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Effects of genotype and nutrition on sheep carcass fat and eye muscle development between weaning and 14 months of age

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ABSTRACT

Romney crossbred lambs (n=711) sired by selected Southdown high fat (SD+), low fat (SD-) and Texel rams were grown from weaning to 14 months of age under high (H), medium (M) or low (L) nutrition. A random half of the H and L groups were run with the L and H groups respectively from 8 months onwards. Samples of lambs were slaughtered at 3, 5, 8, 11 and 14 months of age. Whereas there were significant carcass weight differences between nutrition groups, there were no differences between genotypes. SD+ lambs were more volatile in their subcutaneous fat responses to nutrition and were almost always fatter than the SD- and Texel lambs. All genotypes showed markedly reduced levels of fat development during the post-weaning and winter periods, with highest levels in spring. Eye muscle width was more nutritionally respnsive than eye muscle depth and, in relation to carcass weight changes, was greatest in winter.

Keywords: Nutrition; genotypes; fat; eye muscle development.

INTRODUCTION

There is much debate on the extent to which the rates of development of carcass components can be altered by nutrition (Kirton *et al.*, 1962). This is expecially so for fat, which has significant effects on meat quality and producer returns. The aim of this trial was to evaluate the nutritional sensitivity of breeds and strains with different developmental patterns of muscle and fat. Texels, with a reputation for high muscle development and leanness, and two strains of Southdowns selected for divergent subcutaneous fat development (Solis-Ramirez *et al.*, 1993) were chosen. This paper reports on breed and nutritional effects on carcass weight plus linear fat and muscle measurements.

MATERIALS AND METHODS

Romney crossbred lambs (n=711) sired by selected Southdown high fat (SD+), Southdown low fat (SD-) and Texel rams were born in August (n=326) and September (n=385) 1992. They were reared in groups balanced by sire (5 or 6 per line) to weaning at 10 or 14 weeks of age. From weaning till May groups of lambs balanced for age, sire and sex were reared on pasture on one of three planes of nutrition designed to promote maximum live weight gain (High), approximately half maximum live weight gain (Low), or an intermediate rate of gain (Med). From May until November a random half of each of the High and Low groups were run with the Low and High groups respectively. The 14-month target live weights were 60 kg, 50 kg and 40 kg for the High, Med and Low groups respectively. Samples of lambs were slaughtered at the Ruakura experimental abattoir at 3 (December), 5 (February), 8 (May), 11 (August) and 14 (November) months of age. Kidney fat and GR were measured on the day of slaughter. On the day following slaughter, a sample of carcasses was backed between the 12th and 13th ribs where A, B, C and fat depth J (Palsson, 1939) were measured on both sides and tracings made of the eye muscles. The remaining carcasses were halved and the right sides frozen for cutting into DEVO cuts (Devco, 1982). Measurements A, B, C and J were taken between the 12th and 13th ribs. Eye muscle areas were estimated from the mean of two digitised tracings using an Apple graphics tablet.

Statistical analysis

Breed, sex, rearing rank, early/late lambing group, and slaughter group main effects and their significant interactions for HCW, A, B, EMA, C, GR, J and kidney fat were computed using Genstat 5.0 LEAST procedures. Significant interactions were found for breed.slaughter cell and sex.slaughter cell effects.

Main effects for breed and cell were calculated using Genstat 5.0 REML procedures.

RESULTS AND DISCUSSION

Carcass weights

Texels tended to be heavier than the two Southdown strains (T 103%, SD- 100%, SD+ 98% on average for the means presented in Table 1). The nutritional regimes were effective in producing divergent growth paths. By May, the Low nutrition group was lighter than the Med and High groups. At the end of winter, the High group was heavier than the Med and two crossover groups, which were heavier than the Low group. By November, both the High groups (HH and LH) were heavier than the Med group, which was heavier than the two Low groups (HL and LL).

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TABLE 1: Effects of genotype and nutrition on hot carcass weights.

	Breed Means*			Nutrition
	SD+	SD-	Texel	Group means**
December (3 months)				
All	12.3^{a}	12.7^{a}	12.2^{a}	12.6
February (5 months)				
H	13.9^{b}	14.7^{a}	15.9^{a}	14.8^{z}
M	13.8^{b}	14.7^{ab}	15.6^{a}	14.7^{z}
L	12.8^{a}	13.2^{a}	13.7^{a}	13.2^{z}
May (8 months)				
H	19.5^{a}	18.7^{a}	18.5^{a}	18.9^{z}
M	17.3^{b}	17.7^{ab}	19.2^{a}	18.1^{z}
L	13.3^{a}	12.0^{a}	13.4^{a}	12.9^{y}
August (11 months)				
HH	22.5^{a}	22.0^{a}	22.2^{a}	22.2^{z}
HL	17.0^{b}	17.6^{ab}	18.7^{a}	17.7^{yx}
M	17.8^{b}	19.5^{a}	18.2^{ab}	18.5^{y}
LH	18.1^{a}	19.1^{a}	18.8^{a}	18.7^{y}
LL	14.6^{b}	16.5^{a}	15.9^{a}	15.7^{x}
November (14 months)				
HH	31.2^{a}	31.6^{a}	31.0^{a}	31.3^{z}
HL	20.1^{ab}	19.2^{b}	20.8^{a}	20.0^{x}
M	21.2^{c}	23.1^{b}	24.8^{a}	23.1^{y}
LH	29.7^{c}	30.2^{a}	30.3^{a}	30.1^{z}
LL	18.8^{a}	18.0^{a}	18.7^{a}	18.5^{x}
Average SEDs:	Breed	0.38		
	Nutrition	0.56		
	Breed.Nutrition	0.96		

* Breed means on the same row with different letters are significantly different, P<0.001

** Nutrition group means within the same slaughter period with different letters are significantly different *P*<0.001

Eye muscle dimensions

Eye muscle area showed linear development relative to HCW (Table 2). While this pattern was similar for all strains, SD+ and Texel achieved an advantage of approximately 1 sq cm (6%) over SD- under H winter nutrition. This advantage was maintained through the spring and was twice that achieved under M nutrition.

Eye muscle width increased under all nutritional treatments in spring and especially in winter (even when there was weight loss). In the post-weaning and autumn periods weight gains of 1 to 2 kg (HCW) were necessary to sustain width increases. At the same HCW leaner strains had slightly greater eye muscle widths (T 101%, SD- 100%, SD+ 98%).

Eye muscle width was more nutritionally sensitive than eye muscle depth, yet depth changes were less variable across seasons. Linear regressions of muscle depth changes on HCW changes for different nutrition levels within each season all passed close to the origin (zero change in both traits). SD+ had slightly greater muscle depth (102%) than SD- (98%) with T (100%) intermediate. These greater depths together with smaller widths indicate that the fat strain had rounder eye muscles than the lean strain with Texels intermediate. Within each strain this same trend was increasingly evident at higher HCW. This may be of significance for customers' perceptions of "meatiness", despite its poor correlation with subjective scores of muscularity or conformation (Abdullah *et al.*, 1993).

TABLE 2: Effects of genotype and nutrition on eye muscle dimensions.

	Eye muscle width				Eye muscle depth				Eye muscle area			
	Breed Means*			Nutrition	Breed means*			Nutrition	Breed means*			Nutrition
	SD+	SD-	Texel	gp means**	SD+	SD-	Texel	gp means**	SD+	SD-	Texel	gp means**
December (3 months)												
All	51.6^{a}	52.8^{a}	53.7^{a}	52.7	26.6^{a}	27.9^{a}	27.6^{a}	27.4	990^{a}	971^{a}	1028^{a}	996
February (5 months)												
H	53.1^{b}	53.5^{b}	56.8^{a}	54.5^{z}	27.8^{a}	27.8^{a}	29.0^{a}	28.2^{z}	1055^{b}	1100^{ab}	1178^{a}	1111^{z}
M	52.0^{b}	55.1^{a}	55.4^{a}	54.2^{z}	27.8^{a}	27.0^{a}	27.8^{a}	27.6^{z}	1017^{a}	1057^{a}	1104^{a}	1059^{z}
L	51.6^{b}	52.2^{b}	55.1^{a}	53.0^{z}	26.8^{a}	26.5^{a}	27.1^{a}	26.8^{z}	979^{a}	971^{a}	1041^{a}	997^{z}
May (8 months)												
H	55.4^{a}	56.0^{a}	55.5^{a}	55.6^{z}	32.2^{a}	30.5^{a}	31.2^{a}	31.3^{z}	1300^{a}	1220^{a}	1227^{a}	1249^{z}
M	52.1^{b}	55.8^{a}	57.1^{a}	55.0^{z}	30.5^{a}	30.0^{a}	31.3^{a}	30.6^{z}	1148^{a}	1164^{a}	1227^{a}	1180^{z}
L	50.8^{a}	51.4^{a}	52.0^{a}	51.4^{y}	26.9^{a}	24.7^{b}	24.6^{b}	25.4^{y}	951^{a}	832^{b}	848^{ab}	877^{y}
August (11 months)												
HH	60.4^{a}	60.6^{a}	62.1^{a}	61.0^{z}	35.4^{a}	31.7^{b}	33.5^{b}	33.6^{z}	1537^{a}	1390^{b}	1471^{ab}	1466^{z}
HL	56.8^{b}	60.1^{a}	60.7^{a}	59.2^{yz}	30.3^{a}	30.1^{a}	31.1^{a}	30.5^{y}	1189^{a}	1236^{a}	1292^{a}	1239^{y}
M	57.7^{a}	59.9^{a}	59.1^{a}	58.9^{yz}	31.0^{a}	30.0^{a}	29.7^{a}	30.2^{y}	1269^{a}	1270^{a}	1218^{a}	1252^{y}
LH	57.1^{b}	58.6^{b}	61.6^{a}	59.1^{yz}	31.5^{ab}	32.4^{a}	30.3^{b}	31.4^{zy}	1280^{a}	1326^{a}	1314^{a}	1307^{y}
LL	55.7^{b}	59.1^{a}	58.0^{a}	57.6^{y}	29.1^{a}	28.3^{a}	29.4^{a}	29.0^{y}	1114^{a}	1167^{a}	1182^{a}	1154^{y}
November (14 months)												
HH	62.1^{b}	62.3^{b}	64.8^{a}	63.1^{z}	38.9^{a}	37.6^{a}	38.0^{a}	38.2^{z}	1770^{a}	1702^{a}	1808^{a}	1760^{z}
HL	59.4^{a}	59.9^{a}	61.0^{a}	60.1^{yx}	31.7^{a}	30.4^{a}	31.0^{a}	31.0^{xy}	1308^{a}	1274^{a}	1303^{a}	1295^{xy}
M	59.4^{b}	60.5^{ab}	62.3^{a}	60.8^{yz}	32.2^{a}	32.9^{a}	33.7^{a}	32.9^{y}	1356^{b}	1402^{ab}	1512^{a}	1423^{y}
LH	59.8^{b}	61.9^{ab}	63.8^{a}	61.8^{z}	37.4^{a}	36.3^{a}	37.0^{a}	36.9^{z}	1703^{a}	1671^{a}	1713^{a}	1696^{z}
LL	57.0^{b}	57.1^{b}	61.4^{a}	58.5^{y}	29.9^{a}	28.0^{a}	29.7^{a}	29.2^{x}	1186^{a}	1235^{a}	1275^{a}	1232^{x}
Average SEDs:												
Breed		0.59				0.36				225.7		
Nutrition				0.79				0.69				38.1
Breed. Nutrition			1.36				1.16				65.3	

*Breed means on the same row with different letters are significantly different. *P*<0.001.

**Nutrition group means within the same slaughter period with different letters are significantly different *P*<0.001.

TABLE 3: Effects of genotype and nutrition on subcutaneous fat depths

	Fat depth C				GR				Fat depth J			
	Breed Means*			Nutrition	Breed means*			Nutrition	Breed means*			Nutrition
	SD+	SD-	Texel	gp means**	SD+	SD-	Texel	gp means**	SD+	SD-	Texel	gp means**
December (3 months) All	3.29^{a}	1.29^{b}	1.31^{b}	1.96	7.54^{a}	5.86^{ab}	4.70^{b}	6.03	6.98^{a}	7.18^{a}	4.34^{b}	6.17
February (5 months)												
H	2.09^{a}	1.95^{a}	1.45^{a}	1.83^{z}	6.21^{a}	6.21^{a}	4.68^{a}	5.70^{z}	6.01^{a}	5.34^{a}	3.62^{b}	4.99^{z}
M	1.78^{a}	1.96^{a}	1.68^{a}	1.81^{z}	6.14^{a}	5.95^{a}	4.64^{a}	5.58^{z}	4.66^{a}	4.57^{a}	3.54^{a}	4.26^{z}
L	2.05^{a}	1.41^{ab}	0.79^{b}	1.42^{z}	4.94^{a}	4.08^{ab}	3.01^{b}	4.01^{z}	5.00^{a}	4.10^{a}	2.19^{b}	3.76^{z}
May (8 months)												
H	4.40^{a}	2.55^{b}	2.59^{b}	3.18^{z}	11.36^{a}	8.95^{b}	7.18^{b}	9.16^{z}	8.85^{a}	6.85^{b}	5.58^{b}	7.09^{z}
M	3.31^{a}	1.92^{b}	2.16^{b}	2.46^{z}	9.78^{a}	7.78^{b}	7.18^{b}	8.24^{z}	7.53^{a}	5.68^{b}	6.25^{ab}	6.48^{z}
L	1.45^{a}	1.03^{a}	1.17^{a}	1.22^{y}	4.77^{a}	3.41^{a}	3.18^{a}	3.79^{y}	4.08^{a}	2.87^{ab}	2.27^{b}	3.07^{y}
August (11 months)												
HH	4.17^{a}	2.81^{b}	2.06^{b}	3.01^{z}	11.97^{a}	10.16^{b}	6.71^{c}	9.61^{z}	9.53^{a}	8.30^{a}	6.15^{b}	8.00^{z}
HL	2.35^{a}	1.49^{a}	1.36^{a}	1.74^{z}	6.14^{a}	4.84^{a}	4.56^{a}	5.18^{yx}	4.86^{a}	3.67^{a}	3.34^{a}	3.95^{y}
M	2.23^{a}	1.67^{a}	1.25^{a}	1.72^{z}	7.06^{a}	6.57^{a}	4.75^{b}	6.13^{y}	6.48^{a}	5.55^{a}	3.65^{b}	5.23^{y}
LH	2.69^{a}	2.24^{ab}	1.24^{b}	2.05^{z}	9.00^{a}	7.52^{a}	5.12^{b}	7.21^{z}	7.37^{a}	6.54^{a}	3.91^{b}	5.94^{z}
LL	1.00^{a}	1.35^{a}	0.99^{a}	1.12^{y}	3.66^{a}	3.43^{a}	2.70^{a}	3.26^{x}	3.26^{a}	3.26^{a}	2.64^{a}	3.06^{y}
November (14 months)												
HH	8.41^{a}	7.24^{b}	6.04^{c}	7.23^{z}	25.14^{a}	23.36^{b}	18.93^{c}	22.48^{z}	20.12^{a}	19.02^{a}	16.19^{b}	18.45^{z}
HL	2.46^{a}	1.59^{a}	1.49^{a}	1.85^{y}	6.83^{a}	5.92^{ab}	4.85^{b}	5.87^{y}	5.13^{ab}	5.37^{a}	3.61^{b}	4.70^{y}
M	4.00^{a}	3.03^{a}	3.30^{a}	3.44^{x}	11.53^{a}	9.99^{a}	10.25^{a}	10.59^{x}	8.94^{a}	8.40^{a}	8.07^{a}	8.47^{x}
LH	10.07^{a}	6.51^{b}	6.41^{ab}	7.66^{z}	25.06^{a}	22.62^{b}	18.50^{c}	22.06^{z}	20.32^{a}	18.17^{b}	14.99^{c}	17.83^{z}
LL	2.77^{a}	1.71^{ab}	1.30^{b}	1.93^{y}	7.70^{a}	5.82^{b}	4.12^{b}	5.88^{y}	5.97^{a}	4.71^{a}	2.75^{b}	4.48^{y}
Average SEDs:												
Breed		0.278				0.428				0.404		
Nutrition				0.347				0.689				0.661
Breed. Nutrition			0.609				1.170				1.125	

* Breed means on the same row with different letters are significantly different $P<0.001$

** Nutrition group means within the same slaughter period with different letters are significantly different $P<0.001$

Subcutaneous fat

Kirton *et al.*, indicate that "attempting to alter carcass composition through manipulation of pasture intake is unpredictable". Whereas his high growth lambs had highest weight-adjusted GR values in the first season, they had lowest values in the second season. Furthermore, seasonal differences in two measures of fat depth (C and GR) were inconsistent. The results of Butler-Hogg (1984), Butler-Hogg and Johnson (1986) and Thatcher and Gaunt (1992) are also inconsistent in the effects of changes in the level of nutrition on carcass composition. In contrast to this previous work, the present trial spanned the whole period from weaning to 14 months of age, and also covered a wider range of nutritional treatments, allowing trends to be more clearly elucidated.

Mean values and standard errors of means for fat traits are given in Table 3. There were typical exponential development trends for all fat depots in all strains. Using a subcutaneous fat index of GR+J+(2*C), SD+ were 28% fatter than T which were 26% fatter than SD-. Southdown strains showed more divergent patterns for C than for GR and J. The fatter strain showed greater variation around the trend lines than the leaner strains, suggesting greater nutritional sensitivity.

For kidney fat, Texels were 28% leaner than the Southdown strains which were similar.

Fat changes were greatest in spring (especially in the LH nutrition group), least in winter and post-weaning, with autumn being intermediate. In general, HCW gains of approximately two kg were necessary to sustain fat gains. However, the fat strain showed greater responsiveness to weight changes than the lean strains. In the post-weaning period under High and Medium nutrition, SD- and Texel maintained their weaning levels of fat development, but SD+ reduced their fat development to levels that were similar to SD-.

Under Low nutrition, all genotypes showed reduced fat development and similar ratios of percentage rates of fat loss to percentage rates of HCW gain (ratios of relative growth rates).

During winter, all genotypes showed a similar reduction in subcutaneous fat relative to HCW - approximately 3 mm at 20 kg under High nutrition and 2 mm at 18 kg under Med nutrition.

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