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UNDESIRABLE BIOLOGICAL CORRELATES OF SHEEP WITH A HIGH GENETIC VALUE FOR CLEAN FLEECE WEIGHT

N.R. Adams[1], J.C. Greeff[2], J.R. Briegel[1], E.N. Bermingham[1] and S.M. Liu[1]
[1]Australian Sheep Industry CRC and CSIRO Livestock Industries,
Private Bag 5, Wembley WA 6913,
[2]Australian Sheep Industry CRC and Western Australian Department of Agriculture,
10 Dore St, Katanning WA 6317

SUMMARY
There is a negative genetic correlation between fleece weight and subcutaneous fat depth in Merinos, but the implications of this for body composition are unknown. This study examined Merino sheep with high or low estimated breeding values for clean fleece weight (CFW), selected such that both groups had similar liveweights. The high CFW group had 20% less fat in their body than low CFW sheep. The low fatness probably causes the reported decreases in reproductive turnoff, and is likely to reduce the resilience of high CFW sheep to seasonal shortages in feed supply. A better understanding of the risks associated with high CFW sheep may assist farmers to determine those situations where managing high production animals can allow genetic advances in improved fleece weight to be effectively harnessed for increased profit.
Keywords: risk, fatness, nutrition, wool

INTRODUCTION
Many woolgrowers believe that highly productive sheep cannot withstand the environmental conditions of their district, and so avoid sheep with a high fleece weight (Kaine and Niall 2001). Kaine and Niall (2001) further pointed out that a key to understanding the adoption of new breeding practices lies in the woolgrowers' perceptions of risk. This paper examines biological characteristics that may contribute to perceptions of risk in highly productive sheep.

Clean fleece weight (CFW) is genetically correlated negatively with depth of subcutaneous fat (Greeff *et al.* 2003; Fogarty *et al.* 2003). If whole-body fat content is similarly related to CFW, lower overall fatness might be expected to reduce the capacity of sheep to withstand environmental challenges. Therefore, in this study total body fat was measured in sheep that differed genetically in fleece weight, and examined whether this affected voluntary feed intake. The implications of these characteristics for reproduction rate, and for the capacity of sheep to withstand nutritional challenges, are discussed.

MATERIALS AND METHODS
Two groups of 22 Merino hoggets were selected after shearing at 15 months of age from the Katanning Resource Flocks, and the depth of subcutaneous fat and muscle measured by ultrasound. The groups were ranked on CFW and selected to have either a high or low estimated breeding value for CFW, with the constraint that the mean phenotypic liveweights and fibre diameters of the two groups were similar (Table 1). At 20 months of age, during autumn when the sheep were in relatively poor body condition, they were brought into an animal house and fed a ration of hammer-milled

oaten hay with 10% lupin seed and 2% of a mineral mix. After several weeks to accustom themselves to this situation, voluntary feed intake was measured on this ration for 14 days of feeding *ad libitum*. Body composition was then estimated as described by Searle (1970), using the dilution of an injection of deuterated water measured with GC/MS. Differences in body composition between fleece weight groups were analysed statistically by ANOVA using Systat 10 (SPSS Inc., Chicago Il, USA). The difference in voluntary feed intake was analysed using the generalised linear model, in which CFW group was fitted as a categorical effect, and mass of body protein and of body fat were fitted as continuous effects.

Table 1. Mean estimated breeding values of sheep in the high and low clean fleece weight (CFW) groups

	Low CFW (n = 21)	High CFW (n = 22)	s.e.m	P
CFW (kg)	-0.22	+0.49	0.02	0.000
Fibre diameter (µm)	-0.22	+0.35	0.26	0.14
Liveweight (kg)	1.2	1.1	0.3	0.72
S/C fat depth by ultrasound (mm)	-0.04	-0.03	0.08	0.90

RESULTS

The low and high CFW groups had similar depths of subcutaneous fat (both groups 3.3 mm) and eyemuscle (24.8 vs 24.6 ± 0.4 mm). However, when whole-body fatness was measured, the high CFW sheep had 20% less fat in their body at the same liveweight, as shown in Table 2. The additional liveweight tended to be due to a greater content of water in the high CFW sheep, but the difference was not statistically significant (Table 2).

Table 2. Body composition of sheep in high or low clean fleece weight (CFW) genetic groups

	Low CFW (n = 21)	High CFW (n = 22)	s.e.m	P
Adjusted empty body wt (kg)	46.0	45.2	0.7	0.44
Fat (kg)	11.1	8.9	0.5	0.003
Protein (kg)	6.1	6.2	0.1	0.48
Water (kg)	28.7	30.0	0.6	0.13

The voluntary feed intake was higher in the high CFW group (1.39 *vs* 1.27 ± 0.03 kg/day, $P = 0.01$). Within the same analysis, voluntary feed intake was greater in sheep with a high protein mass ($P < 0.001$), and with a high fat mass ($P < 0.01$), indicating that the effect of CFW on feed intake was additional to effects of body composition. However, neither CFW, nor the mass of fat or protein was significantly related to liveweight gain, which averaged 0.95 ± 0.08 kg/week.

DISCUSSION

Several reports have indicated that high CFW in Merino sheep is genetically associated with a reduced depth of subcutaneous fat (Greeff *et al.* 2003; Fogarty *et al.* 2003). Fogarty *et al.* (2003) did not observe a phenotypic relationship, and no phenotypic difference was apparent in the current experiment. This may have come about because the overall level of fatness was low as a result of prolonged grazing on poor quality pasture before the sheep were brought into the animal house. Even though subcutaneous fatness was not different, the bodies of the high CFW sheep still contained 20% less fat than the low group. The lower fat content is likely to affect function of these sheep in two ways: resilience in the face of short periods of feed deficiency, and reduced reproductive turnoff. Lambe *et al.* (2003) described the importance of body fat reserves in enabling ewes in a pasture system with fluctuating feed supply to provide energy throughout the reproductive cycle of pregnancy and lactation, and suggested that maternal fat content may be an important component of sustainable lamb production in harsh environments.

The higher energy demand in the high CFW sheep, indicated by the higher voluntary feed intake unaccompanied by any difference in liveweight change, supports previous findings by Graham (1968). This higher energy requirement would make the high CFW sheep more vulnerable if feed supply became restricted. Perhaps more importantly, the high CFW sheep have less energy reserves to draw upon, because the mean difference in energy from fat plus protein (Table 2) can be calculated from values from Standing Committee on Agriculture (1990) to be equivalent to an energy advantage of 84 MJ in favour of the low CFW sheep. Reserves can be used to support metabolism with an efficiency of 0.8 (Standing Committee on Agriculture 1990) so the low CFW sheep are calculated to have 67.3 MJ more energy available for tissue maintenance at same liveweight. Estimates from Grazfeed™ (Freer *et al.* 1997) indicate that 2.3 MJ of energy is required per day to prevent a loss of 100 g tissue per day in 50 kg sheep, so potentially the low CFW sheep could resist significant underfeeding for several weeks. As an example, Chilliard *et al.* (2000) observed that sheep fed at 40% of maintenance for 8 weeks lost 28% of their body fat, and in the current study, the high and low CFW groups differed in body fat content by 20%.

When underfed, sheep mobilise both fat and protein, but differences in fat content can play the greatest role in resilience to underfeeding. For example, Panaretto (1964) reported that fatter sheep mobilised relatively more fat than lean sheep during underfeeding, while both groups mobilised similar amounts of protein. Therefore, the greater fat content in the low CFW sheep makes them potentially more resilient when fed below maintenance for short periods. This will have a greater benefit in environments with a seasonally variable feed supply.

High CFW relative to liveweight is associated with reduced total weight of lambs weaned (Cloete *et al.* 2002; Greeff and Cox 2005). The difference in fatness between the high and low groups in this study could contribute substantially to both the number of lambs weaned, and to reduced milk production if the lambs were born at a time when feed is limiting. A difference in fatness of 2.2 kg produced by differential feeding is equivalent to more than half a condition score in Merino sheep (McNeill *et al.* 1999). This could be expected to reduce the number of lambs born by 10% (Oldham and Thompson 2004) and also reduce lamb growth rate to weaning by about 9% as a result of reduced milk production.

These effects may be overcome by genetic selection. Cloete *et al* (2004) have shown that selecting ewes for weight of lamb weaned which is a composite trait that includes fertility, litter size, survival rate, milk production and lamb growth rates, resulted in a large response in this trait without loss in fleece weight. Thus flocks that have been selected for high fleece weights and that suffer from low reproductive rates can improve their overall reproductive efficiency by including selection for reproduction in the breeding program without sacrificing fleece weight. However, direct measurement of reproduction traits is important. It may also be possible to increase fleece weight without loss of fatness, which could be a valuable approach for enterprises where the feed environment undergoes significant variability. Opportunities and costs of improving the fat content of high CFW sheep through lower stocking rates or greater supplementation also need to be defined.

Many growers are averse to risk, and they seek to reduce risks to their enterprise by avoiding highly productive sheep (Kaine and Niall 2001). A focus on risk means that their breeding goals are likely to be substantially different from those that consider only productivity (Kulak *et al.* 2003). To date there has been no way of estimating these risks, but the present data offer an opportunity to quantify some of the risks present in high CFW sheep. The use of this information to develop more sophisticated approaches to breeding goals may allow greater communication between traditional and quantitative breeders.

In summary, the present results indicate that, relative to low CFW sheep at the same bodyweight, high CFW sheep are likely to be less robust in environments with substantial fluctuations in feed supply throughout the year. It may be useful to develop breeding goals that take into account the inherent risks in the feed environment. This offers a quantitative approach to issues about the fitness of highly productive sheep for harsh environments that concern some traditional breeders.

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