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Feed requirements for maintenance of mature rams and ewes from lines selected for differences in body composition

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ABSTRACT

A total of 24 mature rams and ewes (>2.5yrs) from a line selected for high backfat thickness and a unselected control line were used to investigate the relationship between maintenance efficiency and body composition in mature sheep. Over a 6 week period the sheep were fed daily a pelleted ration at levels to maintain liveweight. At the end of this period the weights of total fat, carcass lean, viscera and of the empty body (fleece free) were estimated from X-ray computed tomographic images. After adjustment for empty body weight the control line required 5% more feed to maintain liveweight ($P<0.05$) than sheep from the fat line and males required 19% more feed ($P<0.05$) than females. After adjustment for differences in either total fat or carcass lean weight, there were no significant difference ($P>0.05$) in feed requirement between the lines. This indicated that although a genetic change in body composition did alter maintenance feed requirements at maturity, the efficiency of maintaining a unit weight of either fat or carcass lean remained the same. After adjustment for differences in total fat and carcass lean weight, rams still required 11% more feed than ewes to maintain liveweight. Adjusting for visceral weight had no effect on feed requirements to maintain the mature sheep. It was proposed that differences in the turnover rates of adipose tissue or carcass lean contributes to the higher maintenance feed cost observed for the mature ram.

Keywords: Body composition; maintenance requirements; sex; sheep.

INTRODUCTION

Selection for an increase in the proportion of lean during body growth will allow both beef and sheep producers to provide carcasses that satisfy consumer requirements for a leaner product (Thompson, 1990). A change towards leaner body composition resulting from selection for decreased fatness (see Fennessy *et al.*, 1987), has been shown to alter the gross food efficiency of the growing animal (Webster, 1989; Thompson, 1990). However, in a number of species, leaner animals have higher maintenance energy requirements (Thompson *et al.*, 1983; Hofstetter and Wenk, 1985; Stephens, 1991; DiContanzo *et al.*, 1991), which is consistent with the hypothesis that lean tissue is more expensive to maintain than fat (Webster, 1989; Olthoff *et al.*, 1989). Thus at the enterprise level, genetic improvement in growth efficiency and product suitability, may be mitigated by a correlated increase in maintenance requirements of the breeding female. Therefore the implications of selection for a change in body composition on feed requirements to maintain mature animals warrant investigation.

It is widely accepted that maintenance requirements for entire males are in the order of 1.15 times that of females in both cattle (ARC, 1980) and sheep (Corbett, 1990). Despite this large difference, the mechanisms which contribute to the sex effect are not clearly defined. A higher proportion of the empty body weight as lean in bulls, compared with cows or steers (Russel and Wright, 1983), together with higher fasting heat production of rams compared with ewes and wethers (Graham, 1968), have been suggested as factors that contribute to the sex effect.

A number of authors have indicated that lean body mass may be more appropriate for the estimation of maintenance requirements than metabolic body weight (Pullar and Webster, 1977, McCracken, 1992). Quantifying the relationship between body components and the feed requirements for maintenance at a variety of physiological states, will assess whether an adjustment factor for body composition is necessary in feeding standards that estimate maintenance requirements. This experiment attempts to quantify the effect of body composition differences on feed requirements for maintenance by examining the relationship between the feed required to maintain live weight and the proportions of body components in mature rams and ewes from genotypes which differ in body composition.

MATERIALS AND METHODS

Animals and experimental design

The experiment was a 2x2 factorial design, examining the effects of sex and genotype on the feed intake required to maintain a constant liveweight in sheep. The sheep were from a high backfat selection line and a randomly bred control flock developed at AgResearch Invermay in New Zealand (Fennessy *et al.*, 1987). The high backfat line was a result of selection for ultrasonic backfat depth at the 12th rib (C) site, adjusted for liveweight. A total of 24 mature sheep (12 rams and 12 ewes older than 2.5 yrs of age) from the fat and control lines were used.

The sheep were run on pasture and 2 weeks prior to the commencement of the experiment they were shorn, vaccinated, drenched with anthelminthics prior to being placed into individual indoor pens (3x3 metres). They were weighed after a 24 hour fast and the metabolisable energy required to maintain liveweight for each sheep was estimated as a function of metabolic weight, age and sex using equation 1.21 from

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Corbett (1990). The sheep were fed a pelleted ration (Thompson *et al.*, 1985), once daily at 0800 hours and water was provided *ad libitum* during the experiment. For the first 2 weeks sheep were weighed at 3 day intervals and feeding levels were adjusted when animals had a deviation of ±2 kg from their initial liveweight. When feed intakes had stabilised (2 weeks), these levels were fixed for the next 6 weeks. Thereafter sheep were weighed after a 24 hour fast and randomly moved to pens within the shed weekly.

CAT-scanning procedure

The sheep were scanned using a CAT-Scanner (Hitachi CTW-430 X-ray Computed Tomography system) following the procedure defined by Thompson and Kinghorn (1992). When necessary the sheep were sedated with Acepril® (0.1mg / 10kg liveweight; Troy Laboratories, Australia) to improve image quality. From each sheep, 2-dimensional sagittal cross-sectional scans were made of the whole body from a point behind the rump (distal to the proximal hind limb muscles) to the 3rd/4th cervical vertebrae, at 40 mm intervals. On average, 25 scans were taken for each sheep.

To estimate the weight of body components, each scan was divided into total fat (fat tissue in the subcutaneous, intermuscular, internal and udder/scrotal depots), carcass lean (all lean of the musculature from the carcass), viscera (the alimentary tract, abdominal and thoracic organs, trachea, aorta, and udder scrotal lean tissue) and bone using the program CATMAN (Thompson and Kinghorn, 1992). Contents of the rumen, reticulum, omasum, abomasum, caecum, colon and bladder were excluded from the images. Total tissue area from each slice was also recorded. Tissue areas from each scan were numerically integrated to estimate tissue volume, which were then corrected for density to provide an estimate of tissue weight. Total tissue weight, which comprised total fat, carcass lean, viscera and bone, was used as an estimate of fleece-free empty body weight (EBW).

TABLE 1: Mean fleece free empty body weight (EBW), carcass lean, viscera and total fat weights (±s.e.m.) at the end of the experimental period for control and fat rams and ewes.

	LINE			
	Control		Fat	
	Rams	Ewes	Rams	Ewes
Number	6	6	6	6
Total Fat (kg)	9.30	16.34	15.29	16.71
s.e.m.	1.00	1.47	2.84	1.11
Carcass Lean (kg)	25.15	19.27	24.74	17.10
s.e.m.	1.82	0.62	1.22	0.55
Viscera (kg)	7.84	5.74	6.98	4.64
s.e.m.	0.31	0.27	0.33	0.16
Empty body weight (kg)	47.94	45.64	52.24	42.00
s.e.m.	3.17	1.95	3.83	1.40

Statistical analysis

Data on weekly feed intakes, body components and empty body weight were transformed to $\log_{10}$ to minimise the correlation between the mean and variance. Individual feeding levels (kg/week) needed to maintain liveweight were analysed by a least squares model (model 1) which contained terms for sex, genotype and EBW. First order interactions were tested and found to be non-significant (P>0.05). To determine the effects on the feed required to maintain liveweight, additional covariates for the weights of log10 total fat (model 2), $\log_{10}$ carcass lean (model 3) and $\log_{10}$ viscera (model 4) were included as separate terms in the above model. Again all first order interactions were tested and found to be non-significant (P>0.05).

RESULTS

Mean component and empty body weights for line and sex combinations are presented in Table 1. Rams were significantly heavier than ewes (P<0.05), whilst line and the line x sex interaction was not significant (P>0.05).

Sex, line and $\log_{10}$ empty body weight all had significant effects on the feed required to maintain liveweight (Model 1, Table 2; P<0.05). The antilog of the least square difference

TABLE 2: The effects of line, sex and body components on the feed required to maintain liveweight (log10 kg of feed/week), in rams and ewes from the control and fat selection lines

		Regression Coefficients (±s.e.m.)					
Source of Variation		model 1	(***)	model 2	(***)	model 3	(***)
Constant		-0.155		-0.404		-0.218	
		(0.113)		(0.157)		(0.096)	
Line	Control	0.011	**	0.005		0.006	
	Fat	-0.011		-0.005		-0.006	
		(0.004)		(0.005)		(0.004)	
Sex	Male	0.038	***	0.022	*	0.021	**
	Female	-0.038		-0.022		-0.021	
		(0.004)		(0.008)		(0.006)	
$\log_{10}$ fat weight		-		-0.119	*	-	
				(0.056)			
$\log_{10}$ carcass lean weight		-		-		0.341	**
						(0.109)	
$\log_{10}$ EBW		0.568	***	0.798	***	0.334	**
		(0.068)		(0.126)		(0.093)	

* P<0.05, ** P<0.01, *** P<0.001

between sexes indicated a multiplicative sex difference, whereby the rams required 1.19 times more feed to maintain liveweight than the ewes. Similarly the line effect indicated that the sheep from the control line required 1.05 times more feed to maintain liveweight than sheep from the fat line.

After inclusion of fat weight as a covariate, the line effect was no longer significant (Model 2, Table 2; P>0.05), and the multiplicative sex difference was reduced to 1.11 (P<0.05). The regression coefficient for fat weight was -0.12 showing that an increase in fat weight at the same EBW results in a decrease in feed intake. After inclusion of a covariate for carcass lean, line was again not significant (Model 3, Table 2; P>0.05), and the sex difference was reduced to 1.10. The regression coefficient for carcass lean was 0.34 which indicates that an increase in carcass lean at the same EBW results in an increase in feed requirements. Although not shown in Table 2, the addition of visceral weight to model 1 did not account for a significant component of the variance (P>0.05) and had no effect on the significance or magnitude of the regression coefficients for line, sex and EBW.

DISCUSSION

This study showed that sheep from the control line, which had a higher proportion of lean and a lower proportion of fat, required 5% more feed when compared to sheep from the fat line (Table 1). This supports the work of Olthoff *et al.*, (1989), where fatter sheep had lower maintenance requirements, due to the higher metabolic activity of lean tissue (Webster, 1989). However in the present study, after adjustment to the same total fat weight, or carcass lean weight, there was no difference between the lines in liveweight maintenance requirements. This suggests, that while selection altered gross body composition, the energy requirement per unit of fat, or carcass lean weight, for the two lines remained the same.

After adjusting for differences in EBW, males required 1.19 times more feed to maintain liveweight than females. Therefore equations to estimate maintenance requirements of mature animals require the inclusion of a scaling factor to account for the sex difference (ARC 1980; Corbett, 1990). Unlike the line effect, which appeared to be largely a function of differences in body composition, this study showed that when adjusted to the same total fat or carcass lean weight, males still required 1.11 times more feed than females to maintain liveweight. That is, it is energetically more expensive to maintain a unit of lean or fat respectively, in males than in females. Because of the high negative correlation between fat and lean it is not possible to separate which tissue is having the greater effect.

Webster (1985) showed that males had a higher metabolic heat production then castrates and indicated that the protein synthesis and turnover may be responsible for the difference in maintenance requirements between males and castrates. Adeola *et al.*, (1990) observed that muscle turnover rate was higher in male than female pigs and suggested that differences in the partitioning and turnover of protein within the carcass lean depot would contribute to a higher feed requirement of the male when compared to the female. In contrast Sinnet-Smith and Woolliams (1988) showed that there was no sex effect on the metabolic activity of adipose tissue in sheep from several breeds differing in body composition. Overall these results indicate that a higher turnover rate of protein within the carcass lean depot was probably the major contributing factor to the higher feed requirements of the rams in this experiment. It is interesting to note that Lobley *et al.*, (1990) could not generate a difference in muscle turnover rate when infusing testosterone into wethers, suggesting that the presence of anabolic steroids alone are not responsible for the increase in metabolic energy demands of the entire male.

The work of Afonso and Thompson (unpublished data) who compared maintenance requirements of similar sheep at an earlier stage of growth (22-31 weeks of age) found no difference in the feed requirements between rams and ewes, even after adjusting for the small differences in total fat weight. This contrasts with the present experiment, where significant differences in feed requirements between rams and ewes were identified and these remained after adjustment for differences in body composition. This indicates that as sheep mature, the feed requirements to maintain liveweight become progressively higher in males than in females and that stage of maturity influences the magnitude of the contribution of body components to feed intake requirements

Metabolic activity of the viscera is regarded as a major factor contributing to differences in maintenance efficiency observed both within and between strains of sheep and cattle (Ferrell and Jenkins, 1984; Koong *et al.*, 1985; Solis *et al.*, 1988). In the present experiment visceral mass had no effect on the feed required to maintain liveweight. However it must be noted that the estimates for visceral weight, using the CAT-Scanner, are not as accurate as estimates for the other components in vivo. As the technique used to estimate body components was independent of bias (Afonso, 1993), the comparisons made between sexes and lines were still valid. Therefore this result suggests that the visceral mass differences have no effect on the variation in feed requirements of mature animals when fed at maintenance levels.

CONCLUSION

An understanding of the components that contribute to the efficiency of feed utilisation by mature animals is fundamental to the improvement of, or the manipulation of efficiency in animal production (Olthoff *et al.*, 1989) This study showed that selection for an increase in body fatness reduced the feed requirements for maintenance of liveweight in mature sheep. However after adjustment for line differences in carcass lean or fat weight, differences in maintenance requirements were no longer apparent. This indicated that genetic selection for body fatness changed maintenance requirements per unit of EBW at maturity, but had no effect on the maintenance cost per unit of lean, or fat weight, within the body. In contrast to the line effect, the higher energy requirements of the mature ram, cannot be entirely explained by differences in composition, indicating that the energy cost of maintaining a unit weight of either fat or carcass lean in a ram was higher than in the ewe. Further work is required to establish the factors that contribute to this difference, which may lead to techniques that enable modification of maintenance requirements for breeding animals.

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