GENETIC ASSOCIATION BETWEEN FIBRE CURVATURE, STAPLE CRIMP AND WOOL PRODUCTION AND QUALITY OF MERINO SHEEP

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SUMMARY

Preliminary estimates of genetic parameters for objectively measured fibre curvature mean and standard deviation are presented. Both fibre curvature mean and standard deviation will respond to selection although less so than staple crimp frequency and definition. The curvature traits and staple crimp frequency are favourably correlated with fleece weight but unfavourable correlated with fibre diameter. The implications of the parameters for Merino breeding programs are discussed.
Keywords: Merino, fibre curvature, staple crimp, sheep

INTRODUCTION

Staple crimp is a characteristic of wool that has traditionally been used as a selection criteria to improve wool quality. Among traditional Merino breeders, staple crimp frequency (number of crimps per unit length) is used as an indirect selection criteria for mean fibre diameter and well defined staple crimp is considered an important attribute of style. It has been known for some time that staple and fibre crimp frequency influence spinning performance and yarn characteristics independent of their relationship with fibre diameter (Rogan 1989). More recently it has been established that crimp frequency and definition also influence the average fibre length of wool top (Stevens and Crowe 1994). In line with continuing efforts to provide the wool industry with objective measurements of raw wool characteristics that were subjectively appraised in the past, fibre curvature mean (a correlate of staple and fibre crimp) and fibre curvature standard deviation (a correlate of staple crimp definition), are now routinely provided by fleece testing laboratories using either image analysis or Laserscan technology to measure mean fibre diameter. To assess the likely consequences of selection based on measured fibre curvature mean and standard deviation or staple crimp frequency and definition the Merino breeding industry requires precise estimates of genetic parameters for these traits. Alternatively, breeders imposing much of their selection emphasis on fleece weight and mean fibre diameter to increase the rate of improvement in profit, may be interested in the genetic correlations between these traits and crimp and curvature to pre-empt correlated changes in fibre curvature and staple crimp. Although numerous genetic parameter estimates have been published for fleece weight, fibre diameter, staple crimp frequency (see reviews by Davis and McGuirk, 1987; Mortimer 1987) and staple crimp definition (Beattie 1961, 1962; Gregory 1982a, b; James *et al* 1990) for the Merino breed, there are no estimates published for fibre curvature mean and standard deviation.

This paper presents preliminary estimates of genetic parameters for fibre curvature mean and standard deviation of Merino fleece wool as measured by Laserscan.

MATERIALS AND METHODS

The sheep and wool. Fibre curvature and staple crimp measurements were taken on mid-side fleece samples, of 12 months wool growth, from 1,508 Trangie QPLU$ hogget ewes of 15-16 months of age born in 1996 and 1997. The selection process and management protocol for the flock are described by (Taylor and Atkins 1997). The ewes are fully pedigreed progeny of 1,135 dams and 120 sires. Fibre curvature mean and standard deviation was measured on sub-samples of 2mm fibre lengths prepared for Laserscan measurement of fibre diameter mean and standard deviation. Fibre curvature and diameter measurements are based on 2,000 fibre counts accepted for mean diameter. Crimp frequency and definition were measured on three staples sampled at random from each mid-side fleece sample. Crimp frequency was measured using a crimp wheel prepared to represent frequencies ranging from 3 to 18 crimps per inch. Crimp definition was assessed against standard fleece samples ranging from category 1 (superior definition) to category 6 (inferior definition).

Statistical methods. Variance components were estimated from an animal model by restricted maximum likelihood using ASREML (Gilmour *et al.* 1996). The models included the fixed effects of strain, year, strain by year, birth/rearing status, age of dam and date of birth with sheep fitted as a random effect to estimate direct genetic variance. Selection imposed on clean fleece weight and mean fibre diameter since 1995 has biased estimates of genetic (co)variance in the 1996 and 97 drops compared to the randomly mated base population. To enable ASREML to account for selection effects, multivariate models were fitted to the full set of pedigree, fixed effect and clean fleece weight and mean fibre diameter data from 1993 to 1997 with curvature and crimp data included for the last two years only.

RESULTS

Genetic parameters for each trait are presented in Table 1.

Table 1. Genetic parameters (± se) for curvature, crimp, fleece weight and fibre diameter

Trait	mfd (μm)	cfw (kg)	curv (°/mm)	curvsd (°/mm)	cfreq (no./cm)	cdef (13- 6)
Mean	21.3	4.6	101.5	93.3	3.9	2.9
$\sigma_{phenotypic}$	1.43	0.65	10.54	4.91	0.44	0.80
Response (%/year)	1.6	2.0	1.4	1.0	2.1	2.2
mfd	**0.69** (0.03)	0.15	-0.02	-0.13	-0.17	0.05
cfw	0.25 (0.05)	**0.41** (0.03)	-0.31	-0.37	-0.39	-0.03
curv	-0.20 (0.08)	-0.64 (0.08)	**0.39** (0.07)	0.84	0.40	0.12
curvsd	-0.29 (0.07)	-0.65 (0.07)	0.98 (0.02)	**0.52** (0.07)	0.48	0.17
cfreq	-0.31 (0.07)	-0.71 (0.06)	0.88 (0.06)	0.89 (0.05)	**0.54** (0.07)	0.05
cdef	0.03 (0.11)	-0.01 (0.12)	0.19 (0.16)	0.28 (0.14)	-.002(0.15)	**0.24** (0.06)

Response/year assumes 5% rams, 50% ewes selected with 3.5 year generation interval.
h^2 bold, r_p above (se's range 0.01-0.03), r_g below diagonal

All traits exhibit considerable variation between sheep (range 5.3 % curvsd to 27.6 % cdef) and are moderately to highly heritable. As a result, all show worthwhile potential improvements in response to single trait selection. The phenotypic correlations between mean fibre diameter and the curvature and crimp traits are negligible (curv, cdef) to weak (curvsd, cfreq). In contrast, with the exception of crimp definition, the phenotypic correlations between clean fleece weight and the curvature traits and crimp frequency are moderate. Among the curve and crimp traits there is a strong phenotypic correlation between curvature mean and standard deviation, moderate correlations between these and crimp frequency and weak correlations between all three and crimp definition. The genetic correlations between crimp definition and the other traits are also negligible for mfd, cfw and cfreq but moderate for curv and curvsd. In contrast the genetic correlations between both curvature traits and crimp frequency are very strong. The genetic correlations between fibre diameter, the curvature traits and crimp frequency are moderate (curvsd, cfreq) to weak (curv). Corresponding correlations between the latter traits and clean fleece weight are at least twice as strong.

DISCUSSION

The phenotypic variances and heritabilities of clean fleece weight and mean fibre diameter and the correlations between them are similar to those estimated for the base population of this flock (Taylor *et al.* 1997). The parameters fall within the range of estimates published for the Merino breed (Beattie 1961, 1962; Gregory 1982a, b; Davis and McGuirk 1987, James *et al.*1990) the exception being the correlations involving crimp definition which are generally weaker than previous estimates.

For breeders interested in improving the curvature and crimp characteristics of their wool, the parameters indicate that curvature mean and standard deviation will respond to single trait selection albeit to a lesser extent than crimp frequency and definition. The strong genetic correlations between the curvature traits and crimp frequency indicate that both may be suitable indirect selection criteria to improve crimp frequency but less so for crimp definition. For breeders interested in previewing likely changes in fibre curvature and staple crimp characteristics in response to selection for fleece weight and fibre diameter the phenotypic correlations indicate that heavier than average fleeces will display reduced curvature mean and standard deviation and reduced crimp frequency but no difference in crimp definition. The genetic correlations indicate that these improvements will be more marked in the progeny of high fleece weight sires and dams than the phenotypic correlations suggest. Conversely, the progeny of fine sires and dams will produce wool that displays increases in curvature mean and standard deviation and crimp frequency. Again, more than the phenotypic correlations indicate. The net change in curvature and crimp characteristics will be determined by the relative emphasis applied to fleece weight and fibre diameter in the breeding objective. The stronger correlations between the curvature and crimp traits and clean fleece weight compared to those with fibre diameter indicate a net reduction in curvature mean and standard deviation and crimp frequency except for breeding objectives that place considerably more emphasis on fibre diameter than fleece weight.

The correlations between crimp frequency and fleece weight and fibre diameter have important implications for traditional selection practices in the Merino industry. The correlations, both phenotypic and genetic, indicate that crimp frequency is far more closely associated with fleece weight than with fibre diameter. This implies that, in the absence of other measures of fleece weight and/or fibre diameter as aids to selection, the practice of culling for low crimp frequency in an attempt to maintain or reduce fibre diameter, has the potential to result in a greater loss of fleece weight than of fibre diameter in the current generation and in their progeny. In practice, the magnitude of the reduction in fleece weight relative to fibre diameter will be determined by the traditional breeders' ability to accurately assess a number of selection criteria including fleece weight and make selection decisions on each sheep's overall merit.

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