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Subcutaneous fat distribution as assessed by ultrasound in Border Leicester and Dorset Down ewe hoggets

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ABSTRACT

Forty Border Leicester (BL) and forty-eight Dorset Down (DD) ewe hoggets (7.5 mo) that had been farmed together were scanned using a real-time ultrasound machine, at six sites with one muscle depth (B) and five subcutaneous fat depth measurements (R - tissue depth over fifth rib, C - backfat over last rib, GR, L - backfat over last lumbar vertebrae, T - fat over tail) being taken. Comparisons of tissue ratios (individual fat depth divided by B) were used to characterise subcutaneous fat distribution. From these ratios it was found that the DD had 9%, 10% and 6% greater ratios at R, L and T respectively, and 7% lower ratios at C and GR. Breed differences at R, GR and T were significant (P<0.05). It was concluded that true genetic differences in subcutaneous fat distribution existed between the genotypes studied. These findings have implications for carcass classification, for breeding programmes for lean growth, and for comparisons of the fatness of different genotypes.

Keywords Subcutaneous fat distribution, ultrasound, Border Leicester, Dorset Down, fat depth, muscle depth, carcass classification, selection, lean growth.

INTRODUCTION

Carcass classification systems and breeding programmes for lean growth aim to accurately, but economically, predict carcass fatness. Presently, estimates of subcutaneous fat depth are used, together with other measurements, for this purpose. The New Zealand carcass classification system for sheep meats uses a combination of carcass weight and GR, a rib tissue depth that is predominantly fat (Bennett, 1989), whilst modern selection indices for lean meat production (eg Simm *et al.*, 1987), incorporate liveweight and two ultrasonic measurements, muscle depth, B, and fat depth, C.

Single subcutaneous fat depths do not fully account for all variation between animals in carcass fat content even when differences in carcass weight have been taken into account. For example, Kirton and Johnson (1979) found that when carcass weight, kidney and omental fat weights, GR, C and five other subcutaneous fat depths were used to predict carcass fatness they only accounted for 74% of variation between animals in carcass fatness. This suggests that there is variation between animals in fat partitioning (*ie* subcutaneous fat relative to other carcass fat depots) and/or in the distribution of subcutaneous fat throughout the carcass. Variation in subcutaneous fat distribution may be more significant than variation in fat partitioning since there appears to be little between breed variation in the partitioning of fat between carcass depots (Kempster, 1980). Whilst fat partitioning has been studied in sheep, relatively little is known about fat distribution (Kempster, 1980). Furthermore, there is a perception in the New Zealand meat industry that breed differences do occur in subcutaneous fat distribution with the Border Leicester being considered deviant from other breeds in terms of being relatively fatter on the ribs. This industry perception has not been quantitively examined.

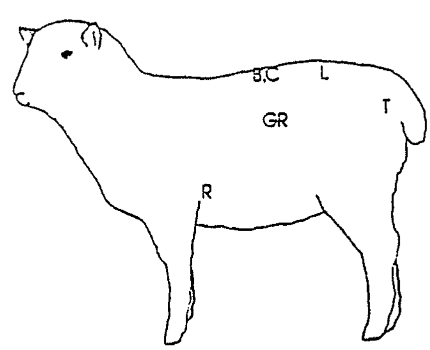
If sheep breeds differ significantly in fat partitioning within the carcass, or in subcutaneous fat distribution, then current carcass classification systems will bias animals which deviate from the average animal in these characteristics, while breeding programmes for lean growth may lead to redistribution of fat in the carcass.

The aim of this trial was to describe differences in subcutaneous fat distribution between two genotypes of sheep.

MATERIALS AND METHODS

Forty Border Leicester (BL) and forty-eight Dorset Down (DD) ewe hoggets (7.5 mo) were ultrasonically scanned at six anatomical sites on their left side as follows: tissue depth over the fifth rib caudal to the major tuberosity of the humerus and dorsal to the olecranon of the ulna (R), depth of muscle (M. longissimus dorsi) over the last rib (B), depth of fat over B (C), GR, depth of fat above the muscle (M. longissimus dorsi) over the penultimate lumbar vertebra (L), depth of fat on the rump lateral to the eighth coccygeal vertebrae and medial to the ischiatic tuber of the tail (T) (Figure 1). C, L and T were measurements of subcutaneous fat depth whilst R and GR were tissue depths that consisted mainly of subcutaneous fat. Scanning was undertaken by an operator experienced at measuring B, C and GR.

FIGURE 1 Approximate location of sites where tissue depths were assessed with ultrasound on the left hand side of ewe hoggets. See text for the anatomical description of each site.



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Animals

Sheep were from lines established with industry genestock at Lincoln University's Sheep Breeding Unit in 1986 and subsequently selected for high lean tissue growth using an index that combines information on liveweight, B and C (Simm *et al.*, 1987). Sheep from both breeds had run together since weaning (c. 3 mo). Dorset Downs were on average three weeks older than Border Leicesters but, since they were scanned two weeks earlier, age at scanning was similar for both breeds.

Records of birth and rearing rank, age of dam, date of birth and autumn liveweight (7.5 mo) were obtained from the Lincoln University Sheep Breeding Unit.

Border Leicesters were used because they are perceived to be deviant in terms of subcutaneous fat distribution whereas Dorset Downs are not.

Scanner

An ALOKA SSD-210DXII (ALOKA Co Ltd, Japan) ultrasound machine was used. This is a real-time B-mode scanner producing two-dimensional images. The probe attached to the scanner had a frequency of 5MHz and a scanning width of 56mm. All images were recorded on VHS videotape by a video-recorder linked to the scanner. Tissue dimensions on these recorded images were measured by computer image analysis at a later date using image analysis software (MIA - Morphological Image Analysis, 1988 version) written by Dr Richard Fright (Department of Medical Physics, Christchurch Hospital) running on an IBM compatible AT computer linked to a video-recorder.

Statistical Analysis

Tests for normality (skewness and kurtosis) on all data were performed after Snedecor and Cochran (1980). Data were not adjusted for environmental effects (birth and rearing rank, age of dam and date of birth) since these had no significant effect on raw data or ratios. Generalised linear models were fitted to assess breed effects with and without liveweight as a covariate (Snedecor and Cochran, 1980).

Conceptual Approach

Subcutaneous fat distribution is a shape and shape is independent of size. Consequently subcutaneous fat distribution was characterised using ratios of subcutaneous fat depths divided by muscle depth and the differences between breeds in these ratios were compared. Dividing by muscle depth served to remove the effect of breed differences in size.

B was used as the divisor in the ratios rather than liveweight. This divisor was chosen since it was more independent of fat depth than liveweight, which comprises the sum of total body fat, muscle and other components. Since all fat depths were divided by B, comparisons between ratios reflected differences in fat distribution, that is, they were independent of size.

RESULTS

No data set was significantly skewed (P>0.05) or kurtotic (P>0.05).

DD were 24% heavier than BL with greater absolute depths at B, R, L and T and similar depths at C and GR (Table 1). DD had similar relative fatness (fat depth in relation to muscle depth) to BL since the average of the differences between genotypes was close to zero (Table 2). However DD had greater ratios for R and T but a lower ratio for GR than BL highlighting a difference in subcutaneous fat distribution (Table 2). When breeds were compared at equal weight all depths were smaller in DD with the greatest differences being at C and GR (Table 3). Liveweight covariates for all ratios were positive and highly significant (P<0.001).

TABLE 1 Comparison of raw means for tissue depths of Border Leicester (BL) and Dorset Down ewe hoggets (DD). A standard error for each mean (sem) is given in brackets.

Tissue Ratios	Mean (sem in brackets) BL	DD	% difference*	Significance
R	16.5 (0.60)	19.1 (0.54)	+16	**
C	4.04 (0.17)	3.98 (0.16)	-1	NS
GR	14.0 (0.37)	13.7 (0.34)	-2	NS
L	4.99 (0.25)	5.86 (0.23)	+17	*
T	12.4 (0.36)	14.1 (0.33)	+14	**
B	23.4 (0.28)	24.9 (0.26)	+6	***
Liveweight (kg)	37.7	46.6	+24	
Number	40	48		

* Difference is [(DD-BL)/BL] x 100.

TABLE 2 Comparison of mean tissue ratios (fat depth/muscle depth) of Border Leicester (BL) and Dorset Down (DD) ewe hoggets. A standard error for each mean (sem) is given in brackets.

Tissue Ratios	Mean (sem in brackets) BL	DD	% difference*	Significance
R/B	0.703 (0.022)	0.764 (0.020)	+9	*
C/B	0.171 (0.006)	0.159 (0.006)	-7	NS
GR/B	0.595 (0.013)	0.551 (0.012)	-7	*
L/B	0.212 (0.009)	0.234 (0.008)	+10	NS
T/B	0.530 (0.013)	0.564 (0.012)	+6	*

* Difference is [(DD-BL)/BL] x 100.

DISCUSSION

Since DD were of greater size it was expected that they would have greater absolute fat depths (Table 1). It would also be expected that DD would be less mature than BL since larger animals generally mature at a slower rate (Taylor, 1985). However, both breeds had similar average tissue ratios (fat depth divided by muscle depth, B) which indicated that they were of similar maturity (Table 2). This also meant that differences in the actual ratios were reflecting a true genetic difference in subcutaneous fat distribution (ie independent of stage of development) since relative maturity affects shape of the subcutaneous fat depot as well as its size relative to other carcass components (Kempster, 1980).

TABLE 3 Comparison of weight-adjusted means for tissue depths of Border Leicester (BL) and Dorset Down (DD) ewe hoggets. A standard error for each mean (sem) is given in brackets.

Tissue Ratios	Mean (sem in brackets) BL	DD	% difference*	Significance
R	19.0	17.0	-11	*
	(0.60)	(0.53)		
C	4.78	3.36	-30	***
	(0.17)	(0.15)		
GR	15.7	12.3	-22	***
	(0.35)	(0.31)		
L	5.90	5.10	-14	NS
	(0.26)	(0.23)		
T	13.8	12.9	-7	NS
	(0.36)	(0.32)		
B	24.6	24.0	-2	NS
	(0.28)	(0.25)		

* Difference is [(DD-BL)/BL] x 100.

Adjustment of fat depths to a common weight (Table 3) removed the effect of differences in size but confounded the comparison because it compared the breeds at different stages of maturity. That is, it adjusted the tissue depths of the BL upward (since these were smaller in liveweight), acting to increase relative maturity, and adjusted the tissue depths of the DD downward, acting to decrease relative maturity. Comparisons made using tissue ratios were not confounded in this way.

Since the BL distributed relatively more fat at C and GR than R, L and T in comparison with the DD the industry perception that the BL is 'fat on the ribs' (in terms of C and GR) relative to the rest of its body is validated. Conversely the DD may be viewed as being fatter at other sites (R, L, T).

Previous discussion had assumed that the Border Leicester used in this trial was representative of the breed. This may not have been the case since the Border Leicester sheep studied had been selected for lean tissue growth rate for five years. However this selection programme is still in its early stages and the flock was set up to be representative of the breed in New Zealand. Also a similar selection strategy in the Dorset Down line used in this trial has resulted in only small changes to date when compared with a randomly bred control line of Dorset Downs (Naber, 1991).

Significant differences in subcutaneous fat distribution between genotypes reveals a problem for carcass classification systems based on weight and a single fat depth. Breeds such as the BL would be biased against, since the BL studied in this trial distributed relatively more fat at GR than at other sites. The magnitude of this problem may be reduced in practice since meat graders subjectively assess the fat cover of the whole carcass and measure GR only in borderline cases (Muirhead, 1989).

Relatively more fat at GR and C, than at R, L and T for the BL compared to the DD may be a valuable attribute since there is less subcutaneous fat covering more valuable parts of the carcass, namely the loin and hindquarter.

Our findings also suggest that use of one fat depth measurement in breeding programmes for lean growth could lead to changes in fat distribution. Furthermore, single site fat depths may not be appropriate for comparison of genotypes for fatness since they would bias some breeds. In both situations more than one fat depth may need to be measured.

CONCLUSIONS

A difference in subcutaneous fat distribution was found between the two genotypes. Border Leicester ewe hoggets had relatively greater fat depths at C and GR than R, L and T compared to Dorset Down ewe hoggets. Use of GR in the current sheep grading system may bias some breeds because of differences in subcutaneous fat distribution. Selection programmes aiming to change carcass composition and breed comparisons studies must be aware of these effects.

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