P<0.01; ***:P<0.001..

TABLE 4: Least squares means for brightness (tristimulus Y) and yellowness (tristimulus Y-Z) of scoured wool at each sampling

Group	Subgroup	I[1]		II		III		IV		V	
		Y	Y-Z	Y	Y-Z	Y	Y-Z	Y	Y-Z	Y	Y-Z
Sire	Bright	63.0	2.4	57.8	5.3	56.0	6.7	62.6	4.4	60.1	4.4
	Yellow	62.6	2.6	56.9	5.7	55.0	7.0	61.4	5.3	59.8	5.0
	SED	0.6	0.2	0.7	0.3	0.8	0.2	0.4	0.3*	0.5	0.3
Location	Invermay	62.9	2.6	61.3	3.9	51.4	10.1	61.9	4.6	59.7	5.2
	Woodlands	62.6	2.5	53.4	7.0	59.5	3.7	62.2	5.0	60.9	4.2
	SED	0.3	0.1**	0.4**	0.2**	0.4**	0.2	0.2	0.4***	0.3***	0.3

[1] See Table 3 for description of intervals.

ferences were not significant except for yellowness of 2-tooth fleeces (Table 4). There were significant interactions ($P<0.05$) between sire group and site at IV and V with the progeny of yellow sires having higher wool yellowness than those of bright sires at Woodlands, but not significant at Invermay. The 2-tooth fleeces were brighter than those of hoggets and 2 year old ewes, and progeny in the bright sire group generally had brighter (higher Y values) fleeces than those in the yellow sire group.

Correlations of yellowness value between different intervals was generally poor. However there were low but significant positive relationships between intervals at III, IV and V, which were the samples of normal fleece shearing (Table 5). The correlations between tristimulus Y measurements was better than those for Y-Z.

TABLE 5: Correlation coefficients of brightness (below diagonal) and yellowness (above diagonal) values between sampling intervals

Intervals[1]	I	II	III	IV	V
I	-	0.08	-0.00	0.03	0.14*
II	0.13*	-	0.08	0.16*	0.12
III	0.01	0.13*	-	0.13*	0.13
IV	0.19**	0.20**	0.29***	-	0.27***
V	0.06	0.11	0.17*	0.33***	-

[1] See Table 3 for description of intervals; *:$P<0.05$; **:$P<0.01$; ***:$P<0.001$.

Wool colour variation with body region:

Patches clipped over six body regions showed lower yield and brightness and higher yellowness for the hogget sampling compared with the 2-tooth sampling (Table 6). The yellow sire group had higher yellowness than the bright sire group. All patch positions were similar for these traits except that the belly was significantly lower in yield and brightness, and higher in yellowness than other positions. Body region colour did not vary significantly between sire groups and locations.

TABLE 6: Yield, brightness and yellowness in serial patches from different body regions, at hogget and 2-tooth for time of shearing x site

Patch Serials	Yield (%)[1] Hogget	Yield (%)[1] 2-tooth	Brightness (Y) Hogget	Brightness (Y) 2-tooth	Yellowness (Y-Z) Hogget	Yellowness (Y-Z) 2-tooth
neck	67.5	73.5	56.9	60.4	5.0	3.8
shoulder	65.1	73.5	55.9	59.7	5.8	4.2
midside	64.5	73.2	56.3	60.1	5.4	3.6
breech	62.4	71.9	56.0	60.1	5.0	4.3
belly	43.5*	60.8*	47.9*	55.4*	7.8*	8.4*
back	64.9	72.8	55.7	57.8	6.1	5.2
Average SED	0.9		0.8		0.5	

[1] yield was not adjusted for moisture reagain; *: $P< 0.05$ for comparison with the other means in the column.

DISCUSSION

The live weight and fleece weight differences for the two locations indicate that there were variations in grazing conditions, with seasonal fluctuations in pasture growth rate and stock management. Fibre diameter and resistance to compression in hogget fleeces were not affected by sire groupings but there were location differences. Variation in brightness and yellowness was found to be similar to previous studies on wool colour in crossbred sheep (Bigham *et al*., 1984). Yellowness differed between seasons with higher yellowness coinciding with the increasing length of wool. From interval I to III, the increasing in yellowness and decreasing in brightness (low tristimulus Y value) coincided with wetter seasons. Such a trend was found in a Northland study where annually shorn fleeces were yellower than biannually shorn fleeces (Fitzgerald *et al*., 1986). Sumner *et al*. (1992) showed that 8 monthly shorn fleeces were significantly less yellow than 12 monthly shorn. The longer wool was also found to be yellower in an incubation test (Reid *et al*., 1996). Although there was no significant difference in wool colour between Romney fleece weight-selected and control flocks at Woodlands, the increasing fleece length of hoggets from autumn through winter to summer coincided with increasing yellowness (Wuliji *et al*., 1995), similar to the current results.

Genetic correlations between colour and other wool traits are strongly masked by environmental factors particularly the influence of temperature and humidity on wool yellowing, which is compounded by both length and structure differences of fleeces (Fitzgerald *et al*., 1986). The correlation in brightness and yellowness between repeated shearings across the two years was low in agreement with those reported by Fitzgerald *et al*. (1986). Whereas the Poorer correlations between tristimulus Y-Z measurements than those for Y in this trial suggests larger environmental effects on yellowness than brightness measurements. Average yellowness was consistently higher for the yellow sire group at both locations and all samplings. As the Perendale breed has less yellowness than Romney (Wood *et al*., 1997), it is likely that Perendale x Romney progeny are lower than Romneys for yellowness.

The small differences between the two sire groups were expected because the heritability for brightness and yellowness (~0.15) is low in crossbred sheep wool (Wuliji *et al*., 1998). Based on the sire selection differentials we would expect progeny to differ by 0.75 for brightness (tristimulus Y) and 0.60 for yellowness (tristimulus Y-Z), while the actual responses were 1.0 and 0.4 at hogget shearing respectively. The fact that there were significant sire group differences on some occasions at Woodlands, but not Invermay, suggests an interaction between genotype and locations, which may have been facilitated by a higher rainfall and wetter local environment at Woodlands.

The patches from the different body regions showed that belly wool was yellower than that from other positions, regardless of the sire group. Bigham *et al*. (1984) showed that differences between crossbreds in yellowness were small, but in decreasing order, averaged over all fleece parts, the breeds were Romney, Coopworth and then Perendale, and that there was a significant breed by body region interaction for tristimulus Y and Y-Z values. Wool from the shoulder, breech and belly were less bright and more yellow than other parts of the fleece.

CONCLUSION

The significant variation between parts of fleece imply that careful skirting is an effective way to improve the brightness of a clip. Alternatively, sheep should be shorn prior to the onset of weather conditions resulting in the expression of yellowness. A profile of wool discolouration in seasons and regions could be established as a guide for improving crossbred wool clip colour.

ACKNOWLEDGEMENTS

This project was funded by the NZ Foundation for Research, Science and Technology. The first author also would like to acknowledge for the Vernon Willey Trust for awarding the initial assistance for this study.

REFERENCES

Bigham, M.L., Sumner, R.M.W. and Cox, N.R. 1984. Sources of variation and experimental design criteria for wool colour measurement applied to Romney, Coopworth and Perendale flocks. *New Zealand Journal of Experimental Agriculture* **12:** 231-236.

Edmunds, A.R. 1977. Colour measurement of scoured wool. *Wool* **6 (4):** 29-32.

Fitzgerald, J.M., Bigham, M.L. and Sumner, R.M.W. 1986. Wool colour: CIE Y and Y-Z tristimulus values. (Wool Production Seminar) *WRONZ Special Publications* Vol **5:** 8-17.

James, P.J., Ponzoni, R.W., Walkley, J.R.W., Smith, D.H and Stafford, J.E. 1983. Fleece rot in South Australian Merinos: heritability and correlation s with fleece characters. *Wool Technology and Sheep Breeding* **31 (4):** 152-157.

Maddever, C.D., Carnaby, G.A. and Ross, D.A. 1991. Relative economic values of wool processing parameters. *Proceedings of the New Zealand Society of Animal Production* **51:** 333-337.

NZS 8707: 1984. Method for the measurement of the colour in wool.

Reid, T.C. 1993. Variability in the susceptibility of wool to yellowing. *Proceedings of the New Zealand Society of animal Production* **53:** 315-318.

Reid, T.C., Sumner, R.M.W., Sedcole, J.R. and Botica, K.J. 1996. Effect of wool length and season of shearing on the propensity of Romney, Coopworth and Perendale wool to yellow. *Proceedings of the New Zealand Society of Animal Production* **56:**324-327.

Rottenbury, R.A. 1984. Colour of wool and processing. *Wool Technology and Sheep Breeding* **32 (3A):** 190-196.

SAS Institute Inc.: 1992. SAS Technical Report P 229, SAS/STAT Software: Changes and Enhancements, Release 6.07, Cary, NC:SAS Institute Inc.

Sumner, R.M.W., During, C. and Webby, R.W. 1981. Effect of grazing management on hogget fleece characteristics. *Proceedings of the New Zealand Society of Animal Production* **41:** 128-132.

Sumner, R.M.W., Webby, R.W. and Winder, R.D. 1992.Comparative performance of ewes shorn either once-yearly or 3 times in 2 years. *Proceedings of the New Zealand Society of Animal Production* **52:** 225-227.

Thompson, B. 1988. Colour in wool: The measurements of average yellowness and its implications. *Wool Technology and Sheep Breeding* **36:** 96-103.

Whiteley, K.J., Clark, M.J., Welsman, S.J and Stanton, J.H. 1980. Observations on the characteristics of Australia greasy wool. Part II: Colour in Merino fleece wools. *Journal of Textile Institute* **71 (4):** 177-188.

Wood, J.E., Reid, T.C., Munro, M.H.G., Sherlock, R.R. and McLaughlin, J.R. 1997. Relationships between the compounds causing scourable diffuse yellow and yellowness of greasy and clean wool. *Proceedings of the New Zealand Society of Animal Production* **57:** 70-72.

Wuliji, T., Dodds, K.G., Andrews, R.N., Turner, P.R and Wheeler, R. 1998. Responses to fleece weight selection and heritability estimates of wool characteristics in Romney sheep. *Proceedings of the 6th World Congress on Genetics Applied to Livestock Production* **24:** 55-58.

Wuliji, T., Weatherall, I.L., Andrews R.N., Dodds, K.G., Turner, P.R and Wheeler, R. 1995. Effect of selection for wool growth on seasonal patterns of yield, fibre diameter, and colour in Romney lines. *Australian Journal of Experimental Agriculture* **35:** 27-31.