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BRIEF COMMUNICATION: Inter-generational effects on male offspring born to ewes whose dams were offered varying feeding levels in pregnancy

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Introduction

There is a growing body of evidence to indicate that pregnancy nutrition can affect the productive performance of the offspring in sheep (Kenyon & Blair 2014). Recently we demonstrated that pastoral-based feeding of the ewe (G0) can affect the milk production of the ewe offspring (G1) and the growth and live weight of the grand-offspring (G2) to weaning (van der Linden et al. 2009; Paten et al. 2013). An effect of feeding on grand-offspring is termed an inter-generational effect, and while these effects have been reported in species such as mice and rats, their occurrence in the sheep literature is rare.

There is some evidence to suggest feeding of the ewe in pregnancy can alter the growth and carcass characteristics of her offspring (see review Greenwood et al. 2010) but there is no data available on potential inter-generational effects. The aim of the present study was to determine if feeding of the ewe (G0) in either early- or mid- to late-pregnancy could alter the live weight and slaughter characteristics of male grand (G2) offspring.

Materials and Methods

The present study is part of a larger study examining the long-term effects of maternal nutrition (van der Linden et al. 2009; Kenyon et al. 2011; Paten et al. 2013). This study examined male G2 lambs born over two successive years (2011 and 2012) from Romney ewes (G1) which, in turn, were born to ewes (G0, grand-dams) in 2009 who had been offered one of three levels of pastoral nutrition in early pregnancy and one of two levels of nutrition in mid- to late-pregnancy (Kenyon et al. 2011). Briefly, the G0 feeding regimens in 2009 were as follows: ewes were randomly allocated to three feeding regimes from day 21 (D21) to D50 (Sub-maintenance (L, resulting in live weight loss of 0.15 kg/d), Maintenance (M, -0.02 kg/d) and *ad libitum* (H, 0.15 kg/d); they were then randomly allocated from D50 to D139 into either Maintenance (MLate, designed to achieve total ewe weight increased with expected conceptus mass, 0.019 kg/d) or *ad libitum* (ALate, 0.26 kg/d) (Kenyon *et al.* 2011). From D140, all groups were merged and offered *ad libitum* feeding conditions until weaning. After weaning, only twin-born-and-reared G1 ewes were retained, and were managed under commercial conditions (Paten et al. 2011).

In 2011 and 2012, G1 ewes (at 18 and 30 months of age respectively) were synchronised using CiDR's (Cidr Type-G, Pfizer, New Zealand) and mated for 2 cycles (5 day synchronised cycle plus 18 days). The G1 ewes were grazed under commercial farming conditions throughout pregnancy as one cohort, regardless of pregnancy status (i.e. single- or multiple-bearing). Subsequently offspring (G2) were born over a 35 day period, and 157 and 175 male G2 offspring from 2011 and 2012 respectively, which survived through to slaughter were used for this study. In each year, G2 lambs were weighed, tagged and identified to their dam within 12 hours of birth. The lambs were then weighed again, on the same day, within an hour of removal from pasture at tailing (average age of 35 and 21 days in 2011 and 2012 respectively), weaning (average age of 99 and 90 days in 2011 and 2012 respectively) and prior to slaughter. All lambs were run together from birth to slaughter under normal farm conditions and were slaughtered together within year regardless of liveweight (average age of 182 and 181 days in 2011 and 2012 respectively). Rearing rank to weaning was determined based on their presence and that of their siblings at weaning. At slaughter in a commercial abattoir, hot carcass weights and GR depth (soft tissue depth at the 12^{th} rib) were collected and a dressing-out percentage (DO%) calculated.

All data were analysed using General Linear Model (SAS, 2011) with fixed effects of year, rearing rank (i.e. single-born-and-reared (11), twin-born but singleton reared (21), twin-born and reared (22) etc), grand-dam (G0) nutrition in early pregnancy (Early Feed) and grand-dam nutrition in mid- to late-pregnancy (MidLate Feed) and the interaction among G0 feeding treatments. The interaction was not found (P>0.05) to be significant in any model and was removed from the model.

Results and discussion

Live weight data is shown in Table 1. The data indicate that multiple-born lambs were lighter (P<0.05) at birth than singletons and those that were reared as a multiple remained lighter to slaughter at the same age (P<0.05). These results match the literature which indicates a negative correlation between rank with lamb live weight up to at least one year of age (Afolayan et al. 2007; Hopkins et al. 2007; Kenyon & Blair 2014). Carcass weight, GR depth and dressing-out percentage are shown in Table 2. Twin-

Table 1 The effect of grand-dam (G0) feeding in early pregnancy (Early Feed) and mid- to late-pregnancy (MidLate Feed) and lamb (G2) rearing rank (R Rank) on the live weight (kg) of male lamb grand offspring (G2) offspring. Data presented as least square means ± standard error of mean.

		Live weight (kg)			
	n	Birth	Docking	Weaning	Pre-slaughter
R Rank					
11	54	$6.4±0.1^{c}$	$17.2±0.4^{e}$	$38.3±0.5^{d}$	$52.1±0.8^{c}$
21	26	$5.4±0.1^{b}$	$14.7±0.5^{c}$	$34.4±0.8^{c}$	$50.0±1.1^{c}$
22	222	$5.3±0.1^{b}$	$12.5±0.2^{bd}$	$29.3±0.3^{b}$	$44.8±0.4^{b}$
31	2	$4.6±0.5^{ab}$	$16.8±1.8^{cde}$	$34.6±2.8^{bcd}$	$50.1±4.0^{bc}$
32	17	$4.4±0.2^{a}$	$13.4±0.6^{ac}$	$29.3±1.0^{ab}$	$44.2±1.4^{ab}$
33	11	$4.6±0.2^{a}$	$12.4±0.8^{ab}$	$26.1±1.2^{a}$	$41.3±1.7^{a}$
Early Feed					
Low	131	5.1±0.1	$14.6±0.4^{ab}$	$32.3±0.6^{b}$	47.1±0.9
Maintenance	110	5.2±0.1	$14.9±0.4^{b}$	$32.7±0.7^{b}$	47.9±0.9
High	91	5.1±0.1	$14.1±0.4^{a}$	$31.0±0.7^{a}$	46.3±0.9
MidLate Feed					
Maintenance	178	5.2±0.1	14.7±0.4	32.4±0.6	47.5±0.8
High	154	5.1±0.1	14.3±0.4	31.6±0.6	46.7±0.9

[abcde] Different superscripts within main effects and columns indicate means differ significantly (P <0.05).

Table 2 The effect of grand-dam (G0) feeding in early pregnancy (Early Feed) and mid- to late-pregnancy (MidLate Feed) and lamb (G2) rearing rank (R Rank) on the carcass weight, dressing out percentage and GR depth of G2 male lamb offspring. Data presented as least square means ± standard error of mean.

	n	Carcass Weight (kg)	Dressing out (%)	GR depth (mm)
R Rank				
11	54	$20.9±0.4^{b}$	$40.4±0.9^{a}$	$9.4±0.4^{b}$
21	26	$20.3±0.6^{b}$	$40.7±1.2^{a}$	$9.2±0.6^{ab}$
22	222	$18.6±0.2^{a}$	$41.4±0.4^{ab}$	$8.5±0.2^{a}$
31	2	$18.1±2.1^{ab}$	$35.8±4.4^{ab}$	$9.5±2.1^{ab}$
32	17	$19.3±0.7^{ab}$	$44.1±1.6^{bc}$	$8.3±0.7^{ab}$
33	11	$19.4±0.9^{ab}$	$46.9±1.9^{c}$	$9.3±0.9^{ab}$
Early Feed				
Low	131	$19.6±0.5^{ab}$	41.7±1.0	9.2±0.5
Maintenance	110	$19.9±0.5^{b}$	41.6±1.0	9.3±0.5
High	91	$18.9±0.5^{a}$	41.3±1.0	8.6±0.5
MidLate Feed				
Maintenance	178	19.4±0.4	41.0±0.9	9.1±0.4
High	154	19.5±0.5	42.1±1.0	8.9±0.5

[abc] Different superscripts within columns by effect indicate values that differ significantly (P <0.05).

born-and-reared lambs had lighter (P<0.05) carcass weights than singleton reared lambs although DO% did not differ (P>0.05). This indicates the lighter carcass weights were driven by a lighter live weight at slaughter. Singleton-born-and-raised lambs had greater (P<0.05) GR depths than those born and reared as a twin supports the findings of McCoard et al. (2010). Previous studies have indicated a positive correlation between GR depth and carcass weight (Kirton & Johnson 1979). Interestingly triplet born lambs that were reared as either a twin or triplet lambs had greater (P<0.05) dressing out percentages than singleton reared lambs. This relationship is intriguing given the current rise in lambing percentages in New Zealand.

Lambs (G2) whose grand-dam (G0) had been fed at a high level of nutrition in early pregnancy were associated with lighter (approximately 5%) live weights (P<0.05) at docking and weaning but not at slaughter, and displayed lighter carcass weights (approximately 5%) than those whose grand-dam had been fed at maintenance. Interestingly, this apparent effect of early pregnancy grand dam nutrition (G0) was not found in the dams (G1 ewes) of the lambs in the present study (Paten et al. 2011; 2013). However, in one of two years (2011 but not 2012) milk production of the G1 ewes was affected by the G0 dam's nutrition in early pregnancy (Paten et al. 2013 and unpublished data). There were no inter-generational effects (P>0.05) of mid- to late-pregnancy nutrition on lamb live weight or carcass characteristics in the present study.

In summary, these results suggest that there can be inter-generational effects of maternal plane of nutrition in early pregnancy on the live weight and carcass characteristics of the grand-offspring. However, while the effects were statistically significant it is unlikely that they would be economically significant.

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