FIBRE DIAMETER MEASURED IN THE POST-WEANING AGE WINDOW IS GENETICALLY THE SAME TRAIT AS YEARLING FIBRE DIAMETER

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SUMMARY

Yearling fibre diameter profiles from the OFDA2000 instrument were used to derive records on mean and coefficient of variation (CV) of fibre diameter at multiple points in the post-weaning age window, from 20 to 90% of staple profile length. Genetic correlations were calculated between these traits and their yearling equivalents. Results showed that from 50% of the staple profile and higher, post-weaning fibre diameter is genetically the same trait as yearling fibre diameter. Although the derivation of CV of fibre diameter was less accurate, genetic correlations with the yearling expression were greater than 0.9 for all except one percentile point. The expected correlation between post-weaning and yearling fleece weight was also derived, and under simple assumptions it is not unreasonable to expect estimates of genetic correlations greater than 0.9.

INTRODUCTION

The MERINOSELECT genetic evaluation system provides Australian Sheep Breeding Values (ASBVs) for wool traits at three age stages: yearling (approximately 12 months of age), hogget (18 months), and adult (2 years and older). Expressions of a particular trait, fibre diameter for example, are treated as separate correlated traits at each age stage. For efficient selection and marketing of rams, ram breeders would like to accurately evaluate wool traits as soon as records can viably be collected. Consequently, there is considerable interest in adding post-weaning wool traits to MERINOSELECT, recorded prior to yearling and potentially from 6 months of age. In order to implement these traits as ASBVs it is necessary to estimate genetic parameters including correlations with traits at later stages. While post-weaning wool records have been accumulating over recent years, including in designed research trials, the difficult combination to estimate is between post-weaning and yearling because there is very limited scope to shear animals twice between 6 and 12 months of age. For fibre diameter however, it is possible to derive records in the approximate window of post-weaning ages, from a yearling record measured using the OFDA2000 instrument (Baxter 2001) which records the fibre diameter distribution in 5mm increments along the wool staple. This study presents correlations between post-weaning mean and CV of fibre diameter derived from OFDA2000 profiles, with mean and CV of fibre diameter, clean fleece weight, and staple strength measured at the yearling stage. The expected correlation between post-weaning and yearling fleece weight was also derived.

MATERIALS AND METHODS

Data. OFDA2000 fibre diameter profiles recorded on yearling fleeces were obtained from Merino progeny born in the Sheep CRC Information Nucleus (IN) flocks between 2007 and 2011 (van der Werf *et al.* 2010). Using profiles on individual animals where the OFDA2000 staple length was greater than 50mm, mean fibre diameter was calculated as the weighted average fibre diameter from the tip of the staple (i.e. the start of the wool growth period at birth) to points extending from 20% to 90% of the staple in 10% steps. That is, a weighted average of the mean diameters at each 5mm increment was calculated within each growth period percentile range, using number of fibres counted as the weights. Each percentile range was then treated as a trait,

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with the range of traits encompassing the post-weaning wool growth period. It is important to note that across animals, variation in wool growth rates mean that at any one percentile point there will be an unknown range in the underlying measurement date. This is a potential source of inaccuracy, although age adjustments are generally not made in analyses of fibre diameter.

CV of fibre diameter was derived for the same percentile ranges, but in order to account for variation both along and across fibres, 50,000 random deviates were sampled from a normal distribution defined by the observed mean and standard deviation of fibre diameter at each 5mm increment, before combining across all 5mm increments within a percentile range to estimate the overall CV of diameter for the percentile range. This is a further potential source of inaccuracy.

Correlations were estimated between these traits and yearling mean fibre diameter (yfd) and yearling CV of fibre diameter measured using the Laserscan instrument, based on an independent sub-sample of wool from the same fleece. Two other key breeding objective correlations were also investigated, between mean fibre diameter at each percentile point and yearling clean fleece weight (ycfw), and between CV of fibre diameter at each percentile point and yearling staple strength (yss). A summary of the data structure by trait is shown in Table 1.

Analyses. Bivariate animal models were fitted in ASReml (Gilmour *et al.* 2009), using the procedure developed by (Swan *et al.* 2015) for data from the IN flocks. Briefly, in addition to standard fixed effects, random effects for genetic groups defined either by flock of origin or Merino strain, additive direct genetic effects, and sire by flock interactions were fitted for each trait. Correlated variance structures were fitted for genetic group and additive direct effects, but not for sire by flock. A random maternal permanent environment effect was also fitted for ycfw. Estimates of genetic correlations were derived from the additive direct genetic effect only.

The expected correlation between post-weaning and yearling fleece weight. There is a part-whole relationship between post-weaning and yearling fleece weights due to the fact that if an animal is shorn as a yearling, all of the wool that was present when the animal was at post-weaning age is contained in the yearling fleece. Yearling fleece weight (Y) can therefore be expressed as $Y = P + (Y - P) = P + D$ where P and D represent post-weaning fleece weight and the weight of wool grown between a post-weaning time point and yearling shearing respectively. The correlation between post-weaning and yearling fleece weight (r_{PY}) can then be derived as $r_{PY} = (r_{PD}\sigma_D + \sigma_P)/\sigma_Y$. If the correlation between P and D is zero this simplifies to $r_{PY} = \sigma_P/\sigma_Y$, the square root of the variance ratio between post-weaning and yearling fleece weight. For example, for a variance ratio of 50%, the expected correlation is 0.71. More likely is that P and D are correlated to a similar degree as two independent fleece weights, say yearling and adult. With fixed values of σ_P and σ_Y and an assumed value of r_{PD}, the value of σ_D can be derived by numerical optimisation, and the expected correlation r_{PY} can be calculated at the phenotypic and genetic levels.

Table 1. Data summary for traits analysed including OFDA2000 mean and CV of fibre diameter (yfd_o and ydcv_o), Laserscan mean and CV of fibre diameter (yfd and ydcv), clean fleece weight (ycfw) and staple strength (yss).

Statistic	yfd_o	ydcv_o	yfd	ydcv	ycfw	yss
Units	micron	%	micron	%	Kg	N/Ktex
Records	4948	4948	5137	5113	5683	4872
Trait mean	17.3	18.3	16.8	18.6	2.4	31.7
Trait SD	1.9	2.0	1.6	2.7	0.7	11.8
Mean age	314	314	330	330	336	331
Sires	200	200	186	186	210	186
Dams	3086	3086	3279	3275	3570	3167
Genetic groups	126	126	126	126	126	126

RESULTS AND DISCUSSION

Results in Table 2 show that for as little as 20% of the yearling staple, the heritability of fibre diameter exceeded 0.5, and the genetic correlation with yearling diameter was close to 0.9 or higher. At 50% of the staple, the genetic correlation reached 0.97, and at 70% of the stable, 0.99. Heritability also increased, to 0.74 at 90% of the staple. This demonstrates that at the likely ages post-weaning wool traits will first be included in MERINOSELECT in the window between 50 and 90% of the staple, mean fibre diameter is genetically the same trait as yearling fibre diameter. Further, it is apparent that mean fibre diameter can be accurately measured for the purpose of genetic analyses from even younger ages. These high heritabilities and genetic correlations were observed even under the circumstances that the measurement points on the OFDA2000 profiles could not be matched to consistent measurement dates across animals, as described above.

The genetic correlations between fibre diameter along the staple and yearling clean fleece weight (Table 2) showed a declining trend, from 0.48 at 20% of the staple to 0.31 at 90%, with the latter effectively the same as the estimate of 0.32 between yfd and ycfw reported by Swan *et al.* (2015) from the same data. Higher genetic correlations between fleece weight and fibre diameter measured at early ages are a cause for concern, and warrant further investigation. An initial step would be to see if the pattern is repeated in OFDA2000 profiles from the second shearing of these animals.

Table 2. Parameter estimates for mean fibre diameter (± standard error) derived from OFDA2000 staple profiles with varying amounts of the staple included (% of staple), including heritability, genetic and phenotypic correlation with Laserscan yearling fibre diameter (r_g yfd and r_p yfd) and yearling clean fleece weight (r_g ycfw and r_p ycfw).

% of staple	Heritability	r_g yfd	r_p yfd	r_g ycfw	r_p ycfw
20	0.54 ± 0.05	0.88 ± 0.02	0.67 ± 0.01	0.48 ± 0.10	0.21 ± 0.02
30	0.56 ± 0.05	0.91 ± 0.02	0.71 ± 0.01	0.46 ± 0.10	0.22 ± 0.02
40	0.58 ± 0.05	0.94 ± 0.01	0.75 ± 0.01	0.44 ± 0.10	0.21 ± 0.02
50	0.62 ± 0.05	0.97 ± 0.01	0.79 ± 0.01	0.41 ± 0.10	0.21 ± 0.02
60	0.65 ± 0.05	0.98 ± 0.01	0.82 ± 0.01	0.39 ± 0.10	0.20 ± 0.02
70	0.66 ± 0.05	0.99 ± 0.01	0.85 ± 0.01	0.36 ± 0.10	0.20 ± 0.02
80	0.69 ± 0.05	1.00 ± 0.01	0.87 ± 0.00	0.35 ± 0.10	0.20 ± 0.02
90	0.74 ± 0.05	0.99 ± 0.00	0.90 ± 0.00	0.31 ± 0.10	0.19 ± 0.02

Results in Table 3 show high estimates of genetic correlations between derived CV of diameter and Laserscan yearling CV of diameter (0.88 to 0.97), although these were lower than the equivalent estimates for mean diameter in Table 2 and did not show the same pattern of increase with staple percentile. Genetic correlations were highest between 30 and 50% of the staple (0.95 to 0.97). By contrast, heritability of the derived measurements did increase, from 0.19 at 20% to 0.31 at 90%, although this was still considerably lower than the estimate of 0.50 for Laserscan ydcv reported by Swan *et al.* (2015) from the same data. The genetic correlation between derived CV of diameter and yearling staple strength followed the expected trend, ranging from -0.50 to -0.61. Although it appears highly likely that the method used to derive CV of diameter for partial staples in these data has reduced accuracy, indications are that the trait can be measured during the post-weaning period and will be a useful selection criterion for staple strength. These results are consistent with the findings of Greeff and Schlink (2013) that CV of diameter on partial staples was genetically the same trait as CV on the whole staple. Interestingly, Greeff and Schlink also found that staple strength could be accurately assessed on staples from 60% of the staple length and higher (genetic correlation estimates of 0.85 for 60%, and 0.99 for 80% of the staple).

Expected correlations between post-weaning and yearling clean fleece weight (pcfw and ycfw) are shown in Table 4. The phenotypic variance of 0.16 for ycfw was taken from Swan *et al.*

(2015), while the value 0.08 for pcfw was from unpublished MERINOSELECT data (Brown, 2015, pers. comm.). To derive genetic variances, heritability was assumed to be 0.3 at both stages, and genetic and phenotypic correlations between P and D were set to the equivalent correlations between yearling and adult clean fleece weight used in MERINOSELECT. Based on these input values, the expected genetic and phenotypic correlations were 0.96 and 0.92 respectively. While yet to be confirmed by estimates from industry data, these theoretical results strongly suggest that fleece weight recorded during the post-weaning stage window will provide accurate information on yearling fleece weight. Collection of fleece weights in industry flocks early in the post-weaning window (around 6 months of age) would be highly desirable to determine how early fleece weight can be measured. The loss in accuracy due to measuring at young ages could potentially be offset by the ability to shorten the generation interval of males leading to increased rates of genetic gain.

Table 3. Parameter estimates for CV of fibre diameter (± standard error) derived from OFDA2000 staple profiles with varying amounts of the staple included (% of staple), including heritability, genetic and phenotypic correlation with Laserscan yearling CV of fibre diameter (r_g ydcv and r_p ydcv) and yearling staple strength (r_g yss and r_p yss).

% of staple	Heritability	r_g ydcv	r_p ydcv	r_g yss	r_p yss
20	0.19 ± 0.04	0.93 ± 0.06	0.39 ± 0.01	-0.50 ± 0.11	-0.16 ± 0.02
30	0.23 ± 0.04	0.95 ± 0.05	0.41 ± 0.01	-0.54 ± 0.10	-0.19 ± 0.02
40	0.25 ± 0.04	0.97 ± 0.05	0.43 ± 0.01	-0.57 ± 0.09	-0.21 ± 0.02
50	0.27 ± 0.04	0.97 ± 0.05	0.45 ± 0.01	-0.58 ± 0.09	-0.24 ± 0.02
60	0.28 ± 0.04	0.92 ± 0.04	0.48 ± 0.01	-0.61 ± 0.08	-0.27 ± 0.02
70	0.29 ± 0.04	0.90 ± 0.04	0.50 ± 0.01	-0.60 ± 0.08	-0.29 ± 0.02
80	0.29 ± 0.04	0.90 ± 0.04	0.51 ± 0.01	-0.61 ± 0.08	-0.30 ± 0.02
90	0.31 ± 0.05	0.88 ± 0.04	0.53 ± 0.01	-0.60 ± 0.08	-0.30 ± 0.02

Table 4. Expected correlations between post-weaning and yearling clean fleece weight (r_{PY}) assuming correlations between P and D (r_{PD}) match MERINOSELECT correlations between yearling and adult fleece weight, and observed variances for post-weaning and yearling fleece weight (σ_P^2 and σ_Y^2).

Correlation	σ_P^2	σ_Y^2	r_{PD}	r_{PY}
Genetic	0.024	0.048	0.71	0.96
Phenotypic	0.08	0.16	0.48	0.92

CONCLUSIONS

The results presented in this study demonstrate that Merino breeders can have confidence in the accuracy of ASBVs for post-weaning wool traits as selection criteria for yearling wool breeding objective traits. Further research to identify how early fleece weight can be recorded in the post-weaning age window, and whether breeding programs using early wool measurements can lead to increased rates of genetic gain would be of value.

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