The effects of ewe size and nutrition during pregnancy on growth and onset of puberty in female progeny

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ABSTRACT

In 2005, 'heavy' and 'light' Romney ewes were selected, synchronized and artificially inseminated. Half of the ewes in each weight group were fed *ad libitum* and the other half were restricted to maintenance from days 21-140 of pregnancy, resulting in four groups: 'heavy'-maintenance (HM), 'heavy'-*ad libitum* (HA), 'light'-maintenance (LM) and 'light'-*ad libitum* (LA). The aim of the present study was to investigate the effects of ewe size and nutrition during pregnancy on growth and onset of puberty in female progeny. Lamb birth weights were recorded. After weaning, the progeny were managed as one flock and weighed monthly. Crayon-harnessed teaser rams were joined with the lambs to investigate the onset of puberty. Maternal nutrition during pregnancy affected live weight of lambs from 22 days of age till weaning (100 days of age) ($P<0.05$). During the first 22 days of life, the growth rate of lambs born to LM was lower ($P<0.05$) compared with the other groups (215 ± 8.2, 261 ± 8.0, 250 ± 7.9, 275 ± 7.3 grams/day, for lambs born to LM, LA, HM and HA ewes respectively). From weaning until one year of age lambs born to LM dams were lighter than lambs born to HM dams ($P<0.05$). No differences in the age of onset of puberty were found among the four groups. Singletons reached puberty earlier than twins ($P<0.01$). At 13 months of age, no long-term effect of maternal nutrition on the live weight of resulting ewe offspring was found, although dam size had a significant effect on live weight and growth rate. However, neither dam nutrition nor size had any effect on the age of onset of puberty.

Keywords: ewe lamb; ewe hogget; liveweight gain; oestrus.

INTRODUCTION

Both human and sheep studies have shown that level of nutrition in foetal and early postnatal life can effect growth, development and physiology in later life (Gunn, 1977; Gunn *et al.*, 1995; Borwick *et al.*, 1997; Ravelli *et al.*, 1998; Ravelli *et al.*, 1999; Roseboom *et al.*, 2000; de Rooij *et al.*, 2006). Being smaller at birth, due to either under nourishment while *in utero* or because of the size of the dam, has consequences on the offspring's postnatal growth. Greenwood *et al.* (1998) showed that small, new-born lambs had lower growth rates compared with their larger new-born counterparts. Undernutrition during pregnancy could also have major implications for the reproductive performance of the offspring in adult life. Maternal undernutrition has been reported to retard foetal ovarian development (Borwick *et al.*, 1997), ovulation rate (Rae *et al.*, 2002) and reproductive performance (Gunn *et al.*, 1995) in ewe progeny.

The size of the dam and her uterine capacity could have major effects on the postnatal life of her offspring. Uterine capacity can be defined as the physiological and biochemical limitations imposed on conceptus growth and development by the uterus. Several studies involving artificial insemination and embryo transfer have demonstrated the effects of uterine capacity, showing the restricting effects of maternal size on birth weight and postnatal growth (Walton & Hammond, 1938; Dickinson *et al.*, 1962; Allen *et al.*, 2002; Allen *et al.*, 2004).

The present study investigates the effects of ewe size and nutrition during pregnancy, on the growth and onset of puberty of female progeny.

MATERIAL AND METHODS

In 2005, 400 'heavy' (60.8 ± 0.18 kg) and 400 'light' (42.5 ± 0.17 kg) Romney ewes were selected from a flock of over 2500 ewes, synchronized using progesterone controlled-internal-drug-release devices (CIDR) and artificially inseminated with Suffolk semen. Approximately half of the ewes in each size group were provided with *ad libitum* feeding from day 21 of pregnancy until day 140 and the other half were restricted to maintenance feeding under pastoral grazing conditions. This resulted in four groups: 'heavy' dams on maintenance feeding (HM), 'heavy' dams on *ad libitum* feeding (HA), 'light' dams on maintenance feeding (LM) and 'light' dams on *ad libitum* feeding (LA). The aim of the

maintenance-feeding regimen was to ensure throughout pregnancy that total dam liveweight gain was similar to that of the expected increase in conceptus mass. One week prior to lambing, all ewes were provided with *ad libitum* feeding.

The average day of birth of the lambs was 28 August 2005. Lambs were weighed within 24 h after birth. After weaning (6 December 2005) at the average age of 100 days, the female progeny were managed as one flock under commercial grazing conditions. The ewe lambs were weighed monthly until 1 year of age.

To investigate the onset of puberty, four crayon-harnessed teaser rams were joined with the ewe lambs from early March until mid June 2006. Ram-harness-crayon marks were recorded and the colour of the crayon changed every 14 days. Marks were recorded the day after each crayon change, to identify the period during which the lamb was in oestrus. Hence, a ewe lamb that was marked the day after the crayon change was recorded as being in oestrus during the previous two weeks. Onset of puberty was defined as being the time when a lamb had her first clear ram-harness-crayon mark.

The current study was conducted at Massey University, Keeble Sheep and Beef Cattle Farm, 5 km south of Palmerston North.

All animal manipulations were approved by the Massey University Animal Ethics Committee.

Statistical analysis

Data were analysed using SAS (SAS, 2006). Repeated measures of weights and growth rates were analysed using the MIXED procedure with a linear model that included the fixed effects of ewe size ('heavy' vs. 'light'), nutrition (*ad libitum* vs. maintenance), birth rank (singleton vs. twin), time, the interactions of ewe size by nutrition, ewe size by time, nutrition by time and birth rank by time and the random effect of animal. Age of puberty and oestrus events were analysed using the MIXED procedure with a linear model that included the fixed effects of ewe size, nutrition, birth rank, the interactions of ewe size by nutrition and ewe size by birth rank with the covariate of growth rate. Accumulated proportion of animals reaching puberty was analysed using the LIFETEST procedure including in the model the fixed effects of ewe size, nutrition and birth rank. Total proportion of animals that reached puberty up to day 305 was analysed with the GENMOD procedure with a linear model that included the fixed effects of ewe size, nutrition, birth rank and the covariate growth rate.

RESULTS

At birth, lambs born to HA ewes were significantly heavier than lambs born to LM ewes (5.4 ± 0.10 vs. 5.0 ± 0.12, P=0.01, respectively) (Table 1). The growth rate of lambs born to LM ewes was lower compared with that of the other groups over the first 22 days of life (P<0.05) (Table 2). From 22 days of age until weaning (100 days of age) nutrition of the dam during pregnancy had an effect on live weight of the offspring, whereby lambs born to LM and HM ewes were lighter than lambs born to LA and HA ewes respectively (P<0.05). After weaning, this nutritional effect was no longer present. From 187 days until 396 days of age, lambs born to LM ewes were lighter and had lower growth rates compared with lambs born to HM ewes (P<0.05). Except for lamb growth rate during the period 208-235 days of age and live weight at 235 days of age, when a tendency was observed (P<0.10). No difference in lamb growth rate during the period 235-263 days of age was found (Table 1, Table 2).

Table 1: Least square means ±S.E. of live weights (kg) from birth (0) until 396 days of age of female offspring born to either a 'heavy' or 'light' dam, fed either *ad libitum* or maintenance from day 21-140 of pregnancy.

	'Heavy'		'Light'	
Age (days)	***Ad libitum***	**Maintenance**	***Ad libitum***	**Maintenance**
0	$5.4^{b} \pm 0.10$	$5.2^{ab} \pm 0.10$	$5.3^{ab} \pm 0.11$	$5.0^{a} \pm 0.12$
22	$11.6^{a} \pm 0.20$	10.4 ± 0.20	$11.1^{a} \pm 0.22$	9.6 ± 0.23
46	$19.9^{c} \pm 0.40$	$18.3^{ab} \pm 0.39$	$19.2^{bc} \pm 0.43$	$17.6^{a} \pm 0.44$
80	$28.3^{c} \pm 0.52$	$26.6^{ab} \pm 0.51$	$27.2^{bc} \pm 0.57$	$25.2^{a} \pm 0.59$
100	$31.7^{b} \pm 0.58$	$30.3^{ab} \pm 0.57$	$31.0^{b} \pm 0.64$	$28.9^{a} \pm 0.67$
187	$37.3^{a} \pm 0.51$	$37.0^{a} \pm 0.51$	$36.7^{a} \pm 0.56$	35.1 ± 0.58
207	$38.7^{b} \pm 0.50$	$38.2^{b} \pm 0.50$	$37.7^{ab} \pm 0.55$	$36.2^{a} \pm 0.57$
235	$35.7^{b} \pm 0.46$	$35.4^{ab} \pm 0.46$	$35.3^{ab} \pm 0.51$	$34.1^{a} \pm 0.53$
263	$41.1^{b} \pm 0.47$	$40.9^{b} \pm 0.47$	$40.3^{ab} \pm 0.52$	$39.3^{a} \pm 0.53$
291	$44.3^{a} \pm 0.49$	$44.5^{a} \pm 0.49$	$44.0^{a} \pm 0.54$	42.3 ± 0.56
319	$46.5^{b} \pm 0.54$	$47.1^{b} \pm 0.55$	$45.8^{ab} \pm 0.61$	$44.7^{a} \pm 0.62$
396	$47.0^{ab} \pm 0.59$	$47.5^{b} \pm 0.58$	$46.3^{ab} \pm 0.66$	$45.4^{a} \pm 0.67$

Means within row with different superscripts are significantly different (P<0.05)

Table 2: Least square means ±S.E. of growth rates (grams/day) until 396 days of age of female offspring born to either a 'heavy' or 'light' dam, fed either *ad libitum* or maintenance from day 21-140 of pregnancy.

	'Heavy'		'Light'	
Age (days)	***Ad libitum***	**Maintenance**	***Ad libitum***	**Maintenance**
0-22	$275^{bc} \pm 7.3$	$250^{bd} \pm 7.9$	$261^{b} \pm 8.0$	$215^{a} \pm 8.2$
23-46	298 ± 10.0	286 ± 9.9	300 ± 10.9	280 ± 11.4
47-80	$285^{b} \pm 6.1$	$272^{ab} \pm 6.1$	$273^{ab} \pm 6.7$	$256^{a} \pm 7.0$
81-100	258 ± 6.1	254 ± 6.0	257 ± 6.8	242 ± 7.0
101-187	$170^{b} \pm 2.5$	$171^{b} \pm 2.5$	$168^{ab} \pm 2.8$	$162^{a} \pm 2.9$
188-207	$160^{b} \pm 2.3$	$160^{b} \pm 2.3$	$156^{ab} \pm 2.5$	$151^{a} \pm 2.6$
208-235	129 ± 1.9	129 ± 1.9	128 ± 2.0	124 ± 2.1
236-263	$135^{ab} \pm 2.2$	$136^{b} \pm 2.2$	$129^{a} \pm 2.4$	$131^{ab} \pm 2.5$
264-291	$133^{b} \pm 1.6$	$136^{b} \pm 1.6$	$133^{ab} \pm 1.8$	$129^{a} \pm 1.8$
292-319	$129^{bd} \pm 1.6$	$132^{cd} \pm 1.7$	$127^{ac} \pm 1.8$	$125^{ab} \pm 1.9$
320-396	$105^{ab} \pm 1.4$	$107^{b} \pm 1.4$	$103^{ab} \pm 1.6$	$102^{a} \pm 1.6$

Means within row with different superscripts are significantly different ($P<0.05$)

Table 3: Total number of ewe lambs in each group, number of ewe lambs that reached puberty, percentage of ewe lambs that reached puberty (± 95% confidence interval), least square means of age at puberty (days) ±S.E., least square means ±S.E. of live weight at the average age of onset of puberty and least square means of oestrus events ±S.E.

	Total (n)	**Reached puberty**	**Reached puberty (%)**	**Age (days)**	**Live weight (kg)**	**Mean oestrus events**
Dam size x nutrition						
'Heavy' *Ad libitum*	62	58	93.9 (84.0, 97.9)	260 ± 3.3	$41.1^{b} \pm 0.47$	2.7 ± 0.20
'Heavy' Maintenance	59	53	89.7 (78.2, 95.5)	262 ± 3.3	$40.9^{b} \pm 0.47$	2.2 ± 0.19
'Light' *Ad libitum*	48	44	93.0 (81.5, 97.6)	264 ± 3.5	$40.3^{ab} \pm 0.52$	2.4 ± 0.20
'Light' Maintenance	44	43	98.1 (87.4, 99.7)	261 ± 3.8	$39.3^{a} \pm 0.53$	2.8 ± 0.20
Birth rank						
Singletons	77	72	94.3 (85.8, 97.8)	$259^{a} \pm 2.9$	$41.7^{a} \pm 0.41$	2.6 ± 0.17
Twins	136	126	94.9 (89.1, 97.7)	$264^{b} \pm 3.0$	$39.0^{b} \pm 0.31$	2.5 ± 0.13

Different superscripts within a column are significantly different ($P<0.05$)

Nutrition during pregnancy and dam size did not influence the number of animals reaching puberty, neither did it effect the age of the onset of puberty (Table 3). After adjusting for live weight, singletons reached puberty five days earlier than twins ($P=0.011$) (Table 3).

Mean live weight at the average age of onset of puberty (day 263) was 41.1 ± 0.47; 40.9 ± 0.47; 40.3 ± 0.52 and 39.3 ± 0.53 kg for offspring born to HA, HM, LA and LM ewes respectively, with lambs born to LM ewes being significantly lighter than lambs born to HA and HM ewes ($P<0.05$) (Table 3).

DISCUSSION

The present study shows that nutrition during pregnancy had an effect on the growth of the offspring until weaning. This effect was most likely caused by ewes that were fed maintenance during pregnancy having lower milk yields than ewes fed *ad libitum* (Wallace, 1938). This is reflected in the growth rates of the progeny, whereby lambs born to LM ewes had the lowest growth rates during the first 22 days of life compared with the other groups. This lower growth rate in lambs born to LM ewes is in agreement with work of Greenwood *et al.* (1998), who found that smaller newborns showed lower growth rates during the first two weeks of life (Greenwood *et al.*, 1998). The effect of dam size on the growth rate and live weight after weaning, found between the lambs born to LM and HM ewes, is most likely due to genetic differences between 'heavy' and 'light' ewes.

The live weights at the time of the onset of puberty in the groups are in agreement with work of Keane (1976). The threshold of live weight for reaching puberty was shown to be in the range 33 to 42 kg, for Suffolk crossbreds (Keane, 1976).

Mean oestrus events from this dataset are only indicative, as it was assumed that the data were normally distributed. The mean age of onset of puberty for each of the four groups was similar and this is in agreement with work of Da Silva *et al.* (2001), in which no differences were found in the time of onset of puberty or number of ovarian cycles between growth-restricted and normally grown lambs. However, when dam's energy requirements were 50% restricted, ovarian

development was significantly retarded in 47- and 62-day-old foetuses (Borwick *et al.*, 1997). Also ovulation rate was significantly reduced in lambs born to undernourished dams in contrast to those fed to requirements (Rae *et al.*, 2002).

Overall, singleton ewe lambs reached puberty five days earlier than did twin lambs. This is probably a result of singleton lambs having greater growth rates than twins throughout the study.

Although no differences were found in the onset of puberty among groups, this does not preclude the possibility of a longer-term or other impact on female reproductive performance, like lower volume-percentage of primordial follicles (de Bruin *et al.*, 1998) or reduced size of the uterus and ovarian volume (Ibanez *et al.*, 2000).

In conclusion, prior to weaning, maternal nutrition had an effect on live weight and growth rate of female progeny and after weaning dam size significantly affected live weight and growth rate. No differences in the age of onset of puberty were found among progeny born to either *ad libitum* or maintenance-fed 'heavy' or 'light' dams.

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