CAN FOLLICLE DENSITY BE USED TO ENHANCE THE RATE OF GENETIC IMPROVEMENT IN MERINO FLOCKS?

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SUMMARY

The genetic relationships between skin follicle measurements, wool measurements and body weight were investigated using data from the CSIRO Fine Wool Project flocks. Follicle density (DEN), the ratio to secondary to primary follicle number (SPR), and the ratio of the fibre diameter from primary and secondary follicles (DPDS) are moderately to highly heritable. Genetic correlations between clean fleece weight (CFW) and the skin follicle traits are all small. By contrast MFD is strongly negatively correlated with SPR and DEN. There is also a strong positive correlation between DPDS and CVFD. Using these parameter estimates the consequences of selection strategies incorporating follicle density were modelled. DEN contributes little extra economic value to the objective of increasing CFW and reducing MFD.

Keywords: Merino, selection, skin follicle traits

INTRODUCTION

There is considerable discussion throughout the Merino breeding sector about the value of using visual and tactile properties of the skin and fleece as selection tools, either by themselves or in conjunction with measurements of wool production and wool quality. Skin assessment is claimed to be a useful low cost method of identifying animals that have high fleece weights and low fibre diameter, and hence offers an alternative to measurement of these economically important traits. The advocates of these methods identify follicle density as one of the underlying biological attributes that needs to be increased in order to achieve production and quality improvements.

Since its inception in 1990, an integral part of the CSIRO Fine Wool Project has been the measurement of follicle morphology. These data, together with measurements of traits of economic importance and assessments of fleece traits by trained sheep and wool classers, allow precise estimates of genetic parameters to be made. From these, it is possible to predict the consequences of different selection strategies, including those involving measures of skin morphology.

The objective of this paper is to evaluate the consequences of using skin measurements as additional selection criteria on genetic improvement of economically important traits in the fine wool Merino industry.

MATERIALS AND METHODS

The CSIRO Fine Wool Flock has been described in detail by Swan *et al* (1993). The flock consists of nine fine-wool and two medium-wool sub-flocks, each of 200 breeding ewes. The fine wool bloodlines were chosen to be representative of the major fine wool producing regions of eastern Australia, and the two medium wool bloodlines provide linkages with genetic studies focusing on medium wool sheep.

Lambs are born in October/November of each year and when aged 9 months midside samples are taken for fleece measurements. Skin biopsies are also taken at this time from the midside area. Data on skin traits used in this analysis have been collected from 2416 progeny from these flocks, sired by 196 rams, and born between 1990 and 1993. Follicles were counted and classified as primary or secondary using techniques outlined by Maddox and Jackson (1988). The following traits were derived: follicle density (DEN), ratio of secondary to primary follicles (SPR), and the ratio of mean diameter of the fibres from primary follicles to that from secondary follicles (DPDS).

Data were analysed by least squares ANOVA techniques to establish an appropriate model for isolating genetic effects. Multi-variate REML analyses using the VCE computer software (Groeneveld 1996) were then used to estimate genetic and phenotypic parameters.

The genetic and phenotypic parameters for the fleece traits used in this analysis were estimated in the same manner, but from a larger data set including 5100 animals born between 1990 and 1994. The traits were clean fleece weight (CFW), mean fibre diameter (MFD), coefficient of variation of fibre diameter (CVFD), and staple length (SL). Body weight (BWT) was also included in the analyses.

The SELIND software package (Cunningham and Mahon, 1974) was used to predict the consequences of using different breeding objectives and selection criteria over a ten year time frame. Proportions selected were 6% and 50% for males and females respectively, and generation intervals were assumed to be 2.5 years for males and 4 years for females. The breeding objectives were to increase clean fleece weight and either reduce or maintain mean fibre diameter. The value of a one micron reduction in fibre diameter was modelled as either 0.3% (equating to maintenance of mean fibre diameter in this flock), 5% or 10% of the clean wool price. The selection criteria included clean fleece weight, mean fibre diameter, and density.

RESULTS

Skin traits. Estimates of genetic and phenotypic parameters for wool and skin traits, and body weight are presented in Table 1. The skin traits were moderately to highly heritable. SPR and DEN were highly correlated, both phenotypically (0.62) and genetically (0.70). The estimates of phenotypic and genetic correlations involving DPDS and other skin traits were all close to zero.

Relationships between skin follicle traits, wool traits, and body weight. There was a strong negative relationship between DEN and MFD at the genetic level, with an estimated correlation of -0.68. There were small positive genetic relationships between DEN and CFW (0.13), and DEN and CVFD (0.15). The estimated genetic correlations between DEN and SL, and DEN and BWT were moderately negative (-0.31 and -0.26 respectively). Estimated phenotypic correlations involving DEN followed similar patterns to genetic correlations, although they were generally smaller in magnitude. Estimated genetic correlations involving SPR followed similar patterns to those involving DEN. There was again a strong negative relationship with MFD (-0.45), and there was a small positive relationship with CFW (0.13). Estimated genetic correlations involving DPDS were in general small to moderate and negative, with the exception of the correlation between DPDS and CVFD, which was highly positive (0.73).

Table 1. Estimates of phenotypic and genetic parameters for wool traits, body weight, and skin follicle traits. Trait means, phenotypic variances, heritabilities (in bold on diagonal), phenotypic correlations above diagonal *(italics)*, and genetic correlations below diagonal

	CFW	MFD	CVFD	SL	BWT	SPR	DEN	DPDS
Mean	1.63	16.9	17.6	66.5	26.0	22.2	83.9	1.09
V_p	0.06	1.13	4.99	0.80	9.95	26.86	262.40	0.02
CFW	**0.29**	*0.20*	*-0.10*	*0.34*	*0.44*	*0.20*	*0.04*	*-0.03*
MFD	0.14	**0.68**	*-0.10*	*0.16*	*0.22*	*-0.23*	*-0.39*	*0.08*
CVFD	-0.09	-0.14	**0.55**	*-0.12*	*-0.19*	*0.04*	*0.11*	*0.58*
SL	0.44	0.14	-0.08	**0.44**	*0.18*	*-0.16*	*-0.22*	*0.02*
BWT	0.27	0.18	-0.23	0.12	**0.48**	*-0.03*	*-0.22*	*-0.12*
SPR	0.12	-0.45	0.04	-0.25	-0.15	**0.52**	*0.62*	*0.00*
DEN	0.13	-0.68	0.15	-0.31	-0.26	0.70	**0.46**	*0.07*
DPDS	-0.13	-0.19	0.73	-0.04	-0.16	-0.09	0.08	**0.67**

Predicted genetic changes using alternative selection strategies. The results of 10 years of selection based on alternative criteria are presented in Table 2. Selection based entirely on follicle density (DEN) delivers substantial increases in DEN (38%) and SPR (34%). Associated with these increases are modest gains in CFW (3.1%) and MFD (-10.2%). There are also small decreases in staple length and liveweight and increases in CVFD and DPDS. By comparison, using an index of CFW and MFD gives changes in follicle traits that are dependent upon the relative economic value of MFD. At a micron premium of 0.3%, which delivers no change in MFD over 10 years, selection on CFW and MFD gives correlated increases in DEN and SPR of 7%. At micron premiums of 5% and 10%, the changes in follicle traits rise to between 27.5-33%. The highest micron premiums are also associated with losses in BWT and SL. Including density as a selection criterion in addition to CFW and MFD results in only minor improvements in the rates of change.

DISCUSSION

The estimates of heritability of follicle density used by Skerritt (1995) and reported by Hynd et al. (1996) for strong wool Merinos (0.20 and 0.18, respectively) are low compared to the estimate of 0.46 derived from the fine wool flocks in this study. The three studies have also yielded a wide range of values for the genetic correlation between clean fleece weight and follicle density in hogget animals. Whilst this study has reported a value of 0.13, Skerritt (1995) used a value of 0.01. By contrast with these two low correlations, Hynd *et al* (1996) reported a value of 0.54 from strong wool hoggets shorn at 10 months of age. These results suggest that there may be significant differences between bloodlines in the genetic relationships between traits related to follicle and skin morphology, and that appropriate estimates of genetic parameters should be used in any evaluations involving these traits.

This study shows that in fine wool flocks, little is gained by using follicle density as an additional selection criteria for an objective that contains clean fleece weight and mean fibre diameter. Similar conclusions were made by Skerritt (1995), who used genetic parameter estimates for skin traits derived from medium wool flocks.

Table 2. Predicted genetic changes over 10 years in the breeding objective ($ Obj), wool traits (CFW, MFD, CVFD and SL), body weight (BWT), and skin traits from selection strategies using CFW, MFD, and DEN. Responses for individual traits expressed as % of mean (Table 1)

Selection criteria	Micron Prem.	$ Obj	CFW	MFD	CVFD	SL	BWT	SPR	DEN	DPDS
DEN	0.3%	4.0	3.1	-10.2	4.1	-3.4	-6.3	34.2	38.0	2.5
	5%	18.0	3.1	-10.2	4.1	-3.4	-6.3	34.2	38.0	2.5
	10%	34.0	3.1	-10.2	4.1	-3.4	-6.3	34.2	38.0	2.5
MFD+CFW	0.3%	15.3	18.9	0.0	-1.5	8.8	4.8	7.2	6.9	-2.6
	5%	30.7	7.5	-15.8	3.2	1.3	-1.8	27.5	31.4	4.7
	10%	57.1	2.9	-17.7	3.9	-1.1	-3.4	28.5	33.0	6.0
MFD+CFW+ DEN	0.3%	15.6	19.1	-0.5	-1.1	8.2	3.9	11.2	11.3	-2.6
	5%	31.5	8.0	-16.2	3.7	0.6	-3.0	32.3	36.7	4.6
	10%	58.4	2.9	-17.7	3.9	-1.1	-3.4	28.5	33.0	6.0

The proponents of the "Soft Rolling Skin" selection methodology argue that their visual assessment of skin quality will lead to higher follicle density and higher ratio of secondary to primary follicles, and that these changes in the skin follicle population will lead to increased fleece weight and reduced fibre diameter (Watts and Ferguson 1996). The results in this study show that direct selection on density results in very small changes in fleece weight and moderate changes in fibre diameter. It is probable that selection purely on skin assessments (as an indirect indicator of density) will result in even smaller changes in these traits. If selection for soft rolling skin is effective in changing fleece weight and fibre diameter, it is not through changes in density.

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