HERITABILITIES FOR SKIN FOLLICLE TRAITS AND THEIR CORRELATIONS WITH PRODUCTION TRAITS IN AUSTRALIAN FINE WOOL MERINO SHEEP

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SUMMARY

Genetic parameters for skin follicle traits, wool traits, body weight and number of lambs weaned per ewe joined were estimated for fine wool Merinos. Total, secondary and primary follicle number index, which are based on skin surface area and skin follicle density, were considered. Heritability estimates for total, secondary and primary follicle number index were 0.45, 0.46 and 0.38 respectively. The genetic correlations between total follicle number index and clean fleece weight, mean fibre diameter, staple strength, coefficient of variation of fibre diameter, body weight and number of lambs weaned were 0.16, -0.67, 0.00, 0.03, 0.22 and 0.22, respectively.

Keywords: Skin follicle traits, Merino, genetic parameters

INTRODUCTION

Animal fibres such as wool, cashmere and angora grow from small skin structures known as follicles (Ryder and Stephenson 1968). The fibre production depends on total skin follicle number, which is the product of skin follicle density and skin surface area. Skin surface area is approximated from body weight ($BW^{0.703}$). Skin follicle density can be measured using skin biopsy and histological techniques as the number of skin follicles per mm^2 (Parry *et al.* 1992). As a result, total skin follicle number index can be calculated by multiplying approximate skin surface area and skin follicle density.

Sheep and goats have primary as well as secondary follicles, the latter being of major importance to fine wool production. In sheep all primary follicles are formed and growing fibres at birth but most of the secondary follicles develop from 2 to 4 months after birth (Ryder and Stephenson 1968; Sumner and Bigham 1993). Consequently, these skin follicle traits are first measurable after 4 months of age.

Genetic parameters for skin follicle density and its correlation with wool and body weight traits have been estimated (Hill *et al.* 1997b; Hynd *et al.* 1997; Skerritt *et al.* 1997; Purvis and Swan 1997). The objective of this study was to compare genetic parameter estimates for skin follicle density with those for skin follicle number index, in particular the correlations with wool and body weight traits and number of lambs weaned in fine wool Merinos.

MATERIALS AND METHODS

Data. Records were collected from CSIRO's Fine Wool Project (Swan *et al.* 2000). The data file contained information regarding wool and body weight traits, number of lambs weaned (NLW)

(Asadi Fozi *et al.* 2005) and skin follicle measurements. Data on skin follicle traits were measured at approximately 10 months of age from 3,788 animals, born between 1990 and 1994, and which were the progeny of 257 sires and 2,307 dams

Traits. The production and reproduction traits that were analysed included clean fleece weight (CFW), mean fibre diameter (MFD), staple strength (SS), coefficient of variation of fibre diameter (CVFD), body weight (BW) and number of lambs weaned per ewe joined (NLW). The skin follicle measurement traits were primary follicle density (PFD), secondary follicle density (SFD), skin follicle density (FDEN) as the sum of primary follicle density and secondary follicle density, total follicle number index (TFNI) as the product of FDEN and approximate skin surface area (ASSA). In addition the traits, secondary follicle number index (SFNI), as the product of SFD and ASSA and primary follicle number index (PFNI), as the product of PFD and ASSA, were included in the analyses.

Genetic analysis. Fixed effects tested for significance included bloodline (BL, 11 levels), dam age (DA, adult and maiden), birth–rearing type (BRT) with 3 levels (SS: born and reared as a single; MS: born as a multiple and reared as a single and MM: born as multiple and reared as multiple), sex, year-management groups (YM) with 61 levels, and shearing age. The effect of shearing age on wool traits (range between 291-349 days) was fitted as a linear regression. Variance components and genetic parameters were estimated using ASREML (Gilmour *et al.* 2002). Univariate analyses were undertaken, using an animal model with all significant fixed effects. In addition to the direct additive genetic effect of the animals, maternal genetic effects and maternal environmental effects were tested as additional random effects. For NLW the effect of "sire mated to ewe" was also fitted as a random effect. Bivariate analysis was used to estimate phenotypic and genetic correlations between different combinations of production, reproduction and skin follicle measurement traits (Asadi Fozi *et al.* 2005).

RESULTS AND DISCUSSION

Fixed effects. Least-square means for the fixed effects on skin follicle traits are presented in Table 1.

Table 1. Least square means and standard errors (in brackets) of fixed effects for PFD (Primary follicles/mm^2), SFD (Secondary follicles/mm^2), FDEN (skin follicles/mm^2), PFNI (PFD $\times$ ASSA), SFNI (SFD $\times$ ASSA) and TFNI (FDEN $\times$ ASSA)

Trait	BL	DA:	Maiden	Adult	BRT:	SS	MS	MM	Sex:	Ewe	Wether	YM
PFD	***	NS	3.80 (0.03)	3.77 (0.02)	***	3.62 (0.02)	3.78 (0.04)	3.94 (0.03)	NS	3.77 (0.03)	3.79 (0.03)	***
SFD	***	***	74.5 (0.93)	78.0 (0.51)	***	80.3 (0.51)	76.0 (1.08)	72.5 (1.02)	***	74.4 (0.63)	78.2 (0.73)	***
FDEN	***	***	78.3 (0.94)	81.8 (0.52)	***	83.9 (0.52)	79.8 (1.10)	76.5 (0.87)	***	78.2 (0.64)	82.0 (0.73)	***
PFNI	***	NS	35.8 (0.42)	36.3 (0.25)	***	35.4 (0.27)	36.1 (0.47)	36.6 (0.39)	***	35.4 (0.31)	36.7 (0.34)	***
SFNI	***	***	700 (10.2)	750 (6.27)	***	778 (6.68)	727 (11.2)	669 (9.59)	***	693 (7.53)	756 (8.27)	***
TFNI	***	***	736 (10.4)	786 (6.34)	***	814 (6.76)	763 (11.4)	706 (9.71)	***	729 (7.62)	793 (8.38)	***

Note: NS = not significant; *** P < 0.01

Bloodlines, birth-rearing type and year-management groups had a significant effect on skin follicle traits. All traits except PFD were affected significantly by sex. Age of dam had a significant effect on skin follicle traits except PFD and PFNI. The significance of fixed effects for wool traits, BW and NLW, were reported in a previous study (Asadi Fozi *et al.* 2005).

Heritabilities and genetic and phenotypic correlations. Maternal genetic and maternal permanent environment effects did not improve the log likelihood of skin follicle traits significantly and therefore were not included in the final model. The appropriate models for analyses of wool traits, BW and NLW have been reported previously (Asadi Fozi *et al.* 2005). The direct additive genetic effects of individual animals as well as maternal genetic effects and a direct-maternal covariance were fitted as random effects for the analysis of CFW and BW. For MFD, SS, CVFD and NLW, only direct additive genetic effects were fitted in the final model as a random effect. The estimates of heritability and genetic and phenotypic correlation of skin follicle traits, wool traits, BW and NLW are presented in Table 2. These values were within the range of estimates found in the literature (Hill *et al.* 1997b; Hynd *et al.* 1997; Skerritt *et al.* 1997; Purvis and Swan 1997; Adams and Cronje 2003; Safari and Fogarty 2003; Asadi Fozi *et al.* 2005).

Table 2. Estimates of phenotypic and genetic parameter for wool traits, skin follicle traits, body weight and NLW. Trait means, phenotypic standard deviations, heritabilities (in bold on diagonal), phenotypic correlations above and genetic correlations below diagonal. (Standard errors for heritabilities ranged between 0.03 and 0.04, for phenotypic correlations between 0.01 and 0.02, and for genetic correlations between 0.03 and 0.12)

	CFW	MFD	CVFD	SS	NLW	BW	PFD	SFD	FDEN	PFNI	SFNI	TFNI
Mean	1.63	16.9	17.6	40.5	0.59	26	3.68	79.7	83.4	36.3	786	823
SD	0.25	1.06	2.24	9.2	0.37	3.17	0.67	17.5	17.6	6.54	156	150
CFW	**0.38**	0.21	-0.07	0.19	0.03	0.45	-0.22	0.02	0.01	0	0.22	0.22
MFD	0.2	**0.68**	-0.11	0.16	0.03	0.24	-0.12	-0.56	-0.56	-0.01	-0.46	-0.46
CVFD	0.04	-0.12	**0.54**	-0.37	-0.04	-0.2	0.03	0.12	0.12	-0.06	0.03	0.03
SS	0.16	0.25	-0.7	**0.33**	0.01	0.03	-0.02	-0.26	-0.25	-0.03	0.04	0.04
NLW	0.06	0.04	-0.2	0.01	**0.06**	0.08	-0.09	-0.06	-0.07	-0.02	0	0
BW	0.37	0.21	-0.26	-0.07	0.24	**0.53**	-0.23	-0.22	-0.22	0.28	0.23	0.24
PFD	-0.24	-0.1	0.08	0.02	-0.06	-0.2	**0.34**	0.29	0.32	0.87	0.18	0.22
SFD	-0.05	-0.73	0.16	-0.39	-0.02	-0.29	0.08	**0.49**	0.99	0.18	0.89	0.89
FDEN	-0.06	-0.73	0.16	-0.39	-0.03	-0.29	0.11	0.99	**0.48**	0.21	0.89	0.88
PFNI	0.06	0.01	-0.08	-0.08	0.17	0.41	0.81	-0.04	-0.02	**0.38**	0.3	0.34
SFNI	0.18	-0.67	0.02	0	0.12	0.22	-0.02	0.88	0.88	0.13	**0.46**	0.99
TFNI	0.16	-0.67	0.03	0	0.22	0.22	0.01	0.87	0.87	0.17	0.99	**0.45**

No estimates have been reported previously for skin follicle number indices. In comparison with FDEN, which has been studied previously, more favourable genetic correlations were estimated between TFNI and most of the other production and reproduction traits.

The genetic correlation between total follicle number index (TFNI) and MFD was highly negative (–0.67). The genetic correlation of TFNI with CFW, BW and NLW was moderately positive. The estimates of genetic correlation for TFNI with SS and CVFD were close to zero. The magnitude and sign of genetic correlations between SFNI and the other production and reproduction traits were similar to those of TFNI and production and reproduction traits. The genetic correlations of PFNI with BW and NLW were moderately sized and positive but small values were found for genetic correlations of PFNI with CFW, MFD, CVFD and SS.

The genetic correlations of TFNI with MFD, CFW, BW and NLW were favourable therefore improvement of these traits is expected using TFNI as a selection criterion. However, genetic correlations of TFNI with SS and CVFD were close to zero. Consequently, TFNI, which is measurable on young animals, could be used as a selection criterion in Merino breeding programs especially where the emphasis placed on SS and CVFD is low. Although it is not currently practical to measure skin traits due to cost, Hill *et al*. (1997a) reported a high genetic correlation (-0.74) between skin biopsy weight and skin follicle density. Accordingly, TFNI could be predicted from skin biopsy weight, which is relatively, easy to measure and skin surface area.

ACKNOWLEDGMENTS
We thank CSIRO Livestock Industries for providing the data from the Fine Wool Project flock.

REFERENCES

Adams, N. R. and Cronje, P. B. (2003) *Aust. J. Agric. Res.* **54:**1.

Asadi Fozi, M., Van der Werf, J. H. J. and Swan, A. A. (2005) *Aust. J. Agric. Res.* (submitted).

Gilmour, A. R., Gogel, B. J., Cullis, B. R., Welham, S. J. and Thompson, R. (2002). ASREML User Guide Release 1.0. VSN International Ltd., Hemel Hampstead, HP1 1ES, UK.

Hill, J. A., Hynd, P. L., Ponzoni, R. W., Grimson, R.J., Jaensch, K. S., Kenyon, R. V. and Penno, N. M. (1997a) *Proc. Assoc. Advmt. Anim. Breed. Genet.* **12:**520.

Hill, J. A., Hynd, P. L., Ponzoni, R. W., Grimson, R.J., Jaensch, K. S., Kenyon, R. V. and Penno, N. M. (1997b) *Proc. Assoc. Advmt. Anim. Breed. Genet.* **12:**524.

Hynd, P. L., Ponzoni, R. W. and Hill, J. A. (1997) *Proc. Assoc. Advmt. Anim. Breed. Genet.* **12:**752.

Parry, A. L., Norton B. W. and Restall, B. J. (1992) *Aust. J. Agric. Res.* **43:**857.

Purvis, I. W. and Swan, A. A. (1997) *Proc. Assoc. Advmt. Anim. Breed. Genet.* **12:**512.

Ryder, M. L. and Stephenson, K. (1968) “Wool growth”. London, Academic Press. 209.

Safari, A. and Fogarty, N. M. (2003) *Technical Bulletin* **49,** NSW Agriculture, Orange, Australia.

Skerrit, J. W., Reverter, A., Kaiser, C. J. and Tier, B. (1997) *Proc. Assoc. Advmt. Anim. Breed. Genet.* **12:**163.

Swan, A. A., Purvis, I. W., Piper, L. R., Lamb. P.R. and Robinson, G. A. (2000) The CSIRO Fine Wool Project-Background Objectives Fine Wool 2000: Proceedings of a Symposium held 27-28 October 2000 Armidale. 65.

Sumner, R. M. W and Bigham, M. L. (1993). *Livest. Prod. Sci.* **33:**1.