GENETIC PARAMETERS FOR SUBJECTIVELY SCORED TRAITS IN YEARLING AND ADULT FINE WOOL MERINOS

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SUMMARY
Genetic parameters were estimated for classer grade, handle, style, crimp definition, colour, neck wrinkle and body wrinkle scores in fine wool yearling wethers and yearling and adult ewes. Most traits had heritabilities of 20-40% and high genetic correlations (0.8 or more) between yearling and adult scores. The estimated genetic correlation between handle scores of independent assessors exceeded 0.99. Genetic correlations between subjective measurements and objectively measured traits were generally favourable. Softer handle was associated with lower fibre diameter (genetic correlations of 0.56 in yearlings, 0.57 in adults), increased yield (-0.55 and -0.39) and whiter colour (0.45 and 0.32). Better crimp definition was associated with lower variability of fibre diameter (0.45 and 0.46), whiter colour (0.31 and 0.51) and stronger staples (-0.24 and -0.37).

INTRODUCTION
Although the breeding objectives of all ram breeders includes subjectively scored traits (often called 'visually assessed' traits), there is little information from relevant sheep genotypes on genetic parameters or the non-genetic effects that influence these traits. These are needed to develop effective genetic evaluation programs and breeding objectives for the Australian sheep industry. This lack of information limits the ability of industry breeding services, such as Sheep Genetics Australia and Central Test Sire Evaluation, to incorporate visually assessed traits in their genetic evaluations (Mortimer 2007). This paper presents genetic parameter estimates for visually assessed and measured traits from a flock of fine wool Merino sheep. More extensive analyses of data from four Merino genetic resource fine, medium and broad wool flocks will be reported later.

MATERIALS AND METHODS
The data analysed here were collected from sheep born in 1990-97 as part of the CSIRO Fine Wool Project comprising 9 fine wool and 2 medium wool bloodlines (Swan *et al.* 2000). A total of 4855 ewes and 4453 wethers were recorded as yearlings (10 months of age). Most ewes (3921) were also recorded at 21 months. Offspring were from 429 sires and 4128 dams.

Traits included: classer grade (Grd, scored at 6 and 18 months of age, on a 3-point scale), neck and body wrinkle (Nwr, Bwr, both scored on 6-point scales), style (Styl, 7-point scale), handle, crimp definition (Crim, 5-point scale) and colour (Col, 5-point scale). All traits were scored by a single scorer each year except grade (where different bloodlines used different scorers) and handle (two independent scorers assessed all animals). Score 1 was for the best grade and style, the whitest colour, highest definition crimp and least wrinkled neck and body. Objective measurements included staple length (SL), staple strength (SS), mean fibre diameter (FD), coefficient of variation of fibre diameter (CVFD), body weight (BWT), greasy fleece weight (GFW) and yield (YLD). Table 1 lists means, minima, maxima and population standard deviations for all traits.

Univariate analyses were carried out using ASREML (Gilmour *et al.* 2002) to determine the most appropriate models. For yearling traits, the final fixed effects model included bloodline, management group, birth-rearing type (single/multiple birth/rearing), dam age (maiden or adult), sex, age (linear and quadratic) and the interaction of age with sex. For adult ewes, the model included birth-rearing type, current management group, dam age and linear effect of age; quadratic effects of age and previous management group (in which ewes were raised as yearlings) were not significant, so not included in the model. Permanent environmental effects of dam and maternal genetic effects were not significant for any subjectively scored trait, yearling or adult, so not included in the final models.

For adult ewes, heritabilities, genetic (r_g) and phenotypic (r_p) correlations were obtained from a multivariate analysis of all traits. For the larger yearling dataset, three multi-trait analyses were required, each including all subjectively scored traits and 1 to 3 objectively-measured traits; values were then averaged over the three runs. Genetic and phenotypic correlations between yearling and adult traits were calculated from bivariate analyses of subjective scores at the two ages.

Table 1. Characteristics of the data for each trait, including numbers of animals (N), means, minima and maxima and population standard deviations

	Yearlings					Adults				
	Min	Mean	Max	SD	N	Min	Mean	Max	SD	N
Grade	1	2.09	3	0.66	1339	1	2.07	3	0.69	3745
Style	1	3.26	7	1.00	6371	1	2.22	5	0.53	3649
Handle (1st scorer)	1	2.74	5	0.74	7658	1	2.78	5	0.78	3659
Handle (2nd scorer)	1	2.74	5	0.75	7358	1	2.76	5	0.75	3647
Crimp	1	2.61	5	0.72	7796	1	2.57	5	0.72	3661
Colour	1	2.64	5	0.77	7448	1	2.67	5	0.94	3662
Neck wrinkle	1	2.47	5	0.78	5017	1	2.69	5	0.76	3633
Body wrinkle	1	2.07	6	0.91	4833	1	2.10	5	0.73	3596
SL (mm)	34	70.9	113	10.9	5061	43	74.4	117	10.9	3645
SS (N/kTex)	10	40.5	76	10.6	5049	10	46.6	81	9.39	3636
FD (μm)	12.4	16.4	23.4	1.37	9251	14.5	18.4	24.5	1.51	3650
CVFD	11.3	17.5	29.0	2.55	8889	10.5	17.2	26.3	2.34	3644
BWT (kg)	11.6	25.3	44.4	4.24	7720	15.2	34.5	52.4	5.00	3636
GFW (kg)	0.62	2.03	4.6	0.54	9263	1.5	3.20	6.02	0.71	3653
YLD (%)	50*	73.2	90.4	4.31	5041	58.8	76.1	91.0	4.20	3620

* Yields of 50% were assumed for 7 animals with extremely low yields (<50%)

RESULTS AND DISCUSSION

Regression coefficients for age were significant for all yearling traits except crimp (Table 2); younger animals tended to have worse grade, style and handle scores, fewer neck and body wrinkles and whiter fleeces. For adult ewes, age at assessment was significant only for classer grade (scored at 18 months) and body wrinkle, the effects being in the same direction as yearlings.

Most subjectively scored traits had heritabilities of 27-40% (Table 2), the main exceptions being classer grade and style in yearlings (19% and 23% respectively) and neck and body wrinkle in adults (21% and 14%). This is in agreement with the conclusion of Mortimer (2007) that visual traits were at least moderately heritable.

Although phenotypic correlations between subjective scores of yearlings and adults were low, estimated genetic correlations for crimp, colour and handle were 0.8 or higher, suggesting that

Table 2. Estimated phenotypic variances (PV), heritabilities (h^2, %), effects of age (%) and genetic and phenotypic correlations between yearling and adult assessments

Trait	Yearlings					Adults					Correlations	
				Effect of age					Effect of age		gen	phen
	PV	h^2	SE	coeff[1]	SE	PV	h2	SE	coeff[1]	SE	r_g	r_p
Grade	0.35	18.9	5.7	-10.1	0.10	0.44	29.8	3.5	-3.7	0.7	39%	22%
Style	0.59	22.6	2.3	-2.0	0.04	0.22	28.0	3.4			45%	3%
Handle	0.52	29.1	2.3	-0.9	0.04	0.55	32.9	3.3			81%	8%
Colour	0.40	32.8	2.5	1.5	0.01	0.50	40.2	3.5			84%	13%
Crimp	0.46	26.8	2.3			0.47	26.6	3.4			86%	11%
Nwr	0.51	39.8	2.9	4.4	0.02	0.48	20.8	3.2			76%	12%
Bwr	0.53	37.8	3.0	4.6	0.02	0.50	14.1	3.0	1.8	0.7	73%	16%

[1] Effect of being 10 days older, expressed as percent of the trait mean, blank if not significant ($P > 0.05$).

Table 3. Estimated genetic *(%, below diagonal)* and phenotypic correlations (%) among subjectively scored traits and genetic correlations between subjective and objectively measured traits

Trait	Yearlings							Adults						
	Grd	Styl	Han	Col	Crim	Nwr	Bwr	Grd	Styl	Han	Col	Crim	Nwr	Bwr
Grade		30	6	19	5	-5	-5		26	15	28	13	-1	-1
Style	*44*		8	17	6	8	7	48		14	25	15	3	3
Handle	*-1*	*18*		25	15	6	5	34	35		21	15	3	5
Colour	*35*	*28*	*45*		17	0	0	62	39	32		26	-2	-3
Crimp	*28*	*15*	*37*	*31*		12	11	37	42	32	51		7	6
Nwr	*38*	*25*	*15*	*-8*	*23*		52	2	21	28	-3	15		52
Bwr	*8*	*23*	*20*	*-2*	*23*	*85*		-16	9	19	-6	20	93	
Estimated genetic correlations with measured traits														
SS	-19	-8	-24	-22	-24	7	21	-3	-27	-12	-25	-37	-14	-13
SL	-35	-48	-33	-5	3	-49	-47	-26	-39	-38	-1	3	-53	-36
FD	-41	-14	56	16	29	3	13	20	1	57	12	25	15	12
CVFD	28	10	16	18	45	20	10	23	35	16	28	46	24	13
BWT	-55	-21	7	1	-7	-18	-14	-37	-10	3	-5	-5	-12	5
GFW	-50	-24	-5	21	14	6	17	-5	-9	-12	21	32	30	54
YLD	-6	-21	-55	-48	-20	-3	-6	-36	-23	-39	-39	-37	-22	-21

Estimated standard errors of phenotypic correlations were less than 3.0. Estimated standard errors of genetic correlations: yearlings, 4-7, except classer grade (13-15); adults 5-9, except body wrinkle (9-11).

yearling and adult traits are under similar genetic control (Table 2). Grade (based on a 3-category scoring system) and style had lower estimated genetic correlations (0.39 and 0.45 respectively) between adult and yearling animals. The genetic correlation between the two handle scores (which were analysed as separate traits) exceeded 0.99 with phenotypic correlations of 0.66 for yearlings and 0.68 for adults. The results in Tables 2 and 3 are averages of parameter estimates for the two handle scores, so represent parameters values for a single score per animal. Neck and body wrinkle were also highly correlated (estimated genetic correlations were 0.85 for yearlings and 0.93 for adults, with phenotypic correlations of 0.52 for both age groups).

Estimated genetic correlations among subjectively scored traits and between subjectively scored and measured traits were generally favourable and often small (Table 3). Genetically superior animals for classer grade (scored 4 months before the other traits) tended to have above average genetic values for style, colour, crimp, body weight and staple length. Handle had high genetic correlations with fibre diameter (0.56 for yearlings and 0.57 for adults), but lower phenotypic correlations (0.31 and 0.33), in agreement with estimates reviewed by Mortimer (2007). Soft handle was also genetically associated with better colour (0.45 for yearlings, 0.32 for adults), higher yield (-0.55 for yearlings and -0.39 for adults), better crimp definition (0.37 for yearlings, 0.32 for adults) and longer staples (-0.33 and -0.38 for yearlings and adults respectively). White colour was also associated with higher yield (-0.48 yearlings, -0.39 for adults).

Phenotypic correlations were generally weaker than genetic correlations; the main exceptions were 0.26, 0.23 and -0.16 for GFW with neck and body wrinkle (yearlings) and grade (adults).

CONCLUSIONS

Visually assessed traits in fine wool Merinos had at least moderate heritability, with generally favourable genetic correlations both among visual traits and with measured traits. This implies that selection procedures that include visual traits will achieve some genetic gain. However, more sophisticated selection procedures (e.g. selection indexes, desired gains) should be investigated to identify potential improvements from strategies that can make optimal use of both measured and visual assessments.

Future reports will present genetic parameter estimates for a wider range of visually assessed traits from four Merino genetic resource flocks, representing fine, medium and broad wool types. This will be a step towards improving the availability of appropriate genetic parameters for these traits. In time, estimates from genetic resource flocks will be complemented by estimates recorded in industry flocks using approved standard scoring systems (Mortimer 2007).

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