
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

BRIEF COMMUNICATION: The effects of dam nutrition during pregnancy on the postnatal growth and puberty attainment of ewe progeny

A.M. PATEN*, K. ASMAD, M.F.P. LOUREIRO, P.R. KENYON, S.J. PAIN, S.W. PETERSON, W.E. POMROY, I. SCOTT and H.T. BLAIR

Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Private Bag 11-222, Palmerston North 4442, New Zealand
*Corresponding author: a.m.paten@massey.ac.nz

Keywords: nutrition, pregnancy, ewe progeny, growth, puberty.

INTRODUCTION

In New Zealand's pastoral sheep-production systems, feed can become limiting during winter, when breeding ewes are pregnant. Ewes are often restrictively fed during early-gestation (Kenyon & Webby, 2007) to enable greater levels of nutrition in late-gestation. Many studies have demonstrated that dam nutrition during various stages of pregnancy can program the fetus *in utero*, influencing development, growth and performance later in life. Postnatal production traits, including: lamb survival, health, reproduction, growth, meat, wool (Ashworth *et al.*, 2009; Kenyon, 2008) and milk production (van der Linden *et al.*, 2009) have been shown to be programmed by maternal nutrition. However, little is known regarding the impact of differing levels of nutrition during specific periods of gestation or the potential interactions between nutrition provided during early-, mid- and late-gestational periods.

To date, most studies have only examined the effects of maternal nutrition during one period of gestation; either early- to mid-pregnancy or mid- to late-pregnancy. This study was therefore designed to investigate the effect and potential interactions of nutrition during early (P21 to P50) and mid-to-late (P50 to P139) pregnancy on the growth performance, puberty attainment and parasite susceptibility of female progeny from birth to approximately 12 months of age.

MATERIALS AND METHODS

This study used 879 Romney ewes which had been synchronised using progesterone controlled internal drug releasing devices (CIDRs) and artificially inseminated using fresh semen randomly allocated from one of five Romney rams. Ewes were randomly assigned to one of three nutritional regimens at P21 until P50: Sub-Maintenance (L_{P21-50}) with the aim of achieving a loss in mean ewe live weight of 0.1 kg/day, Maintenance (M_{P21-50}) with the aim of achieving no change in mean live weight or *Ad libitum* (H_{P21-50}) to provide unrestricted herbage intake conditions as previously described by Kenyon *et al.* (2011). At P50, ewes from all nutritional regimens were reassigned to one of two further nutritional treatments until P139: Maintenance ($M_{P50-139}$), designed to match predicted change in gravid uterine mass (Rattray *et al.*, 1974) or *Ad libitum* ($H_{P50-139}$), designed to provide unrestricted herbage intake conditions; creating a 3 x 2 factorial design. At P139, ewes were merged for lambing and were managed under commercial conditions (Kenyon *et al.*, 2011). Twin-reared female offspring (n = 370) were retained and live weight was recorded monthly from birth (D1) to 12 months (D360) of age. Eight crayon-harnessed vasectomised rams were joined with the ewe lambs (n = 264) on D261 for 17 days. Crayon marks were used as an indication of puberty attainment. Faecal egg counts (FEC; eggs/g of faeces) were conducted at D244 (n = 235) and D277 (n = 228) for determination of strongyloides infection and for infection of nematodes at D277.

Data were analysed using a general linear model in Minitab® 16 (Minitab Inc, Pennsylvania, USA) unless otherwise stated. Univariate models used to analyse live weight and FEC included the fixed effects of sire, dam nutritional regimen during P21-50 and P50-139 and their interaction, with and without date of birth as a covariate. Non-significant two-way interactions between dam-nutrition treatment periods were not removed, to allow for testing of the study design, however, only significant ($P < 0.05$) interactions are reported. A repeat measures model was used to analyse live weight, however, results were not statistically significant so are not reported. The FEC data were normalised using a square root transformation prior to analysis. The total proportion of female twin offspring that displayed oestrus, indicating puberty attainment, was analysed with the GENMOD procedure in SAS 9.2 (SAS Institute, Cary, NC, USA) which included the fixed effects of sire, dam nutritional regimen during P21-50 and P50-139 and their interaction, with and without weight at puberty as a covariate.

RESULTS AND DISCUSSION

Numerous studies have demonstrated the "fetal programming" effects of altered levels of maternal nutrition during various stages of pregnancy (Wu *et al.*, 2004). For fetal programming effects to be relevant to livestock industries they must affect production traits. Maternal nutrition, particularly during mid- to late-pregnancy, when the placenta is developing and fetal growth is greatest, has been reported as exerting strong effects on progeny birth weights and postnatal growth trajectories (Kenyon, 2008). In the present study, there was no effect of maternal nutrition in early gestation (P21-50) on offspring live weight from birth (D1) through to D360 (Table 1). However, maternal nutrition in mid-late gestation (P50-139) did have an effect, with lambs born to $M_{P50\text{-}139}$ dams being heavier at birth than those from $H_{P50\text{-}139}$ dams. This is in contrast with many studies which report positive associations between nutrition in later gestation and offspring birth weight (Gardner *et al.*, 2007). There is some evidence that over feeding can result in fetal growth restriction. However, to date, this has only been shown in offspring born to overfed adolescent ewes (Wu *et al.*, 2004). The liveweight gains observed in the dams in this study do not appear to indicate overfeeding from the $H_{P50\text{-}139}$ treatment (Kenyon *et al.*, 2011). This outcome should therefore be interpreted with some caution, given the differences in weight observed were minimal and the mean birth weights of the nutritional treatments were within the optimum range for lamb survival (Kenyon *et al.*, 2011).

Onset of puberty of ewe offspring was found to be unaffected by dam nutrition during early- to mid- (P21-50) and mid- to late-pregnancy (P50-139) which is consistent with the findings of da Silva *et al.* (2001) and van der Linden *et al.* (2007). Interestingly the sire affected (P <0.05) the attainment of puberty of offspring. This finding warrants further investigation.

Rooke *et al.* (2010) found FEC were increased in 3-month-old lambs that were born to nutrient

TABLE 1: Least square means ± standard error of live weight (kg) from birth (D1) until 360 days of age (D360) of female twin offspring born to dams on differing nutritional regimens during P21-50 of Sub-maintenance (L), Maintenance (M) or *Ad libitum* (H); and during P50-139 of Maintenance (M) or *Ad libitum* (H). n = Number of lambs in group.

Lamb age (days)	Dam nutrition P21-50						Dam nutrition P50-139			
	n	L	n	M	n	H	n	M	n	H
D1	102	5.3 ± 0.1	124	5.3 ± 0.1	144	5.3 ± 0.1	196	5.4 ± 0.1[a]	174	5.2 ± 0.1[b]
D90	84	24.9 ± 0.4	108	24.8 ± 0.4	118	25.4 ± 0.3	165	24.9 ± 0.3	145	25.2 ± 0.3
D185	70	31.4 ± 0.4	95	31.3 ± 0.4	102	31.4 ± 0.3	144	31.1 ± 0.3	123	31.6 ± 0.3
D261	70	35.5 ± 0.4	94	35.7 ± 0.4	100	36.1 ± 0.4	145	35.8 ± 0.3	119	35.7 ± 0.3
D308	69	38.5 ± 0.4	95	38.8 ± 0.4	100	38.8 ± 0.4	143	38.6 ± 0.3	121	38.9 ± 0.4
D360	69	43.3 ± 0.5	94	43.9 ± 0.4	99	43.6 ± 0.4	142	43.8 ± 0.4	120	43.3 ± 0.4

[ab]Superscripts within a row are significantly different (P <0.05).

TABLE 2: Percentage of puberty attainment and 95% confidence interval in brackets during D261-D278 and least square means ± standard error of the square root transformation of faecal strongyloid and nematode egg counts of female twin offspring born to dams on differing nutritional regimens during P21-50 of Sub-maintenance (L), Maintenance (M) or *Ad libitum* (H); and during P50-139 of Maintenance (M) or *Ad libitum* (H). n = Number of lambs in group.

Measurement	Dam nutrition P21-50						Dam nutrition P50-139			
	n	L	n	M	n	H	n	M	n	H
Onset of puberty (%)										
Show oestus	70	37.0 (35.3 – 38.6)	94	36.4 (35.0 – 37.9)	100	52.2 (50.8 – 53.6)	145	47.2 (46.0 – 48.4)	119	36.4 (35.1 – 37.7)
Faecal egg count (Square root transformation of eggs/g faeces)										
Strongyloid D244	63	11.0 ± 1.0[ab]	77	13.5 ± 0.88[a]	95	10.1 ± 0.78[b]	126	10.6 ± 0.70	109	12.5 ± 0.76
Strongyloid D277	56	32.5 ± 1.99	84	33.6 ± 1.62	88	33.3 ± 1.57	122	32.8 ± 1.38	106	33.4 ± 1.49
Nematode D277	56	2.2 ± 0.52	84	1.9 ± 0.43	88	2.6 ± 0.41	122	2.0 ± 0.36	106	2.5 ± 0.39

[ab]Superscripts within a row are significantly different (P <0.05).

restricted ewes, fed 75% energy requirements for maintenance and fetal growth, during early- to mid-pregnancy (D0-D90). However, in this study, lambs born to $M_{P21\text{-}50}$ dams had more strongyloides eggs than those born to $H_{P21\text{-}50}$ dams at D244 (Table 2) with lambs born to $L_{P21\text{-}50}$ not differing from either group. This effect was no longer apparent in the second sample on D277. While the results of the present study indicate that nutrition during early- to mid- pregnancy may influence parasite susceptibility in the offspring, the differences between levels of infection are unlikely to be of economic significance.

In summary, despite large differences in nutritional treatments placed on dams during P21-50 and P50-139, there were minimal effects on female progeny performance to 12 months of age. However, fetal programming effects often manifest later in life, therefore, it would be worthwhile to investigate the performance of these ewe progeny as they age.

ACKNOWLEDGMENTS

We would like to acknowledge Dean Burnham and Geoff Purchas for their technical assistance and the National Research Centre for Growth and Development, % The Liggins Institute, The University of Auckland for funding this research.

REFERENCES

da Silva, P.; Aitken, R.; Rhind, S.; Racey, P.; Wallace, J. 2001: Influence of placentally mediated fetal growth restriction on the onset of puberty in male and female lambs. *Reproduction* **122(3)**: 375-383.

Kenyon, P.R. 2008: A review of in-utero environmental effects on sheep production. *Proceedings of the New Zealand Society of Animal Production* **68**: 142-155.

Kenyon, P.R.; Pain, S.J.; Hutton, P.G.; Jenkinson, C.M.C.; Morris, S.T.; Peterson, S.W.; Blair, H.T. 2011: The effects of twin-bearing ewe nutritional treatment on ewe and lamb performance to weaning. *Animal Production Science* **51**: 406-415.

Rattray, P.V.; Garrett, W.N.; East, N.E.; Hinman, N. 1974: Growth, development and composition of ovine conceptus and mammary-gland during pregnancy. *Journal of Animal Science* **38(3)**: 613-626.

Rooke, J.A.; Houdijk, J.G.M.; McIlvaney, K.; Ashworth, C.J.; Dwyer, C.M. 2010: Differential effects of maternal undernutrition between days 1 and 90 of pregnancy on ewe and lamb performance and lamb parasitism in hill or lowland breeds. *Journal of Animal Science* **88(12)**: 3833-3842.

van der Linden, D.S.; Kenyon, P.R.; Jenkinson, C.M.C.; Peterson, S.W.; Lopez-Villalobos, N.; Blair, H.T. 2007: The effects of ewe size and nutrition during pregnancy on growth and onset of puberty in female progeny. *Proceedings New Zealand Society of Animal Production* **67**: 126-129.

Wu, G.; Bazer, F.W.; Cudd, T.A.; Meininger, C.J.; Spencer, T.E. 2004: Maternal nutrition and fetal development. *The Journal of Nutrition* **134(9):** 2169-2172.