'EXTREME EWES' - AN INVESTIGATION OF THE RELATIONSHIP BETWEEN CLEAN FLEECE WEIGHT, FIBRE DIAMETER AND BODYWEIGHT

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SUMMARY

A group of ewe hoggets from the QPLU$ Merino selection project was identified as being extreme for 8 combinations of clean fleece weight (CFW), fibre diameter (FD) and bodyweight (BW). They formed the basis of an experimental group to investigate the biology linking these 3 traits, along with other wool production, wool quality, growth, carcass and reproduction traits. This initial analysis has clearly established the usefulness of this sub-population of sheep as an experimental unit to further our knowledge in this area. The 8 groups are clearly divergent with respect to CFW, FD and BW. At the phenotypic level, CFW and the carcass traits were independent, as were BW and the wool quality traits. However, FD has varying relationships with a wide range of traits in addition to CFW, which will require careful monitoring with respect to the long term selection for reduced FD. The 8 groups of extreme ewes and their progeny will be further studied to quantify differences in skin biology, feed intake, reproductive performance, FD profiles and body composition as they age.

Keywords: Merino sheep, clean fleece weight, fibre diameter, body weight

INTRODUCTION

Comparative analysis of Merino bloodline performance has clearly demonstrated the economic advantage of finer wool, as well as the trade-offs that occur between clean fleece weight (CFW), fibre diameter (FD) and bodyweight (BW). Finer wool bloodlines tend to have both reduced CFW and BW compared with the broader strains. These trade-offs can be substantial, with a reduction of 1 μm in FD resulting in 8-9% less CFW, and 4% lower BW (Coelli *et al*. 2000). Similar trade-offs have been identified within the Condobolin fine wool flock (Hatcher *et al*. 2000). The trade-offs between FD, CFW and BW suggest that reducing FD could limit the ability of wool producers to maximise returns from surplus sheep sales as the finer animals will have lower BW and, thus, may not meet market specifications. Furthermore, these observed trade-offs between FD, CFW and BW contradict the theoretical relationships that should exist between these 3 traits based on the partitioning of protein between wool and muscle.

In theory, a reduction in CFW resulting from a decrease in FD should allow finer wool sheep to partition more nutrients to reproduction and muscle growth. However, this does not occur in practice. Adams and Cronje (2003) recently reviewed the biology linking FD with CFW, BW and reproduction in Merino sheep. They concluded that the decrease in CFW that would be predicted from a decrease in FD is normally partially offset by increased follicle density and increased fibre length relative to FD. Additionally, they found that these changes appear to mediate effects on body metabolism, with the finer sheep having lower BW, a lower proportion of fat in the body of younger sheep, and variable reductions in reproduction rate. The data relating FD to other characteristics used by Adams and Cronje (2003) were derived from a wide range of experimental situations that varied in their ability to clearly define these relationships due to confounding of main effects, and the separation of genotypic and phenotypic comparisons from correlated environmental effects.

A subset of animals from the Trangie QPLU$ Merino Selection project (Taylor and Atkins 1997) were selected to further examine the relationship between CFW, FD, BW and reproduction in a contemporary group of Merino sheep run under the same environmental and management regime. The aim of this initial analysis was to quantify the differences occurring between the 8 'extreme' combination groups of CFW, FD and BW into which the ewes were classified, and then to determine the relative impact of these 3 traits on the expression of secondary traits relating to wool production, wool quality, growth and carcass composition.

MATERIALS AND METHODS

One hundred and ninety seven hogget ewes (2001 drop) were identified from the medium strain of the

Trangie QPLU$ flock as being extreme for 8 combinations of CFW, FD and BW. The 8 groups represent those sheep classified as high for each of the 3 traits (HHH) through to those classified as low (LLL) and the 6 combinations in between (HHL, HLH, HLL, LHH, LHL and LLH). The hoggets were allocated to 1 of the 8 groups on the basis of their wool production and wool quality as measured at shearing in October 2002, and their subsequent unfasted off-shears bodyweight. A standardised deviation approach was used to identify the extreme ewes, and a revolving pattern of allocation to each of the 8 groups ensured that the best available ewe was allocated to each group. Therefore, each ewe was selected and classified based on a combination of traits, thus identifying a unique group of sheep with which to empirically study the relationships between CFW, FD and BW. Then we determined which of these 3 traits had the largest impact on a range of wool production, wool quality and growth and body composition traits recorded as part of the normal QPLU$ measurement protocol (Taylor and Atkins 1997). Differences between the 8 groups in CFW, FD and BW were determined using ASREML (Gilmour *et al.* 1999) after fitting a model that included the main effect of group. The relative impact of CFW, FD and BW on each of the wool production, wool quality, growth and carcase composition traits was determined by coding each animal as either H (High) or L (Low) for the 3 primary traits before fitting these codes in subsequent models.

RESULTS

The standardised deviation approach was successful in separating the ewes into the 8 distinct groups based on their hogget performance. The HHH and LLL groups were clearly distinct from each other and the remaining 6 groups in terms of CFW, FD and BW (Figure 1). However, the differences between the intermediate 6 groups, although still significant, were smaller.

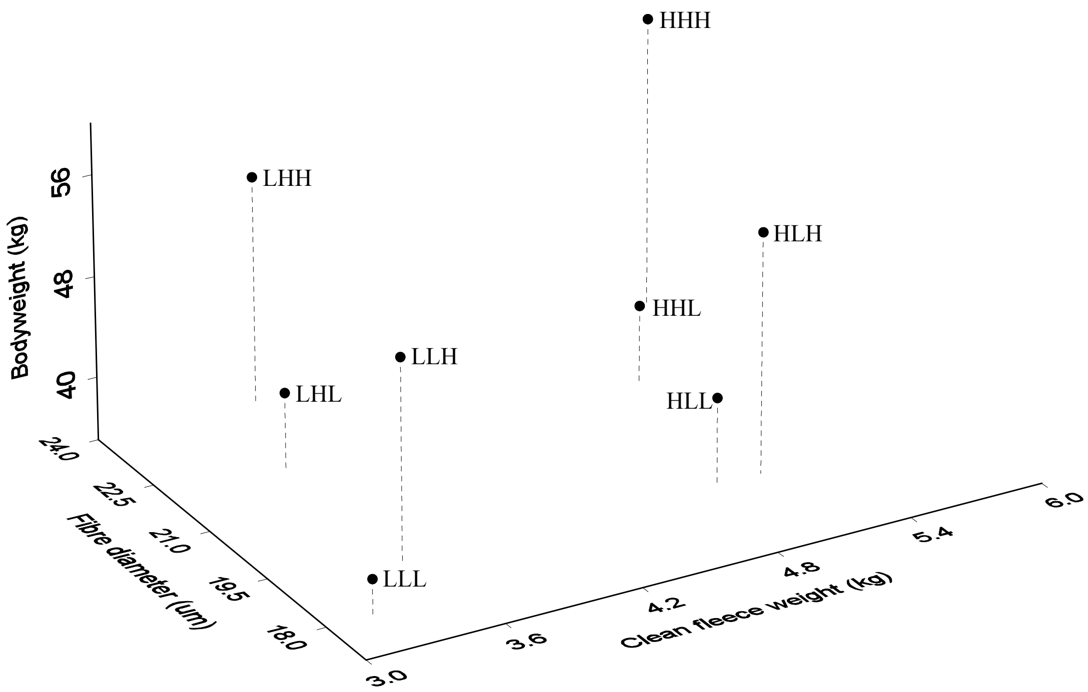

Figure 1. Separation of the 8 groups with respect to clean fleece weight, fibre diameter and bodyweight.

It is important to recognise that although CFW, FD or BW each had a major impact on most of the wool production, wool quality growth and body composition traits, in most instances more than 1 of the primary traits contributed to the observed variation (Table 1). The 3 exceptions were coefficient of variation of (CVFD), crimp definition (CD) and muscle depth (MD); for these 3 cases, only CFW, FD and BW, respectively, had a significant influence on the observed variation. For each of the other traits, at least 2, and sometimes all 3, of the primary traits contributed to the phenotypic differences between the high and low groups.

The relative magnitude of the deviation occurring in each of the associated traits provides a clear indication as to whether selection on CFW, FD or BW had the largest impact on the changes in each. As expected, CFW was the principal driver of the wool production traits with the differences between the low and high groups being -2.29 kg, -3.96 % and -1.70 kg for greasy fleece weight, yield and CFW, respectively (Table 1). However, CFW was also the major determinant of 3 of the wool quality (FDCV, dust penetration (DP) and crimp frequency (CF)) and 2 of the growth traits (birth weight (BTW) and weaning weight (WW)). In these instances, the differences between the low and high groups were -2.06 %, -10.00 % and 1.92 crimps/25 mm for CVFD, DP and CF, respectively, and -0.91 kg for BWT and -3.44 kg for WW. In addition to being the principal driver of the majority of the wool quality traits, FD also had the most influence on staple length; in this case, the difference between the low and high animals was -9.94 mm compared with -8.06 mm and -2.80 mm for CFW and BW, respectively. As expected, BW was the principal driver of the majority of the growth and body composition traits.

Table 1. The relative impact of clean fleece weight (CFW), fibre diameter (FD) and body weight (BW) on wool production, wool quality, growth and carcass composition.

			Clean fleece weight		Fibre diameter		Body weight	
Wool production								
Greasy fleece weight	GFW	kg	-2.19	***	-0.51	***	-0.44	***
Yield	Y	%	-3.96	***	1.69	*	0.20	Ns
Clean fleece weight	CFW	kg	-1.70	***	-0.23	***	-0.29	***
Staple length	SL	mm	-8.06	***	-9.94	***	-2.80	*
Wool quality								
Fibre diameter	FD	μm	-0.15	ns	-4.61	***	-1.07	***
Standard deviation of FD	SDFD	μm	-0.45	***	-0.88	***	-0.14	Ns
Coefficient of variation of FD	CVFD	%	-2.06	***	0.59	ns	0.37	Ns
Fibre curvature	CURVE	degrees/mm	7.14	***	8.96	***	0.63	Ns
Dust penetration	DP	% from tip	-10.00	***	-2.66	*	-0.40	Ns
Crimp frequency	CF	/25 mm	1.92	***	1.78	***	0.35	Ns
Crimp definition[A]	CD	score 1 - 6	0.05	ns	-0.27	***	-0.05	Ns
Staple definition[A]	SD	score 1 - 6	0.04	ns	0.22	*	0.19	Ns
Staple tip structure[A]	STS	score 1-3	-0.05	ns	0.13	ns	0.01	Ns
Growth & body composition								
Birth weight	BTW	kg	-0.91	ns	0.23	*	-0.24	*
Weaning weight	WW	kg	-3.44	***	0.51	ns	-2.98	***
10 month weight	10BW	kg	-5.01	***	-2.59	***	-8.18	***
Fat depth (at 10 months)	FTD	mm	-0.03	ns	-0.53	***	-0.61	***
Muscle depth (at 10 months)	MD	mm	0.03	ns	-0.12	ns	-0.25	***
Condition score (at 10 months)	CS	score 1 - 5	0.12	ns	-0.38	***	-0.55	***
Off shears bodyweight	BW	kg	-3.14	***	-2.22	***	-13.48	***

[A] For each of these assessed traits, 1 represents the best and the higher number the worst.
The numbers in the table represent the deviation between the high and low animals within each of the CFW, FD and BWT classifications.
ns denotes not significant, * $P<0.05$, ** $P<0.01$ and *** $P<0.005$.

DISCUSSION

The classification of the ewes into the 8 clearly divergent groups or sub-populations based on CFW, FD and BWT deviations at their hogget shearing has provided an ideal basis to further empirically elucidate the phenotypic relationships between these 3 traits, as well as their respective impacts on other wool production, wool quality, growth and body composition traits. The alternative approach to this type of study, namely the use of selection index theory to gain knowledge of partial correlations between traits, is less informative than this method of empirical analysis as the existing correlations between CFW, FD and BW themselves complicate the separation of the influence of these primary traits on other important characteristics. Furthermore, the QPLU$ flock from which these ewes were drawn is representative of bloodlines of major impact on the Australian Merino flock, and their yearly management routine is based on stud best practice. Therefore, the various relationships identified among the traits of the extreme ewes are likely to be also representative of, and thus have relevance to, the wider Merino population.

The CFW, FD and BW trends observed among the extreme ewes reflect those identified in previous studies (Adams and Cronje 2003). The finer ewes had lower CFW, lower BW, as well as shorter staples, and thus conformed to the trends observed by Coelli *et al.* (2000), however, the trade-offs between CFW, FD and BW in the current study were not as large. This most likely reflects differences in the range of each of the 3 traits between the 2 analyses as the relative trade-offs have been shown to depend on FD, with larger trade-offs occurring at the finer end of the range (Coelli *et al.* 2000). Additionally, the age at which the sheep were measured may also have had an impact as the extreme ewes were measured as hoggets, while those represented by the Merino bloodline comparison analysis generally enter wether trials prior to their hogget shearing, and are then assessed over a number of years.

In addition to being lighter, the finer ewes in the present study were also significantly leaner than the broader ewes in terms of both ultrasonic fat depth and condition score measured at 10 months of age. While this is in agreement with previous work (Lee *et al.* 2002), the trade-offs are again lower in the current study. Repeat measures of each of the traits of the extreme ewes at adult ages (in 2003 and 2004), as well as monitoring of the performance of their progeny, will allow the impact of age on the trade-offs between each of these traits to be determined.

While the aforementioned trends in CFW, FD and BW were in agreement with previous work, differences between the low and high groups for each of the 3 traits indicate that, at the phenotypic level, there appears to be some independence between CFW and carcass characteristics, and between BW and wool quality traits. In contrast, FD has varying relationships with most of the traits included in the analysis to date. Therefore, the long term impact of selecting for reduced FD must not be confined to wool production and wool quality traits alone, but must consider the whole package and include both growth and carcass traits. The impact of FD on additional traits such as feed intake and reproductive performance will be determined for the ewes themselves and their progeny over the coming months.

The initial results of this study contradict some widespread industry beliefs regarding the performance of fine wool sheep, and the factors that drive change in CFW, FD and BW. It would generally be expected that CFW would be the principal driver of the wool production traits, FD for the wool quality traits, and BW for the growth and body composition traits. This was clearly not the case. The large impact of CFW on CVFD in particular, but also on DP and CF, was unexpected as was its impact on BW and WW. These findings clearly warrant further investigation. Future experimentation will include the quantification of differences in skin biology (follicle density, S:P and skin thickness), feed intake, reproductive performance, FD profiles and body composition at older ages. In addition, the performance of their progeny for many of these traits will also be quantified.

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