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INTERRELATIONSHIPS OF PLACENTAL DEVELOPMENT WITH NUTRITION IN PREGNANCY AND LAMB BIRTH WEIGHT

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SUMMARY

In two experiments with over 90 ewes where the nutrition in pregnancy was varied and placental development and foetal weight measured close to term, variation in the extent of placental growth was closely associated with variation in foetal weight. The results suggest that the ability to alter lamb birth weight by variation in late-pregnancy nutrition was limited by the extent of placental growth. It was proposed that the optimisation of lamb birth weight will be better achieved by consideration of factors influencing the extent of placental growth rather than the manipulation of feed intake in late pregnancy.

INTRODUCTION

Variation in lamb birth weight is associated with birth rank (Donald and Purser, 1956), lamb genotype and sex (Meyer and Clarke, 1978), maternal nutrition in mid pregnancy (Rattray *et al.*, 1980), and in late pregnancy (Robinson, 1977) and placental size (Alexander, 1974). Lambs of low birth weight are most susceptible to death through starvation and/or exposure soon after birth while large lambs may die as a consequence of dystocia (Hight and Jury, 1970; Dalton *et al.*, 1980).

The present study investigated the effect of nutrition during pregnancy on placental development and its relationship with lamb birth weight.

MATERIALS AND METHODS

EXPERIMENT 1

Coopworth ewes (300 mature, mixed-age) were mated to Suffolk rams at a synchronised oestrus and offered a high (H) or low (L) pasture allowance from day 40 to day 95 of pregnancy. Single or twin pregnancy was diagnosed by X-rays at day 90. On day 95, ewes were re-randomised onto H and L pasture allowances according to pregnancy rank and previous nutritional status. Ewe liveweight was recorded following a 24 h fast at the start (day 40) and end (day

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137) of the trial. A full liveweight was taken at day 95 of pregnancy and adjusted (− 1.5 kg) for the extra gut-fill.

At day 137 of pregnancy slaughter groups were taken from each nutritional group. Following slaughter, the uterus was dissected and foetal weight determined. Foetal cotyledons and chorionic membrane were removed from the uterus by manual compression of the maternal cotyledons. Foetal cotyledons were then cut from the membrane, drained and weighed.

EXPERIMENT 2

The design and management of this experiment has been described elsewhere (Rattray and Trigg, 1979). Briefly, 5 groups of approximately 8 mature twin-bearing Coopworth ewes were housed indoors and individually offered a pelleted diet of 60% lucerne meal and 40% barley meal at one of 5 feeding levels; 1.0, 1.1, 1.3, 1.5 and 1.7 times non-pregnant maintenance (maintenance was assumed to be 40 g DM/kg$W^{0.75}$ where W was the initial wool-free empty liveweight).

Slaughter procedures were the same as in Experiment 1, except that the foetal cotyledons were not cut from the chorionic membrane, these tissues being weighed together. Ewes were slaughtered at 140 days of gestation.

RESULTS

EXPERIMENT 1

In early pregnancy H ewes gained and L ewes lost, on average, 13% of intiial liveweight. There was a significant ($P < 0.001$) effect of nutrition in early pregnancy on weight change in late pregnancy, HH and HL ewes tending to gain less than the LH and LL ewes (Table 1).

While HH and LH twin-bearing ewes gained more weight in late pregnancy than their respective well-fed single-bearing counterparts there was little difference in observed weight gain between the single- and twin-bearing ewes on a similar pasture allowance (viz. HH-single and HL-twin; LH-single and LL-twin; Table 1). Conceptus-free liveweight change in late pregnancy was negatively correlated with initial ewe liveweight ($P < 0.05$).

TABLE 1: PREGNANCY LIVEWEIGHT CHANGE, FOETAL WEIGHT AND FOETAL COTYLEDON WEIGHT IN EXPERIMENT 1

Nutritional group (1)		Initial liveweight (kg) Day 35	Pasture allowance in pregnancy (kg DM/head/d) Day 40-95	Day 95-137	Liveweight change (kg) Day 95-137[2]	Foetal Cotyledon weight (g)	Total foetal weight (kg)
Single	HH (6)	49.3	2.1	2.1	3.2 (−5.5)	441	4.9
	HL (6)	53.1	2.1	1.0	0.3 (−8.7)	351	4.8
	LH (6)	50.5	0.8	2.1	13.4 (5.5)	386	4.8
	LL (6)	46.5	0.8	1.0	7.5 (−1.4)	401	4.8
Twin	HH (8)	53.2	2.1	6.0	13.1 (−1.6)	640	8.7
	HL (8)	52.9	2.1	2.1	5.7 (−7.7)	557	8.2
	LH (8)	49.0	0.8	6.0	20.6 (8.0)	503	7.8
	LL (8)	54.5	0.8	2.1	15.3 (1.2)	583	8.5
	SD	7.0			2.4 (3.0)	119	1.2
Significance of main effects		Single v Twin			$P > 0.001$ ($P > 0.01$)	$P > 0.001$	$P > 0.001$
		Early-pregnancy nutrition: H v L			$P > 0.001$ ($P > 0.001$)	ns	ns
		Late-pregnancy nutrition: H v L			$P > 0.001$ ($P > 0.001$)	ns	ns

[1] Number of ewes in slaughter group

[2] Conceptus-free liveweight changes (liveweight after 24 h fast minus weight of uterus and contents).

Nutritional treatment did not affect foetal weight at day 137 of pregnancy. The weight of a foetus from a twin-bearing ewe was, on average, 86% of that of a foetus from a single-bearing ewe (Table 1). The effect of sex on foetal weight was more marked in the twin-bearing ewes, male foetuses being heavier than female foetuses (twin: 4.41 v 3.94 kg $P > 0.05$; single: 4.85 v 4.74 kg, n.s.).

The weight of the foetal cotyledons at the end of pregnancy was 45% greater in twin- than single-bearing ewes but was not significantly affected by nutritional treatment (Table 1). However, there was a significant interaction of early- and late-pregnancy nutrition on cotyledon development ($P > 0.05$), ewes well-fed throughout pregnancy having a larger foetal cotyledon mass than ewes in the other groups. The pooled linear regression coefficients from each nutritional group indicated that foetal weight changed by 77 g ($P > 0.01$) and cotyledon weight by 7.19 g ($P > 0.01$) per kg difference in initial ewe liveweight.

Foetal weight and foetal cotyledon weight were highly correlated in both single- and twin-bearing ewes ($P > 0.001$). Regression analysis of total foetal weight (Y, kg) against cotyledon weight (C, g) and initial ewe liveweight (W, kg) generated the following equations:

$$\text{Single: } Y = 1.72 + (4.27 \pm 1.3)C + (0.029 \pm 0.012)W \quad (RSD = 0.48;\ R^2 = 0.54) \quad (1)$$

$$\text{Twin: } Y = 2.35 + (6.29 \pm 1.5)C + (0.045 \pm 0.036)W \quad (RSD = 1.11;\ R^2 = 0.52) \quad (2)$$

The regression coefficients of cotyledon weight and ewe liveweight did not differ significantly between the single- and twin-bearing ewes.

Experiment 2

Changes in maternal and foetal tissue mass and composition with nutritional treatment have been described elsewhere (Rattray *et al.*, 1979). There was a significant ($P > 0.05$) response of foetal weight to feed intake in late pregnancy (Table 2). There was also substantial within-group variation in lamb birth weight which was associated with variation in placental mass and initial ewe liveweight. Regression analysis of these data generated the following equations predicting foetal weight (Y, kg) at term from placental (chorion plus foetal cotyledons) weight (P, kg) and initial ewe liveweight (W, kg at day 90 of pregnancy).

TABLE 2: FOETAL WEIGHT, PLACENTAL WEIGHT AND LATE-PREGNANCY LIVEWEIGHT CHANGE IN EXPERIMENT 2

Nutritional Group (1) (x Maintenance)	*Total foetal weight (kg)*	*Foetal cotyledon + chorion weight (kg)*	*Late-pregnancy liveweight change (kg)*
1.0 (8)	7.7	1.05	5.0
1.1 (7)	7.8	0.97	6.8
1.3 (7)	8.4	1.10	11.0
1.5 (7)	8.9	1.21	13.5
1.7 (8)	9.4	1.10	13.2
Pooled S.D.	1.11	0.18	2.23
Significance of trend:			
linear:	$P < 0.01$	ns	$P < 0.001$
quadratic:	ns	ns	$P < 0.01$

[1] Number of ewes in slaughter group.

$$Y = \begin{matrix} 3.37 \pm 0.68 \\ 3.62 \pm 0.77 \\ 3.71 \pm 0.70 \\ 3.84 \pm 0.61 \\ 4.42 \pm 0.70 \end{matrix} P + \begin{matrix} (0.088 \pm 0.015)W \\ (RSD = 0.61) \end{matrix} \qquad (3)$$

The response of foetal weight to placental mass increased with increasing feed intake. Reading down column in equation (3), coefficients in order, refer to nutritional groups fed 1.0, 1.1, 1.3, 1.5 and 1.7 x maintenance, the trend being significant ($P < 0.05$, Kendall rank correlation). The response to initial ewe liveweight did not differ between groups and the intercept term was not significantly different from zero.

As in Experiment 1 there was a significant correlation of placental (chorion plus foetal cotyledon) weight (P, kg) with initial ewe liveweight (W, kg) the following equation being derived from the pooled regression.

$$P = 0.015 \pm 0.006\,W + 0.36\ (r = 0.40;\ P < 0.05) \qquad (4)$$

DISCUSSION

The present experiments show that placental size (foetal cotyledon mass) was associated with lamb birth weight in single- and twin-bearing ewes, particularly when undernutrition in late pregnancy was not severe. The experiments discussed by Alexander (1974) demonstrate the causal nature of the relationship between the extent of placental growth and lamb birth weight. As the transfer of nutrients across the placenta is largely a function of concentration gradients between maternal and foetal blood (Meschia, 1978) the ability to manipulate lamb birth weight by nutritional means may be limited by placental size.

Placental growth is normally complete by day 100 of pregnancy (Alexander, 1974). Factors which regulate placental growth are largely unknown but both severe undernutrition (Everitt, 1965) and heat stress (Alexander 1974) have inhibitory effects. Some variation in placental weight is attributable to individual sires (Everitt, 1965) which may explain the response of lamb birth weight to differing sire breeds (e.g. Meyer and Clarke, 1978; Large, 1980). Maternal liveweight (see results) and/or body condition at mating (Clark and Speedy, 1980) may also influence placental development and lamb birth weight.

Thus, the optimisation of lamb birth weight (and by inference lamb survival, Dalton *et al.,* 1980) might be better achieved by consideration of factors influencing placental growth rather than, for example, preferential nutrition of twin-bearing ewes in late-pregnancy. However, the degree to which undernutrition in late-pregnancy contributes to low lamb birth weights in commercial New Zealand sheep flocks remains to be determined.

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