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GENETIC PARAMETERS FOR STAPLE STRENGTH AND COEFFICIENT OF VARIATION OF FIBRE DIAMETER IN MERINO WOOL OF DIFFERENT STAPLE LENGTH

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SUMMARY

Staple strength (SS) and coefficient of variation of fibre diameter (FDCV) were measured on full length staples from 12 months of wool growth, and wool staples cut to 80 or 60 % of their full length from the tip. The results show that SS and FDCV for the different staple length treatments are heritable but lower for staples 60% or shorter than their full length. SS and FDCV measured on wool staples greater than 60 % of their normal length are genetically the same trait.

BACKGROUND

Staple strength (SS) is the second most important wool trait affecting the price of wool after fibre diameter, and tender wools are consistently penalised, especially for the finer types. Stott (2004), as quoted by Smith *et al.* (2004), indicated that SS was the single largest contributing factor to variation in price received for wool less than 19.5 micron. SS is a heritable trait exhibiting large phenotypic variation (Greeff *et al.* 1995) and it will respond to selection (Greeff *et al.* 1997). SS is generally expensive to measure but it is genetically highly correlated to coefficient of variation of fibre diameter (FDCV). The latter trait is obtained automatically when measuring fibre diameter with the Optical Fibre Diameter Analyser (OFDA) or Laserscan®. FDCV is therefore an effective indicator trait to indirectly select for SS.

However, ram breeders have recently expressed concern that SS could be affected by staple length (SL). Anecdotal information indicates that shorter staples from premature shearing have higher SS than full grown staples, which could impact on the effectiveness of SS measurements for selection purposes. This paper aims to determine whether reducing SS has a significant effect on the genetic parameters of SS and FDCV measurements and whether SS should be adjusted for SS to increase the accuracy of breeding values for SS.

MATERIAL AND METHODS

Midside wool samples were collected from 2642 Merino hoggets, born from 1992 to 2005 in a fully pedigreed Merino resource flock based at Katanning, Western Australia. The progeny were produced by 120 sires that were mated to 1081 dams. The establishment of this flock was described by Greeff *et al.* (1997) and consisted of high, average, and low staple strength lines. The animals were born in July/August in a Mediterranean environment and managed as one group from marking to weaning. All males were castrated during the first 4 years. In 1996 every second male within a sire progeny group was castrated at marking. From 1997 all males were left intact. After weaning at approximately 100 days of age, the animals were separated on sex and managed separately up to hogget shearing.

Sampling of wool. All lambs received an even-up shearing after weaning in November and were shorn again as hoggets in November the following year. Wool samples were collected with Oster® clippers immediately prior to shearing, on the midside of all animals. Ten pencil sized wool staples were pulled from each midside sample and measured for SS (SSMS) and SS.

From 1997, 1060 individual fleeces of the 1996, 1997 and 1998 born progeny were stored in separate plastic bags. These fleeces were re-sampled in 2012 at the estimated midside site. All the fleeces were in good condition and allowed to recover from compaction in the bale before sampling. Thirty pencil sized staples were pulled from each of the stored fleece samples.

Measurement of staple sections. SS of the 2642 midside samples were measured with using ATLAS. SS of the 1060 stored fleeces, were measured with an Agritester. SS can only be reliably measured on staples that are longer than 40mm (MicronMan, personal communication). Therefore, from each stored fleece, SS was measured on 10 full length wool staples (SS100), on 10 staples that were cut with a guillotine at 80% of their length (SS80), and on a further 10 wool staples that were cut at 60% of their length (SS60). All staples were measured and cut from the tip end of the staple to achieve the required length reductions in order to leave the tip intact.

FDCV of all the wool samples were measured with an OFDA2000 but the original midside samples were measured on an OFDA100. The traits were defined as CVMS (FDCV of the midside samples), CV100, CV80 and CV60 (FDCV of staples from stored fleeces not cut, cut at 80% or at 60% of their length, respectively), and CVbutt80 and CVbutt60 (FDCV of leftover butts from staples of stored fleeces cut at 80% or 60% of their length).

Data analysis. The data were analysed with ASREML (Gilmour *et al.* 2009). An animal model was fitted with year of birth, sex, age of the dam and birth status as fixed factors and all 2 way interactions. Univariate analyses were carried out to identify significant fixed effects, followed by bivariate analysis to obtain variances and covariances for genetic parameter estimation.

RESULTS AND DISCUSSION

The average fibre diameter of this flock was 19.8 ± 1.5 micron with an average SS of 107 ± 12 mm for wool samples collected on the midside. The average SS of the full length staples sampled from the stored fleeces was 99 ± 10 mm, demonstrating that wool samples collected on the shearing board were shorter on average than midside wool samples removed with Oster® clippers prior to shearing. The average SS of the staples cut at 80% of their SS was 78 ± 9 mm, and 61 ± 6 mm for staples cut at 60% of their length. The butts of the 80% and 60% cut staples were 21 mm and 38 mm long, respectively, which relates to 20% and 40% of the full length staples. Thus, the data set consisted of FDCV measured on midside staples (CVMS), on staples that were collected on the shearing board (CV100), and on staples that were 80% (CV80), 60% (CV60), 40% (CVbutt60) and 20% of full length staples (CVbutt80).

A significant sex x birth year interaction ($P<0.01$) was found for all the SS and FDCV traits, while age of the dam, birth status and day of birth were not statistically significant ($P>0.10$). The sex x birth year interaction could be explained by the fact that the males and females were managed separately from weaning to hogget shearing. Table 1 shows the basic statistics in wool from different length staples treatments.

SS of the different length treatments differed significantly ($P<0.01$). Table 1 show that SSMS exhibited double the amount of phenotypic variation compared to SS100, SS80 or SS60. However, SSMS and SS100, SS80 and SS60 measurements were carried out with different machines and with different wool sampling protocols. Pre-testing evaluation of the Agritester and ATLAS found that both instruments produced the same outcomes in SS when evaluated using a common set of samples. Table 1 also shows that as SS reduced, SS increased from 27.4 N/Ktex for SS100 to 31.3 N/Ktex for the SS60 length staples.

CVMS showed higher levels of phenotypic variation compared to CV100, CV80, CV60, CVbutt60 and CVbutt80. CVMS was measured on an OFDA100 whereas the CV100, CV80, CV60, CVbutt60 and CVbutt80 measurements were measured on single, greasy staples using OFDA2000. FDCV tended to decrease as the staples became shorter.

Table 1. Number of samples, mean, standard deviation (SD), minimum, maximum and the phenotypic variation (Vp) of staple strength and coefficient of variation of fibre diameter traits for wool with different length staple outcomes

Trait	n	Mean	SD	Min	Max	Vp
SSMS (N/Ktex)	2642	30.9	10.76	3.7	69.6	84.53
SS100 (N/Ktex)	1060	27.4	7.85	4.0	74.5	44.10
SS80 (N/Ktex)	1060	28.9	7.44	4.9	54.0	40.11
SS60 (N/Ktex)	1060	31.3	7.52	9.9	99.4	44.23
CVMS (%)	2642	21.8	3.08	14.3	35.8	8.08
CV100 (%)	1060	22.3	2.93	15.6	35.0	6.98
CV80 (%)	1060	19.8	2.40	14.8	28.6	4.75
CV60 (%)	1060	19.9	2.63	13.5	29.0	5.38
CVbutt60 (%)	1060	17.3	2.43	12.4	27.5	5.05
CVbutt80 (%)	1060	16.9	2.30	12.0	26.7	5.16

Heritability estimates. The heritability estimates for the SS measurements are shown in Table 2. Except for the low estimate of 0.31 for the SS60 measurement, the heritability of the other SS traits agrees with previous (Greeff *et al*. 1995; Greeff and Paganoni 2004). This shows that the heritability of SS is low in very short staples. However, adjusting SS measurements for SS resulted in no significant changes in heritability estimates for SS. The only improvement was a small increase from 0.31 ± 0.07 to 0.33 ± 0.07 for SS60.

Table 2. Heritability (on diagonal) of, and the phenotypic (above diagonal) and genetic (below diagonal) correlations between the different staple strength measurements and their standard errors in brackets

	SSMS	SS100	SS80	SS60
SSMS	**0.44 (0.05)**	0.73 (0.01)	0.69 (0.02)	0.51 (0.02)
SS100	0.99 (0.02)	**0.50 (0.08)**	0.69 (0.02)	0.48 (0.03)
SS80	0.99 (0.02)	1.01 (0.02)	**0.49 (0.08)**	0.52 (0.02)
SS60	0.85 (0.08)	0.98 (0.05)	0.97 (0.05)	**0.31 (0.07)**

The heritability estimates of the CVFD traits are shown in Table 3. All the h^2 estimates were above 0.5 with CV100 having the highest heritability estimate of 0.73 ± 0.07. The lowest heritability was found for CVbutt80 (0.51 ± 0.08) which represents only 20% of the staple. However, all these estimates agree strongly with published results in the literature (Greeff *et al.* 1995) and on estimates of short wool sections (Greeff and Paganoni 2004). Adjusting FDCV traits for SS had no effect on the heritability of FDCV traits.

Phenotypic correlations. Table 2 shows the phenotypic correlations between the different SS measurements, while that of the CVFD traits are shown in Table 3. Moderately high phenotypic correlations were found between the SS measurements with the lowest correlation between SSMS

Table 3. Heritability (on diagonal) and the phenotypic (above diagonal) and genetic (below diagonal) correlations between the different coefficient of variation of fibre diameter measurements (standard errors (SE) in brackets)

Trait	CVMS	CV100	CV80	CV60	CVbutt60	CVbutt80
CVMS	**0.63 (0.04)**	0.66 (0.02)	0.67 (0.02)	0.69 (0.02)	0.62 (0.02)	0.60 (0.02)
CV100	0.97 (0.02)	**0.73 (0.07)**	0.59 (0.02)	0.63 (0.02)	0.61 (0.02)	0.57 (0.02)
CV80	0.97 (0.02)	0.97 (0.02)	**0.53 (0.05)**	0.72 (0.02)	0.60 (0.02)	0.65 (0.02)
CV60	1.02 (0.02)	0.97 (0.02)	0.97 (0.02)	**0.61 (0.07)**	0.68 (0.02)	0.60 (0.02)
CVbutt60	1.00 (0.02)	0.97 (0.03)	0.96 (0.03)	0.95 (0.03)	**0.62 (0.07)**	0.70 (0.02)
CVbutt80	1.02 (0.02)	0.98 (0.03)	1.01 (0.02)	1.02 (0.02)	1.02 (0.01)	**0.51 (0.08)**

and SS60. The correlations between SS measurements of the different length staples decreased from 0.73 for SSMS and SS100, to 0.69 for SSMS and SS80, and to 0.51 for SSMS and SS60. The moderately high phenotypic correlation between SSMS, SS100, SS80 and SS60 of greater than 0.5, suggests that the measurements are repeatable.

The phenotypic correlations between the different FDCV traits are shown in Table 3. Again moderately high correlations were found with the lowest correlation of 0.57 being between CV100 and CVbutt80. No clear pattern was found as the staples became shorter indicating that FDCV of a short section of wool gives a reliable indication of FDCV of whole staple.

Genetic correlations. The genetic correlations among the SS measurements (Table 2) and among the FDCV measurements (Table 3) of the different length staples were generally very high. Some estimates fall outside the parameter space but were not significantly different from unity. This indicates that the same genes are controlling SS in staples that are up to 60 % shorter than full length staples.

CONCLUSIONS

This study shows that SS measured on short staples are heritable and genetically representative of SS measured on 12 month wool. SS measured on staples that are approximately 60 % or longer than their normal length, is genetically the same trait. Similar results were obtained for FDCV on staples of different length. The results confirm that SS and FDCV are reliable measurements to estimate a breeding value for SS in Merino sheep. However more work is needed to determine whether this finding will also apply in production systems with 8 months or shorter shearing times.

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