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Age effects and interrelationships between wool characteristics of genotypes used to develop GrowBulk sheep

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ABSTRACT

Groups of 10 ewes of four breeds (Romney, Dorset cross Romney, Texel cross Romney, (Dorset x Romney) cross (Texel x Romney) born in two years (1994, 1995) were used to investigate the changes of wool characteristics with increasing age. Each ewe was wool sampled at hogget shearing in October and at each subsequent annual shearing in July until 1999. Romney fleeces had higher clean fleece weight, lower core bulk, longer staple length, less fibre curvature and lower crimp frequency. All genotypes exhibited similar ageing patterns for each measured wool characteristic except fibre diameter variability. Days to form a crimp increased, staple length and core bulk did not change and fibre curvature and crimp frequency decreased with increasing age. Clean fleece weight and fibre diameter increased to a plateau between 2 and 4 years of age before declining. The repeatability of all individual characteristics decreased with increasing age. There were no consistent differences in the relationship between core bulk and a combination of fibre curvature and fibre diameter across genotypes within age groups. Crossing Dorset and Texel rams over Romney ewes to generate a specialty high wool bulk composite genotype did not influence the age trends and interrelationships between individual wool characteristics inherent in the base Romney flock.

Keywords: wool bulk; age; fibre characteristics; Romney; Dorset; Texel.

INTRODUCTION

Crossing individually selected sheep of different breeds according to objectively assessed criteria is increasingly being used to generate composite genotypes with specified performance attributes to meet the requirements of, leather and wool processors. As many of these criteria are relatively expensive to measure, individual sheep in both the foundation and composite flocks are usually measured only once during their lifetime. These measurements are most commonly made at about 1 year of age before the sheep are first mated. All subsequent breeding decisions are then related to the yearling measurement ignoring subsequent ageing changes. Most studies on age trends in growth and wool characteristics have tended to focus on a single genotype (Brown *et al.*, 1966, 1968; Hight *et al.*, 1976; Sumner & Dick, 1997).

One recently developed composite is the GrowBulk sheep (Sumner, 1999a) developed by crossing high-wool-bulk Poll Dorset and Texel rams with high-fleece-weight Romney ewes. Intensive selection of the resulting progeny has enabled the production of a specialty genotype with the capacity to produce high bulk wool with a minimal reduction in fleece weight (Sumner *et al.*, 1998). Wool bulk, a measure of the ability of a mass of wool fibres to resist compression and fill a space, is an important characteristic associated with superior performance for many end-products produced from Romcross type wool (Sumner *et al.*, 1991).

No comparative studies have been undertaken of changes in wool characteristics associated with the expression of wool bulk, during the productive life of genotypes used to generate GrowBulk sheep to ascertain whether they exhibit different ageing patterns that could impact on the pattern expressed by GrowBulk sheep. As no mixed-age flocks of Poll Dorset or Texel ewes were maintained at a single site during development of the GrowBulk sheep, the only opportunity to compare the

relative effect of ageing in these genotypes was to compare groups of Dorset cross Romney, Texel cross Romney, interbred sheep and Romney sheep maintained within the nucleus flock.

This study investigated the changes in wool bulk and related fibre characteristics during the productive life of Romney, Dorset cross Romney, Texel cross Romney and (Dorset x Romney) cross (Texel x Romney) ewes.

MATERIALS AND METHODS

Sampling

During development of the GrowBulk sheep (Sumner *et al.*, 1998) groups of Romney (R), Dorset x Romney (DR), Texel x Romney (TR) and interbred DR x TR (DTR) ewes were maintained at AgResearch, Whatawhata Research Centre. The TR group and half the DTR group were born at the AgResearch, Gore Research Station and transferred to the Whatawhata Research Centre in 1997. Ewes were first shorn as lambs in mid December at approximately 3 months of age. They were next shorn as hoggets the following October and thereafter, once yearly in mid July before lambing. Beginning at hogget shearing, each sheep was weighed before shearing and a midside wool sample collected. The data analysed in this study were collected from 10 sheep in each of the four genotypes born in 1994 and 10 sheep of each of the four genotypes born in 1995 that survived until the 1999 shearing with the exception of the TR group. In this group, 10 sheep in each of the two lamb drops were available for sampling up to and including 1998, but only 6 sheep born in 1994 and 5 sheep born in 1995 were available for sampling in 1999. Where more than 10 sheep were available within a genotype group, the ewes from which data were analysed were selected by restricted randomisation to balance pregnancy/rearing status.

Wool measurements

Individual greasy fleece weight was recorded at each

shearing. Staple length of the greasy wool sample was measured and the total number of crimps along the staple counted. Crimp frequency was calculated as total number of crimps along the staple divided by staple length. Time to form a crimp was calculated as the number of days since the sheep were previously shorn divided by the total number of crimps along the staple. Each midside wool sample was aqueous scoured and the washing yield calculated to derive the clean fleece weight. Core bulk (Standards Association of New Zealand, 1994), and mean fibre diameter, fibre diameter variation and fibre curvature were measured by optical fibre diameter analyser (OFDA) (Edmunds, 1995).

Statistical analysis

Data measured at each sampling were analysed by Bayesian smoothing (Upsdell, 1994) using multiple variate extensions (Upsdell, 1985). The effects of age, pregnancy/rearing status and genotype were fitted using shearing date, and curves for individual sheep as error terms. Correlations (repeatability) between measurements of samples taken at hogget and each subsequent shearing were calculated. A measure of the overall repeatability, or intra-class correlation, between measurements at each shearing with each other shearing pooled within year born groups was derived by residual maximum likelihood procedures (GENSTAT, Lawes Agricultural Trust, 1993). This was calculated as the square root of (between sheep variance / (between sheep variance + residual variance)) (Turner & Young, 1969). As the measured fibre characteristics associated with core bulk are interrelated and exhibit different ageing patterns, their effect on bulk was assessed by multiple regression analyses at each year of age

(GENSTAT, Lawes Agricultural Trust, 1993). Linear combinations of fibre curvature and fibre diameter were used to generate predictive models for core bulk at each age.

RESULTS

The adjusted mean values for pre-shear live weight, clean fleece weight and each of the measured wool characteristics within each genotype over time are plotted in Figure 1 along with the pooled least significant differences (LSD) between the predicted curves for each characteristic.

The R ewes had a higher clean fleece weight, a lower core bulk, a longer staple length, less fibre curvature and a lower crimp frequency at all ages than the other three genotypes which were not significantly different. There were no significant differences between the genotypes in pre-shear live weight, fibre diameter or time to form a crimp. Fibre diameter variability, however, exhibited a significant genotype-by-age interaction. It increased slightly in the R group but decreased in the DR, TR and DTR genotypes with increasing age such that fibre diameter variability in the R group exceeded that in the other three genotypes from 3 years of age.

Time to form a crimp increased progressively with increasing age. Pre-shear live weight increased to a plateau at 3 years of age. Mean values for staple length were greatest at 2 years of age. Clean fleece weight and fibre diameter increased to a plateau at 2 to 4 years of age, before declining. Core bulk did not change significantly, and fibre curvature and crimp frequency decreased gradually with age.

FIGURE 1: Mean values for live weight, wool production and wool structural characteristics within the R (●), DR (△), TR (▽) and DTR (○) breed groups over time. The cross-hatched area indicates the pooled least squares difference (LSD). Lines further apart than the LSD at a particular age are significantly different at the 5% level.

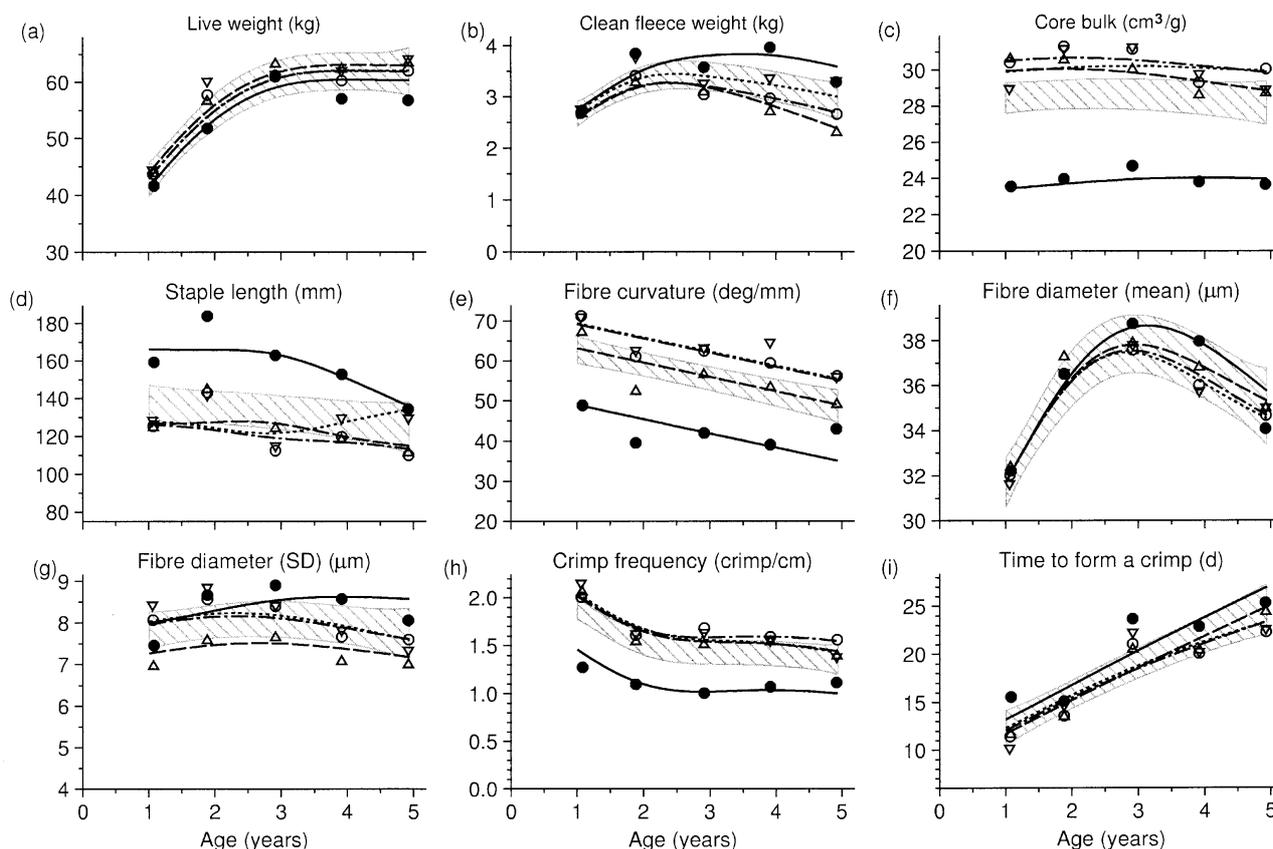


TABLE 1: Correlation coefficients (\pm SD) between measurements taken at hogget shearing and each of the subsequent shearings and the overall correlation coefficient (\pm SD) between all measurements, in order of decreasing values for the overall correlation coefficient.

Characteristic	Age (years)				Overall
	2	3	4	5	
Fibre curvature ($^{\circ}$ /mm)	0.81 \pm 0.08	0.69 \pm 0.10	0.75 \pm 0.09	0.70 \pm 0.10	0.91 \pm 0.06
Core bulk (cm^3/g)	0.83 \pm 0.08	0.73 \pm 0.10	0.74 \pm 0.10	0.63 \pm 0.11	0.89 \pm 0.07
Crimp frequency (crimp/cm)	0.69 \pm 0.10	0.53 \pm 0.12	0.39 \pm 0.13	0.47 \pm 0.12	0.84 \pm 0.08
Staple length (mm)	0.80 \pm 0.08	0.68 \pm 0.10	0.59 \pm 0.11	0.63 \pm 0.11	0.81 \pm 0.08
Fibre diameter (SD) (μm)	0.68 \pm 0.10	0.54 \pm 0.12	0.57 \pm 0.12	0.54 \pm 0.12	0.78 \pm 0.09
Clean fleece weight (kg)	0.54 \pm 0.13	0.36 \pm 0.15	0.45 \pm 0.14	0.47 \pm 0.14	0.70 \pm 0.11
Live weight (kg)	0.44 \pm 0.15	0.49 \pm 0.14	0.51 \pm 0.14	0.40 \pm 0.15	0.64 \pm 0.13
Fibre diameter (mean) (μm)	0.64 \pm 0.11	0.49 \pm 0.12	0.58 \pm 0.12	0.52 \pm 0.12	0.63 \pm 0.11
Time to form a crimp (d)	0.45 \pm 0.13	0.38 \pm 0.13	0.24 \pm 0.14	0.28 \pm 0.14	0.53 \pm 0.12

An estimate of the correlation coefficient between the value of each measured characteristic at one year of age and the value at each subsequent shearing, and an estimate of the overall repeatability across all shearings are given in Table 1. No breed effect could be detected due to the small size of each breed group. The relationship between characteristics measured at hogget shearing weakened with increasing age. There was no significant relationship between the hogget fleece and later fleeces after 3 years of age for the time to form a crimp. Overall repeatability for each of the measured characteristics consistently exceeded

the estimated correlation coefficients between measurements collected at 1 and 2 years of age.

The proportions of variation in core bulk at each age for the sheep in this trial that could be explained by a combination of fibre curvature and fibre diameter (Sumner & Upsdell, 2001) were 66, 69, 78, 69 and 62% at each successive shearing between 1 and 5 years of age respectively, with an overall estimate of 65% across all age groups and 69% across adult sheep between 2 and 5 years of age.

TABLE 2: Individual coefficients \pm SE for (a) fibre curvature and (b) fibre diameter and (c) the constant \pm SE for the relationship between core bulk and a combination of fibre curvature and fibre diameter for each breed at each age.

		R	DR	Breed TR	DTR	Overall
(a) Fibre curvature						
Age (years)	1	+0.17 \pm 0.05	+0.14 \pm 0.07	+0.15 \pm 0.04	+0.14 \pm 0.06	+0.25 \pm 0.02
	2	+0.15 \pm 0.08	+0.22 \pm 0.06	+0.29 \pm 0.04	+0.12 \pm 0.06	+0.28 \pm 0.02
	3	+0.18 \pm 0.06	+0.32 \pm 0.05	+0.30 \pm 0.04	+0.15 \pm 0.04	+0.29 \pm 0.02
	4	+0.23 \pm 0.05	+0.25 \pm 0.05	+0.23 \pm 0.06	+0.19 \pm 0.07	+0.25 \pm 0.02
	5	+0.07 \pm 0.06	+0.22 \pm 0.06	+0.20 \pm 0.16	+0.18 \pm 0.04	+0.27 \pm 0.03
	2 - 5	+0.18 \pm 0.03	+0.24 \pm 0.03	+0.26 \pm 0.02	+0.16 \pm 0.03	+0.27 \pm 0.01
Overall		+0.16 \pm 0.02	+0.21 \pm 0.02	+0.24 \pm 0.02	+0.15 \pm 0.02	+0.25 \pm 0.01
(b) Fibre diameter						
Age (years)	1	+0.10 \pm 0.18	+0.54 \pm 0.20	+0.37 \pm 0.20	+0.65 \pm 0.20	+0.65 \pm 0.11
	2	-0.24 \pm 0.16	+0.25 \pm 0.16	+0.44 \pm 0.13	+0.39 \pm 0.19	+0.30 \pm 0.09
	3	+0.25 \pm 0.24	+0.05 \pm 0.17	+0.27 \pm 0.17	+0.38 \pm 0.18	+0.25 \pm 0.10
	4	-0.05 \pm 0.17	+0.38 \pm 0.16	+0.53 \pm 0.26	+0.50 \pm 0.16	+0.34 \pm 0.09
	5	-0.29 \pm 0.21	+0.07 \pm 0.24	-0.10 \pm 0.71	-0.02 \pm 0.18	+0.24 \pm 0.14
	2 - 5	+0.06 \pm 0.07	+0.18 \pm 0.08	+0.37 \pm 0.09	+0.30 \pm 0.08	+0.23 \pm 0.05
Overall		+0.16 \pm 0.06	+0.30 \pm 0.07	+0.50 \pm 0.08	+0.36 \pm 0.07	+0.40 \pm 0.04
(c) Constant						
Age (years)	1	+12.5 \pm 7.3	+4.2 \pm 10.2	+6.8 \pm 8.5	-0.2 \pm 8.8	-7.9 \pm 4.1
	2	+26.8 \pm 7.8	+9.6 \pm 7.8	-2.5 \pm 5.9	+10.2 \pm 7.8	+3.0 \pm 3.8
	3	+8.0 \pm 10.9	+10.0 \pm 7.8	+2.3 \pm 8.5	+7.5 \pm 7.9	+3.6 \pm 4.3
	4	+16.8 \pm 6.0	+1.6 \pm 6.2	-3.5 \pm 12.1	+0.2 \pm 7.6	+2.2 \pm 3.7
	5	+30.8 \pm 9.3	+15.3 \pm 10.3	+20.9 \pm 32.6	+20.7 \pm 7.5	+6.2 \pm 5.9
	2 - 5	+14.8 \pm 3.2	+10.2 \pm 3.5	+0.8 \pm 4.3	+10.0 \pm 3.4	+6.1 \pm 1.9
Overall		+11.4 \pm 2.8	+7.5 \pm 3.4	-2.4 \pm 3.7	+8.4 \pm 3.1	+0.22 \pm 1.6

The coefficients and constant for the linear relationship between core bulk and fibre curvature and fibre diameter are given in Table 2. While there were no consistent trends across breeds within ages for either of the coefficients or the constant term, the slope of the overall fibre diameter relationship was greater and the overall constant term less for the 1-year-old sheep than for the other age groups. Although the overall slopes of the fibre curvature and fibre diameter relationships across all age groups were greater in the TR group than in the R and DTR groups, the effect

was reduced when the hogget fleece data was dropped from the analysis. Coincident with the differences in the slopes, the overall constant term was also lower for the TR group than for the other three groups.

DISCUSSION

The age trends for all the characteristics reported here within a sample of R, DR, TR and DTR genotypes are similar in direction and magnitude to those previously reported for lines of Perendale ewes selected for or against

wool bulk (Sumner & Dick, 1997). Ewes in this trial progressively increased in live weight prior to shearing up to 3 years of age and days to form a crimp continued to increase gradually over the period of measurement. Clean fleece weight and fibre diameter increased to a plateau between 2 to 4 years of age before declining. Core bulk did not change significantly and fibre curvature, and crimp frequency decreased gradually with age. Fibre diameter variation did not change in the R fleeces but gradually declined in the other three genotypes. Similar age trends for greasy fleece weight and staple length have also been reported for Romney and Dorset x Romney ewes at the same location (Bigham *et al.*, 1978). As with Perendale sheep, it is apparent that age changes in individual fibre characteristics interact to the extent that the compressibility of the fibre mass, or core bulk, is not influenced by the age of the sheep growing the wool.

Although age trends in the TR group were similar to those in the other genotypes, relationships between fleece characteristics within the TR group appeared to differ from those within the other genotypes. These differences may be a reflection of an experimental bias, which was not statistically significant, through these sheep being born, reared and grazed for a period at another location before being transferred to the Whatawhata Research Centre. While grazing apart, samples from the two flocks were measured by the same laboratory but in different batches.

There was a good agreement between the order of magnitude of the overall correlation coefficient between measurements across all sheep in both the data collected during this trial and the data reported by Sumner & Dick (1997). It is of particular note that, in these data, the correlation coefficients between measurements collected at 2, 3 and 4 years of age and later shearings exceeded the values of the coefficients between measurements collected at hogget and later shearings.

Previous studies (Sumner & Dick, 1997; Sumner, 1999b) have shown the feasibility of using predictive relationships combining fibre curvature and fibre diameter measurements at the base of the staple of 6-month-old sheep to rank sheep for core bulk as a hogget as an aid for culling. Similar predictive relationships across adult sheep of increasing age, as reported by Sumner & Dick (1997) and in this trial, suggest that the interrelationship between core bulk and its associated dimensional fibre characteristics may continue to change, albeit slowly, until sheep are at least 1 year of age. While these changes do not appear to impact on between-sheep ranking, they do impact on the magnitude of the predicted value. As hogget wool is traded as a unique entity it may be appropriate for practical purposes that different predictive equations be used for hogget, as distinct from "adult" or "mixed-age" fleece wool. The reported similarity in relationships between core bulk and fibre curvature and fibre diameter in sheep from 2 to 5 years of age indicates that a similar prediction equation will be equally effective for individual fleeces of adult sheep or blended lines of wool grown by adult sheep of different ages.

Crossing Dorset and Texel rams over Romney ewes to generate a specialty high wool bulk composite genotype has not influenced the age trends and interrelationships between individual wool characteristics inherent in the base Romney flock.

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