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# Observations on the effect of litter size, pregnancy nutrition and fat genotype on ewe and foetal parameters

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## ABSTRACT

Fat and lean Coopworth ewes that were daughters of fat and lean rams were joined with rams from the Invermay lean and fat selection lines to study the effects of genotype (fat, lean) and mid-pregnancy feeding level on foetal weight and ewe carcass measurements at day 135 of gestation. Ewes offered a high level of feed during days 30 to 100 of gestation gained 3% while those on a low level lost 9% of their day 30 live weight. All ewes were offered the same level of feeding from day 100 until slaughter on day 135. Mid-pregnancy nutrition had no effect on foetal weight. Litter size had significant effects on foetal weight (single 4.56 kg, twin 3.99 kg, triplet 3.24 kg.). The weight of foetuses of the lean genotype adjusted for litter size and nutrition was 270g heavier ( $P < 0.01$ ) than that of the fat genotype. The weight of placenta, and placentome number/foetus decreased with litter size and were associated significantly with foetal weight. Fat genotype, however, had no effect on placental weight or placentome number. Fat genotype of the ewe and foetus did not affect a number of foetal skeletal size parameters but influenced foetal weight despite ewe nutrition. Consequently it appears that this influence on foetal weight is independent of any effect of the placenta *per se*.

**Keywords** Lean; fat; foetal weight; pregnancy nutrition; placenta; sheep.

## INTRODUCTION

The production and marketing of New Zealand sheep meat is sensitive to the problem of excess carcass fat. The development of genetically leaner genotypes (Fennessy *et al.*, 1982) is a means of overcoming this problem. While most research has concentrated on the production of a lean carcass, other production traits need to be assessed if genetically leaner genotypes are to be of practical use. This experiment was designed to evaluate the effect of fat and lean sire genotype on foetal weights and to investigate any possible effects of level of mid-pregnancy nutrition.

## EXPERIMENTAL

### Animals and Experimental Design

The ewes for this experiment were selected as fatter or leaner than average on the basis of their sire's progeny test. In the progeny test 20 rams were tested by slaughtering male progeny at an average carcass weight of 16 kg. The overall sire mean was 23.0% (SD 1.27) fat. The fat ewes were the progeny of 3 rams whose male progeny at slaughter had an average of 1.7% units more chemical fat than average (24.7 v 23.0%) while the lean ewes were the progeny of 2 rams with 1.4% units less fat than average (21.6 v 23.0%). The rams mated to those ewes used were selected on the basis of their own weight-adjusted backfat thickness from the Invermay lean and fat selection lines, and were approximately one SD leaner or fatter than their line means respectively (i.e. approximately 4 SD apart).

Oestrus was synchronised with MAP sponges (60 mg "Repromap") inserted on 14 March and sponges were removed 14 days later. Fat rams were joined with

fat ewes and lean ram with lean ewes from 11 April for 8 days. Mating marks were recorded each day. All ewes were laparoscoped on 26 April. Live weights were recorded pre-joining and on day 30, 100 and 135 (pre-slaughter) of gestation. From day 30, approximately half of the fat and lean ewes were randomly allocated to a high nutrition level (ad-lib. pasture). The remaining ewes were allocated to a low nutrition (restricted pasture fed to lose 10% of the pre-joining live weight). Nutrition treatment ended on day 100 and all ewes were offered the same level of feeding (2 kg DM/head/d) until slaughter on day 135.

### Slaughter Procedure and Measurements

The gravid uterus was removed from the carcass at slaughter. Litter size, sex and weight of each foetus was recorded together with crown to rump, skull, radius and humerus lengths, kidney, heart, liver and brain weight and placentome (i.e. cotyledonary sites of attachment) weight and number. Ewe carcass traits (carcass weight, C, GR, S1, S2, L3 and tail fat depths) and weight of mammary gland were measured.

### Analysis

A parsimonious model (Aitkin, 1978) was fitted to the data. In all cases the interaction terms were eliminated from the model leaving the main effects model of genotype (fat, lean), mid-pregnancy nutrition (high, low) and litter size from which predicted values and standard errors were obtained.

Initial live weight was fitted as a covariate in the main effects model with ewe live weight and carcass data adjusted for initial live weight. Ewe carcass weight at slaughter was also fitted as a covariate in the main

effects model in a separate analysis for ewe carcass data.

Foetal weight was fitted as a covariate in the main effects model for analyses of foetal traits measured at slaughter.

## RESULTS

Ovulation rates (2.19, SD 0.15) and litter size at slaughter (1.76 SD 1.17) were similar for both genotypes.

### Ewe Live Weight

Live weight pre-joining and at day 30 (prior to nutrition treatment) was similar for lean (68.0 SE 0.4 kg) and fat (70.5 SE 0.4 kg) genotypes.

At 100 days of gestation (after 70 days of differential nutrition), lean ewes under low nutrition had lost on average 9.3% of the day 30 live weight whilst fat ewes had lost 8.3% of that live weight. Lean and fat ewes under high nutrition gained 2.6% and 4.3% of the day 30 live weight, respectively. Genotype of ewe had no effect on 100 day live weight (Table 1). Ewes on high nutrition were heavier ( $P < 0.01$ ) than ewes on low nutrition. Litter size affected live weight such that triplet-, twin-, and single-bearing ewes were heavier ( $P < 0.01$ ) than non-pregnant ewes (Table 1).

Similar effects were evident at the pre-slaughter (day 135) live weight (Table 1). Triplet-, twin-, and single-bearing ewes were heavier ( $P < 0.01$ ) than non-pregnant ewes and ewes on low nutrition were lighter than those on high nutrition.

Cold carcass weights (Table 2) indicate that the heavier live weight of twin- and triplet-bearing ewes was attributable to conceptus weight. Carcasses of triplet-bearing ewes were lighter ( $P < 0.01$ ) than twin- and single-bearing ewes. Low nutrition reduced carcass weight ( $P < 0.01$ ).

**TABLE 1** Effect of litter size, nutrition treatment and fat genotype on mean (SE) ewe live weight (kg) at 100 and 135 days of gestation adjusted for initial ewe live weight (69.2 kg).

	No. ewes	Gestation (days)	
		100	135
Litter size			
0	6	64.4 (0.9)	60.4 (1.1)
1	11	66.8 (0.7)	68.0 (0.8)
2	27	68.4 (0.4)	71.5 (0.5)
3	8	68.9 (0.8)	72.3 (0.9)
Nutrition			
Low	25	63.5 (0.5)	66.0 (0.6)
High	27	72.5 (0.4)	72.9 (0.5)
Genotype			
Lean	26	67.5 (0.4)	69.6 (0.5)
Fat	26	67.9 (0.4)	69.6 (0.5)

### Ewe Carcass Traits

An increase in litter size resulted in an increase in the amount of mammary gland tissue after adjustment for initial live weight. The mammary glands of triplet- (1.09, SE 0.07 kg), twin- (0.86, SE 0.04 kg) and single-bearing (0.60, SE 0.06 kg) ewes were heavier ( $P < 0.01$ ) than non-pregnant ewes (0.30, SE 0.08 kg). Neither nutrition nor genotype had any effect on mammary gland weight.

Triplet-bearing ewes had leaner ( $P < 0.01$ ) carcasses (for GR, S1, S2, L3 and tail fat depths) than non-pregnant ewes after adjustment for initial live weight (Table 2). Single- and twin-bearing ewes tended to be leaner than non-pregnant ewes. Low nutrition reduced carcass fat for all fat measurements ( $P < 0.01$ ). Lean genotype ewes had less subcutaneous fat at several sites (C, GR, L3 and tail fat) than fat genotypes

**TABLE 2** The effect of litter size, nutrition treatment and fat genotype on mean (SE) ewe carcass fat measurements after adjustment for initial ewe live weight (69.2 kg).

	No. ewes	Carcass weight (kg)	Gravid uterus (kg)	Carcass fat measurements (mm)					
				C	GR	S1	S2	L3	Tail
Litter size									
0	6	32.7(0.8)	0.23(0.59)	14.0(2.32)	28.7(3.04)	12.5(1.58)	16.7(2.04)	24.5(3.39)	
1	11	32.5(0.5)	6.90(0.40)	12.3(1.68)	26.8(2.20)	9.3(1.14)	14.3(1.48)	22.4(2.46)	27.2(2.81)
2	27	30.5(0.3)	12.30(0.25)	11.8(1.07)	22.8(1.40)	8.9(0.73)	13.4(0.94)	19.0(1.59)	23.5(1.78)
3	8	28.0(0.7)	15.88(0.47)	8.0(2.01)	15.8(2.63)	5.8(1.37)	8.8(1.77)	13.0(2.94)	14.5(3.35)
Nutrition									
Low	25	28.3(0.4)	10.06(0.27)	8.5(1.13)	9.0(1.48)	7.8(0.77)	11.6(1.99)	15.9(1.69)	19.2(1.89)
High	27	33.3(0.4)	10.94(0.26)	14.4(1.08)	27.2(1.42)	10.1(0.74)	14.8(1.96)	22.6(1.59)	27.7(1.81)
Genotype									
Lean	26	31.5(0.4)	10.90(0.26)	9.3(1.09)	20.3(1.43)	8.2(0.74)	12.2(1.96)	16.5(1.64)	20.3(1.83)
Fat	26	30.1(0.4)	10.13(0.26)	13.8(1.09)	26.1(1.43)	9.8(0.74)	14.3(1.96)	22.3(1.60)	26.9(1.83)

( $P < 0.01$ ). When data were adjusted for carcass weight at slaughter the same trends associated with litter size were apparent (Table 3) although the triplet-bearing ewes had significantly less ( $P < 0.01$ ) fat than non-pregnant ewes at GR and SI sites only. Although there was a trend for high plane ewes to be fatter, none of the differences attained significance ( $P > 0.05$ ). Fat genotype ewes were fatter than lean ewes at all sites but the differences were significant for C and GR only ( $P < 0.01$ ).

### Foetal Traits

Litter size and genotype affected foetal weight ( $P < 0.01$ ). With adjustments for litter size and nutrition, lean foetuses were on average 0.27 kg heavier than fat foetuses (4.00 SE 0.09 kg,  $n = 41$ , 3.73, SE 0.08 kg,  $n = 48$ ). Single foetuses were heavier (4.56, SE 0.17 kg,  $n = 11$ ) than twins (3.99, SE 0.08 kg,  $n = 54$ ) which were heavier than triplets (3.24, SE 0.12 kg,  $n = 24$ ). Nutrition of the dam and sex of the foetus did not affect foetal weight.

After adjustment for foetal weight there were no genotype, nutrition or litter size effects on the crown to rump length (44.7, SE 0.3 cm), skull length (crown to nose tip, 11.4, SE 0.1 cm), radius length (9.7, SE 0.1 cm), liver weight (108.9, SE 3.3 g), kidney weight (21.7, SE 0.5 g) or heart weight (28.1, SE 0.6 g). Fat foetuses had a lower brain weight (42.4, SE 0.65 g) than lean foetuses (45.0, SE 0.71 g) ( $P < 0.01$ ) and had a longer ( $P < 0.05$ ) humerus (8.83, SE 0.09 cm, 8.48, SE 0.10 cm respectively.)

Litter size had significant ( $P < 0.01$ ) effects on the placental traits after adjustment for foetal weight (Table 4). Triplet litters had a lower number of placentomes/foetus than twins, which had fewer than singles. The total amount of placenta/foetus showed a similar decline with litter size. However the mean placentome weight increased ( $P < 0.05$ ) with litter size. Ewes on a low plane of nutrition had a higher placental weight (356, SE 7.9 g) than those on a high plane of

nutrition (331, SE 8.2 g;  $P < 0.05$ ). Genotype had no effect on any of the placental traits.

There was a significant regression relationship ( $P < 0.01$ ) between foetal weight ( $Y$ , kg) and total placental weight ( $X_1$ , kg) and placentome number ( $X_2$ )/foetus:

$$Y = 1.72 + 5.03X_1 + 8.55X_2$$

### DISCUSSION

Both litter size and mid-pregnancy nutrition affected ewe live weight during the mid- to late-pregnancy period. The ewe carcass weight differences with nutrition and litter size indicate that triplet-bearing ewes lost more body weight in supporting the greater number of foetuses. Similarly, as Rattray and Trigg (1979) found, ewes on low nutrition during pregnancy lost more body weight than well fed ewes to maintain foetal growth.

The lack of any effect of nutrition on mammary gland weight and the changes associated with litter size are in agreement with Robinson *et al.* (1978). They suggest that the number of foetuses present influences the endocrine status in ewes which in turn controls mammary tissue development.

**TABLE 4** Effect of litter size on mean (SE) placental traits after adjustment for foetal weight.

	Litter size		
	1	2	3
Number foetuses	11	54	24
Weight of placenta/foetus(g)	404 (17.8)	345 (7.3)	314 (12.7)
Placentome number/foetus	68.2 (3.7)	48.0 (1.5)	38.5 (2.7)
weight/foetus(g)	6.1 (0.6)	7.5 (0.3)	8.6 (0.5)

**TABLE 3** The effect of litter size, nutrition treatment and fat genotype on mean (SE) ewe carcass fat measurements after adjustment for ewe carcass weight at slaughter (30.8 kg).

	No. ewes	Carcass fat measurements (mm)					
		C	GR	SI	S2	L3	Tail
Litter size							
0	6	13.1 (2.06)	27.1 (2.42)	11.8 (1.40)	15.4 (1.73)	22.7 (2.88)	27.1 (3.24)
1	11	11.0 (1.56)	24.6 (1.82)	8.5 (1.05)	12.9 (1.30)	20.2 (2.18)	24.4 (2.45)
2	27	12.0 (0.97)	23.0 (1.13)	9.1 (0.65)	13.6 (0.51)	19.3 (1.38)	23.9 (1.52)
3	8	9.9 (0.87)	19.1 (2.18)	7.2 (1.26)	11.0 (1.56)	16.3 (2.60)	18.9 (2.93)
Nutrition							
Low	25	10.1 (1.05)	21.7 (1.23)	8.9 (0.71)	13.4 (0.88)	18.8 (1.50)	22.8 (1.65)
High	27	13.0 (1.01)	24.6 (1.18)	9.1 (0.68)	13.1 (0.84)	20.1 (1.41)	24.3 (1.58)
Genotype							
Lean	26	9.9 (1.01)	21.3 (1.18)	8.6 (0.68)	12.8 (0.84)	17.5 (1.44)	21.5 (1.58)
Fat	26	13.3 (1.01)	25.2 (1.18)	9.4 (0.68)	13.7 (0.84)	21.3 (1.41)	25.7 (1.58)

It was evident that both low nutrition and increased litter size reduced the energy reserves of the ewe, especially in triplet-bearing ewes, by the reduction of carcass fat even when adjusted for carcass weight and initial live weight.

Differences in brain weight and humerus length between foetal genotypes cannot be adequately explained. The genotype effects on foetal weight which were evident after correction for nutrition and litter size are not explained by any differences in the measurements of foetal skeletal size or placental weight. Further support for the difference in foetal weight with genotype comes from the Invermay selection lines where the lean lambs in 1985 were approximately 15% heavier than fat lambs at birth (P.F. Fennessy, G.J. Greer and W.E. Bain, personal communication). Foetal weight differences between fat and lean genotypes may be associated with differences in

- (i) placental function and metabolism i.e. uptake and transfer of glucose and amino acids which may be influenced by uterine blood flow (Christenson and Prior, 1978) and
- (ii) maternal metabolic activity which may control the supply of nutrients and hormones to the foetus and influence uterine blood flow (Jones, 1976)
- (iii) foetal metabolic activity in which the foetus may regulate its own growth in response to maternal influences.

Falcolner *et al.* (1985) have shown that placental size *per se* has effects on placental metabolism. A small placenta has reduced placental lactogen and increased metabolism of insulin which may indicate a redirection of placental metabolism to improve the nutrient supply to the foetus. Oddy and Jenkin (1981) suggest that placental lactogen may be involved with the redirection of nutrients from the maternal reserves to the foetus. In the present study genotype had no effect on placental size but the concept of differences in placental metabolism as shown by changes in placental lactogen and insulin may explain genotype differences i.e. lean ewes may produce more placental lactogen and therefore have more efficient placentas.

Litter size effects on birth weight are related to placental weight (Davis *et al.*, 1981). The decrease in total weight of placenta and placentome number per foetus with litter size may have been partially compensated by an increase in the individual placentome weight and probably function. Similar effects were found by Mellor (1983).

In the present study low nutrition had the converse effect of increasing the placental weight which for these animals may have been a response to compensate for low nutrition.

Production from these lean Coopworth ewes will result in an increased birth weight above that for fat ewes and consequently for single births dystocia problems may be encountered. However, because of the relationships between birth weight and survival (Hinch *et al.*, 1985) higher survival rates of multiple born lean genotype lambs would be expected. Differences in placental function and maternal metabolic activities between lean and fat genotypes would have to be investigated to explain foetal weight differences.

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