EXTREMES OF PERFORMANCE IN CLEAN FLEECE WEIGHT AND AVERAGE FIBRE DIAMETER BY MERINO WETHERS ARE MAINTAINED UNDER DIETS DIFFERING WIDELY IN QUALITY

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SUMMARY

This study was conducted to investigate the biological mechanisms underlying the wool production of 40 Merino wethers from 4 strains that had been at the extremes of performance for clean fleece weight (CFW) and average fibre diameter (AFD) during their first year of growth. The animals were either high CFW and high AFD, high CFW and low AFD, low CFW and high AFD or low CFW and low AFD The animals were evaluated under pen conditions over 4 periods of 6 weeks on diets differing widely in protein and energy. Animals in the 4 extreme wool groups generally maintained their relative AFD and fibre length growth on all diets, although the size of the differences increased as the quality of the diet improved.

Keywords: Merino, wool production, diet, genetic.

INTRODUCTION

Merino breeders who have the improvement of fleece value as their primary objective are confronted by a positive genetic association between the 2 primary determinants of fleece value; ie. clean fleece weight (CFW) and average fibre diameter (AFD). In economic terms this association is unfavourable. The strength of the genetic correlation ($r_g = 0.3$) is such that, given appropriate selection pressures on the 2 traits, simultaneous improvement is possible. However, the situation remains that the overall rate of genetic progress is restricted by the direction and the magnitude of the correlation between CFW and AFD.

Is there a way around this antagonistic association in order to improve rates of gain in both traits? One approach to the problem is to study the complex of biological relationships between the 2 characters and the other components of wool growth. With this knowledge it may be possible to identify new selection criteria to effectively concentrate selection on the genes that independently influence average fibre diameter and clean fleece weight. Historically, investigations aimed at understanding the biological factors controlling the expression of wool production and its components have utilised lines selected on single characters or made comparisons between breeds differing widely in one of the traits. For example, animals from the lines selected on clean fleece weight that were established by the CSIRO and the NSW Department of Agriculture have been studied extensively with the aim of determining which biological functions have changed in association with the character under selection (see Davis and McGuirk 1987 for review). The problem with this approach is that selection pressure could be acting, in part, on an entirely different set of genes to that when selection is simultaneously applied to fleece weight and average fibre diameter.

It is our hypothesis that the most suitable populations in which to study the causative mechanisms underlying the genetic association between wool production and its components (in particular, average fibre diameter) are those that reflect a history of simultaneous selection for economic value in these traits. In particular, we propose that a detailed study of certain physiological and morphological differences of animals with extremes of fleece weight and average fibre diameter, within Merino flocks with a history of selection for improved fleece value, will reveal associations that actually cause the co-variation between fleece weight and average fibre diameter.

This paper, and another in this proceedings (Bailey *et al.* 1994), report the results of the first phase of a detailed evaluation of these hypotheses. In this study, components of wool production were measured on hogget wethers from 4 Merino strains during periods when they were maintained in an animal house on 4 diets. The animals were chosen because they were at the extremes of performance, within their strains, for hogget clean fleece weight and average fibre diameter. The diets were chosen to mimic the magnitude of seasonal change in quality that can occur in pastures in southern Australia. The study thus tests whether animals at the extremes of performance for hogget fleece traits maintain their relative rankings across diets of widely different quality.

METHODS AND MATERIALS

Specific details of the 42 animals, their strain details, diets and experimental conditions used in this study are described by Bailey *et al.* (1994).

Animals

The hogget wethers were selected on the basis of their CFW and AFD to form 4 groups: High CFW and high or low AFD (HH and HL, respectively); and low CFW and high or low AFD (LH and LL, respectively). This stratification produced wool groups with the following mean values: HH (4.03 kg CFW, 22.48 μm AFD), HL (4.10 kg, 18.92 μm), LH (2.80 kg, 22.00 μm) and LL (2.59 kg, 18.16 μm).

Experimental Treatments

The experimental periods consisted of 4, 6 week periods in which diets of differing quality were offered *ad Zibitum.* The first and last diets (1 and la) were an identical basal diet of only wheat straw. The other diets contained either 20% (diet 2) or 40% lupin seed (diet 3) and minerals. Each feeding period comprised a 2 week introductory period and a 4 week experimental period.

Table 1. Strain and wool group least squares means (SE) for clean fleece weight (CFW, kg) and average fibre diameter (AFD, μm) in 1992 and 1993 and average staple length (SL, mm) in 1993

	Year				
	1992		1993		
	AFD	CFW	AFD	CFW	SL
Strain					
Peppin	20.18 (0.12)^a	3.39 (0.08)^a	21.15 (0.42)	2.78 (0.11)	78.0 (2.3)
Collinsville	20.17 (0.12)^a	3.28 (0.08)^a	20.90 (0.42)	2.73 (0.11)	73.6 (2.3)
Bungaree	20.72 (0.11)^b	3.54 (0.08)^b	22.19 (0.40)	2.71 (0.10)	79.0 (2.1)
AMS	20.51 (0.13)^a	3.23 (0.09)^a	21.52 (0.46)	2.77 (0.12)	81.6 (2.5)
Wool group					
High/High	22.48 (0.12)^a	4.03 (0.08)^a	23.47 (0.44)^a	3.18 (0.11)^a	80.1 (2.4)
High/Low	18.92 (0.10)^c	4.10 (0.07)^a	20.40 (0.38)^b	3.04 (0.10)^a	78.8 (2.0)
Low/High	22.00 (0.14)^b	2.80 (0.10)^b	22.54 (0.50)^a	2.43 (0.13)^b	79.9 (2.7)
Low/Low	18.16 (0.10)^d	2.59 (0.07)^b	19.36 (0.38)^b	2.35 (0.10)^b	73.4 (2.0)

Different alphabetical superscripts within effects and traits differ significantly ($P < 0.05$).

Measurements

Daily feed and water intake were recorded each morning and fasted animals were weighed every 2 weeks. At the end of the introductory and experimental period of each diet, dye-bands were placed in the wool of each animals midside. At the completion of the experiment all sheep were shorn, the fleece was weighed and sub-sampled for the determination of CFW and AFD. Dye-banded staples were removed and measured for fibre length growth (FL) for each period. The AFD of the wool at the end of each introductory and experimental period was determined. The weight of wool grown in subsequent periods, relative to that grown during the period on the first diet (RCFW), was also determined from the dye-banded wool staples following solvent scouring.

Statistical

The FL growth and AFD data were analysed using a repeated measures ANOVA that contained the effects of wool group, strain, animal and diet and the appropriate 2-way interactions. The data for RCFW were analysed separately for diets *2, 3* and la by a model that contained the effects of wool group and strain, and their interaction.

RESULTS

Full fleece measurements

Fleece data obtained at the hogget shearing and at the shearing 10 months later are presented in Table 1. The significant differences between the Bungaree strain and the 3 other strains in hogget CFW and

AFD were not maintained in the fleeces grown during the subsequent 10 months that included 7.5 months in a single pen environment. The highly significant differences in CFW and AFD created by the assignment of the wethers into the 4 wool groups ($P < 0.001$) were maintained during this period of growth. The ranking of the 4 wool groups for AFD and CFW did not change between the hogget fleece and the fleece grown over the subsequent experimental period.

Table 2. Strain and wool group least squares means (SE) for average fibre diameter (AFD, μm) and average length growth (FL, mm) for the 4 diet periods

	Diet 1		Diet 2		Diet 3		Diet 1a	
	AFD	FL	AFD	FL	AFD	FL	AFD	FL
Strain								
Peppin	19.38	6.88^{a}	21.13	8.16^{a}	21.32	8.07	18.29	6.76^{a}
	(0.46)	(0.23)	(0.44)	(0.30)	(0.46)	(0.29)	(0.28)	(0.18)
C'ville	19.54	5.69	21.08	7.11^{b}	21.70	7.55	18.55	6.25^{b}
	(0.46)	(0.23)	(0.44)	(0.30)	(0.46)	(0.29)	(0.28)	(0.18)
Bungaree	20.54	6.53^{a}	22.09	8.35^{a}	22.19	8.46	19.25	6.97^{a}
	(0.44)	(0.22)	(0.42)	(0.28)	(0.43)	(0.27)	(0.27)	(0.18)
AMS	20.08	6.69^{a}	21.24	8.13^{a}	21.58	8.10	18.89	6.82^{a}
	(0.51)	(0.25)	(0.48)	(0.32)	(0.50)	(0.32)	(0.31)	(0.20)
Wool Group								
High/High	21.44^{a}	6.66^{a}	23.87^{a}	8.51^{a}	24.23^{a}	8.84^{a}	20.23^{a}	7.13^{a}
	(0.42)	(0.32)	(0.42)	(0.32)	(0.42)	(0.32)	(0.42)	(0.32)
High/Low	18.50^{b}	6.44^{a}	19.83^{b}	7.98^{a}	20.04^{b}	8.05^{b}	17.43^{b}	6.68^{a}
	(0.36)	(0.29)	(0.36)	(0.29)	(0.36)	(0.29)	(0.36)	(0.29)
Low/High	21.00^{a}	6.70^{a}	22.87^{a}	8.04^{a}	23.07^{a}	8.04^{b}	20.36^{a}	6.98^{a}
	(0.42)	(0.32)	(0.42)	(0.32)	(0.42)	(0.32)	(0.42)	(0.32)
Low/Low	18.33^{b}	6.15^{a}	18.88^{b}	7.31^{b}	19.23^{b}	7.35^{b}	17.03^{b}	6.08^{b}
	(0.36)	(0.29)	(0.36)	(0.29)	(0.36)	(0.29)	(0.36)	(0.29)

Different alphabetical superscripts within effects and traits differ significantly ($P < 0.05$).

Wool measurements during treatment periods

RCFW Relative to the wool grown on diet 1, growth on diets 2, 3 and la averaged 121%, 130% and 99%, respectively. There were no significant effects of strain or wool group on the weight of wool grown during each of the treatment periods.

AFD The AFD of the animals on the 4 diets are presented in Table 2. There were no significant differences in AFD between strains in any of the 4 treatments. By contrast, the effects of wool group, diet and wool group by diet interaction were highly significant ($P <$ '0.0001). Over all diets, the differences in AFD between the groups of the same diameter classification (ie. HH vs LH and HL vs LL) were not significant. By contrast, differences in AFD between groups of the same CFW classification (ie. HH vs HL and LH vs LL) were highly significant and averaged 3.5 m. The mean AFD's on each of the 4 diets were significantly different from each other ($P < 0.05$). The significant interaction between wool group and diet was due to the small differences in AFD between groups of similar classification on the low quality diets expanding to large differences on the higher quality diets 2 and 3.

FL The length of fibres grown during the periods on diets 1, 2 and la differed significantly between strains (Table 2) with the animals from the Collinsville strain growing significantly shorter wool fibres on these diets. On all except diet 1 there were significant differences between the wool groups, with the LL group consistently growing the shortest fibres. Only on the highest quality diet (diet 3) did the HH group grow significantly longer fibres than the HL and LH groups.

DISCUSSION

The results of this study show that groups of Merino sheep that have extremes of performance in wool production and AFD, relative to their strain mean, maintain this relative performance from hogget to 2.5 years of age and more particularly across diets that differ widely in the level of crude protein. As such, they behave no differently to sub-populations that are based on random sampling (Mortimer 1987). However, as the quality of the diet increases and then reverts to low quality again, so the magnitude of the differences in performance between the groups similarly increases and contracts. For example, the difference in AFD between the HH group and the HL group under diet 1 was 3 m, increased to 4.2 m under diet 3 before returning to 2.8 m under the diet la. There were similar interactions for fibre length growth. The feed intake data for these animals (Bailey *et al.* 1994) follow a similar pattern suggesting that a component of the differences in fibre dimensions between the wool groups is due to feed intake.

Given the significant differences between the wool groups for AFD and FL over all diets, the absence of significant differences in RCFW is surprising and may be associated with the imprecision of the measurement of clean wool weight from short periods of growth.

The results of this preliminary study suggest that because they are repeatable across years and diets of very different quality, the examination of animals of extreme performance will provide valuable information on the association between underlying biological mechanisms and wool production traits.

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