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BRIEF COMMUNICATION: The effects of dam nutrition during pregnancy on the growth of male offspring

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INTRODUCTION

During pregnancy, nutritional status of the ewe is crucial because of its potential effect on fetal development, subsequent lamb survival and reproduction post-birth (Rhind *et al.*, 2001). Manipulation of the progress of fetal development can affect the structure and physiology of adult offspring through the process of fetal programming (Barker *et al.*, 1993). Epidemiological data in sheep indicates that maternal nutritional status during specific periods of gestation has an impact on offspring in later life (McMillen *et al.*, 2001). In support of this, experimental nutritional restriction during pregnancy is associated with postnatal metabolic and endocrine disorders (McMillen *et al.*, 2001). Additionally poor carcass quality has been reported in offspring from undernourished ewes (Bell, 1992). The objective of this study was to examine the effects of maternal nutrition during early and late pregnancy on the growth and the parasite load of male offspring from birth to 12 months of age.

MATERIALS AND METHODS

Romney ewes (n = 879, three to five year old multiparous ewes) from a commercial flock, conceived to artificial insemination using fresh semen from one of five Romney rams, were randomly allocated to one of three nutritional treatments from Day 21 of pregnancy (P21) until P50: Sub-Maintenance$_{P21-50}$, Maintenance$_{P21-50}$ or Ad libitum$_{P21-50}$ (Kenyon *et al.*, 2011). The aim of three treatment were; Sub-Maintenance$_{P21-50}$ to achieve a loss in mean ewe live weight of 0.1 kg/d; Maintenance$_{P21-50}$ to achieve no change in ewe live weight; and Ad libitum$_{P21-50}$ to provide unrestricted herbage under grazing conditions. At P50, ewes were reallocated to one of two further nutritional treatments for the period P50 to P139 (Maintenance$_{P50-139}$ versus Ad libitum$_{P50-139}$). The aim of the Maintenance$_{P50-139}$ treatment was to achieve a mean ewe live weight increase similar to that of the expected normal increase in gravid uterine mass, whilst Ad libitum$_{P50-139}$ aimed to provide unrestricted herbage intake conditions. Therefore, this study had a 3 x 2 factorial design (Sub-Maintenance$_{P21-50}$-Maintenance$_{P50-139}$ (SmM), Sub-Maintenance$_{P21-50}$-Ad libitum$_{P50-139}$ (SmA), Maintenance$_{P21-50}$-Maintenance$_{P50-139}$ (MM), Maintenance$_{P21-50}$-Ad libitum$_{P50-139}$ (MA), Ad libitum$_{P21-50}$-Maintenance $_{P50-139}$ (AM) and Ad libitum $_{P21-50}$-Ad libitum$_{P50-139}$ (AA)). At P139 groups were merged and managed under commercial conditions from then onwards (Kenyon, *et al.*, 2011). The present study only reports on twin-born male lambs (n = 292) from both mixed and same sex sets. This study, conducted at the Massey University Keeble Sheep and Beef farm, five kilometres south of Palmerston North, was approved by the Massey University Animal Ethics Committee (MUAEC 09/18).

Lambs were weighed at birth (D1) (lambing dates; from 2 to 13 September 2009) and then approximately once a month until 12 months of age (D1, D29 (29 days after midpoint of lambing), D56, D97, D134, D163, D192, D218, D252, D282, D315 and D343). A faecal sample was collected at D163 for faecal egg count (FEC; strongyloides eggs/g; n = 227). At D164, 216 males were randomly assigned within treatment to be slaughtered (n = 38, 37, 30, 34, 42 and 34, for AA, AM, SmA, SmM, MA and MM treatments respectively) in a commercial slaughter house. Carcass weight, dressing-out percentage (DO %) and GR measurement (fat depth at 12th rib) were determined.

Lamb data were subjected to analyses of variance using the GLM procedure in Minitab 16 (Minitab Inc, Pennsylvania, USA). The models used to analyse lamb live weight, carcass weight, GR and FEC included the fixed effects of dam nutritional regimens during P21-50 and P50-139 and their interaction. Unless reported in the text, interactions between P21-50 and P50-139 were not significant ($P > 0.05$). Sire was fitted as a fixed effect and date of birth was fitted as a covariate in models for lamb live weights, carcass weight, DO%, GR and FEC. To normalise FEC values they were $\log_{10}$ transformed.

TABLE 1: Effects of multiparous ewe nutrition during pregnancy D21 to D50 (P21 to P50) (Sub-maintenance (Sm) versus Maintenance (M) versus *Ad libitum* (A)) and D50 to D139 (P50 to P139) (Maintenance (M) versus *Ad libitum* (A)) on live weight of male lamb offspring (kg). Data presented as a least square mean ± standard error of the mean. n = Number of lambs in group.

Lamb age (days)	Days during preceding pregnancy when each nutrition treatment applied									
	P21 to P50						P50 to P139			
	n	Sub-Maintenance	n	Maintenance	n	*Ad libitum*	n	Maintenance	n	*Ad libitum*
1	92	5.4 ± 0.08	99	5.5 ± 0.08	101	5.5 ± 0.08	144	5.5 ± 0.06	148	5.4 ± 0.06
29	92	11.6 ± 0.16	99	11.7 ± 0.16	101	11.6 ± 0.16	144	11.7 ± 0.13	148	11.6 ± 0.13
56	92	18.0 ± 0.29	99	18.3 ± 0.28	101	18.1 ± 0.28	144	18.1 ± 0.23	148	18.2 ± 0.23
97	92	26.7 ± 0.36	99	26.6 ± 0.35	101	26.9 ± 0.34	144	26.6 ± 0.29	148	26.9 ± 0.28
134	92	33.3 ± 0.41	99	33.6 ± 0.41	101	33.7 ± 0.40	144	33.2 ± 0.34	148	33.8 ± 0.33
163	92	34.8 ± 0.42	99	35.0 ± 0.42	101	35.5 ± 0.41	144	34.8 ± 0.35	148	35.4 ± 0.33
192	92	37.9 ± 0.47	99	38.8 ± 0.47	101	39.3 ± 0.47	144	38.5 ± 0.39	148	38.8 ± 0.38
218	92	41.9 ± 0.50	99	43.0 ± 0.49	101	42.7 ± 0.48	144	42.1 ± 0.41	148	42.9 ± 0.39
252	92	46.7 ± 0.55	99	48.2 ± 0.54	101	47.8 ± 0.53	144	47.2 ± 0.45	148	47.9 ± 0.43
282	24	50.3 ± 1.60	23	51.9 ± 1.63	23	51.7 ± 1.68	35	52.4 ± 1.32	35	50.2 ± 1.29
315	24	52.5 ± 1.01	23	53.0 ± 1.03	23	54.7 ± 1.07	35	53.6 ± 0.85	35	53.2 ± 0.82
343	24	58.4^{b} ± 1.19	23	60.2^{ab} ± 1.21	23	63.2^{a} ± 1.28	35	61.0 ± 1.00	35	60.3 ± 0.97

^{ab} Means between columns within rows with differing superscripts are significantly different (P <0.05).

TABLE 2: Effects of multiparous ewe nutrition during pregnancy D21 to D50 (P21 to P50) (Sub-maintenance (Sm) versus Maintenance (M) versus *Ad libitum* (A)) and D50 to D139 (P50 to P139) (Maintenance (M) versus *Ad libitum* (A)) on carcass weight, dressing out %, tissue depth at the GR site and $\log_{10}$ transformed faecal egg count with the back transformed value in parenthesis, of male lamb offspring. Data presented as a least square mean ± standard error of the mean. n = Number of lambs in group.

Measurements	Days during preceding pregnancy when each nutrition treatment applied									
	P21 to P50						P50 to P139			
	n	Sub-Maintenance	n	Maintenance	n	*Ad libitum*	n	Maintenance	n	*Ad libitum*
Carcass										
Carcass weight (kg)	54	19.7 ± 0.3	64	19.7 ± 0.3	66	19.7 ± 0.3	89	19.1^{b} ± 0.3	95	20.2^{a} ± o.2
Dressing out %	54	41.3 ± 0.3	64	40.8 ± 0.3	66	41.3 ± 0.3	89	41.8 ± 0.2	95	41.5 ± 0.2
GR depth (mm)	54	8.3 ± 0.2	64	8.6 ± 0.2	66	8.5 ± 0.2	89	8.2 ± 0.2	95	8.7 ± 0.2
Faecal egg count										
Log_{10} strongloid eggs/g wet faeces	81	2.9 ± 0.1 (2,625)	73	2.8 ± 0.1 (1,930)	73	2.6 ± 0.1 (1,417)	116	2.8 ± 0.1 (2,212)	111	2.7 ± 0.1 (1,770)

^{ab} Means between columns within rows with differing superscripts are significantly different (P <0.05).

RESULTS AND DISCUSSION

There were few effects of either early or mid- to late-pregnancy nutrition on male lamb live weight, except at D343 when Ad libitum$_{P21-50}$ were heavier than Sub-Maintenance$_{P21-50}$ (Table 1). Further monitoring is required to see if the early nutrition affect on live weight at D343 persists. There were no interactions between early or late nutrition for any time points for live weight except D252, when offspring from MA ewes were heavier (P <0.05) than those from SmM ewes (49.1 ± 0.71 (Standard deviation) versus 45.9 ± 0.76 kg, respectively), with neither differing from AA, AM, SmA and MM offspring (P >0.05, 47.3 ± 0.73 versus 48.3 ± 0.76 versus 47.4 ± 0.80 versus 47.3 ± 0.81 kg, respectively). In contrast, Ford *et al.*, (2007) reported that male lambs born to an early nutrition restricted ewe were heavier than a control group at 280 days of age. Others have reported no effect of early nutrition on ewe offspring live weight (Corner *et al.*, 2005). In support of the present findings, late pregnancy nutrition has generally been reported to have no effect on offspring live weight (Corner et al., 2005). Although, Kelly *et al.* (2006) did show that adult offspring from late-pregnancy (D50 to D140) sub-maintenance fed ewes were lighter than those from late-pregnancy control-fed ewes. The lack of an effect of late-pregnancy nutrition in the present study on offspring live weight may be due to the $\text{Maintenance}_{P50\text{-}139}$ ewes utilising their own body reserves to support fetal growth.

Ewe nutrition during early or mid- to late pregnancy had no effect (P >0.05) on carcass GR or DO% of male offspring at D164 (Table 2). However, there was an interaction between P21-50 and P50-139 treatments for carcass weight (P <0.05) such that carcasses of lambs born to MA-ewes were heavier (P <0.05) than those of lambs born to MM-fed ewes (20.7 ± 0.40 versus 18.7 ± 0.46 kg for MA and MM, respectively). Carcasses of lambs born to AA, AM, SmA and SmM-fed ewes did not differ (P >0.05) from either MA or MM carcasses or each other (19.7 ± 0.42 versus 19.7 ± 0.42 versus 20.3 ± 0.48 versus 19.0 ± 0.46 kg, respectively). This finding agrees with that of Munõz *et al.* (2009) who reported that maternal nutrition during pregnancy affected the ratio of perinephric and retroperitoneal fat of male offspring carcass weight with no effect on DO%. Ford *et al.* (2007) also showed that restricted feeding of ewes from D28 to D80 of gestation was associated with an increase in fetal adipose tissue. However, Daniel *et al.* (2007) reported no difference in slaughter weights of male lambs born to ewes that were restrictively fed between days 30 to 85 of gestation. Even though, in this study, there were differences for carcass weight, they were small and given there were no differences in either DO% or GR they are unlikely to be of economic importance.

This study demonstrated that nutrition of the dam during early or mid- to late pregnancy had no effect (P >0.05) on FEC at D163 in the male lambs. Similarly, Paganoni (2005) also reported no significant effect of maternal nutrition during gestation on the FEC of offspring at 7 to 27 months of age. However, Rooke *et al.* (2010) showed that restricted maternal nutrition resulted in greater FEC in the offspring. It is not possible to reconcile these differences with current knowledge.

In conclusion, this study indicates that maternal nutrition during pregnancy resulted in minor effects on live weight and carcass weight and no effect on FEC in male offspring. These results suggest that up to one year of age, maternal nutrition during pregnancy has little impact on the performance of male offspring.

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