The effect of dam age on ewe offspring productive performance and efficiency

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Abstract

The objective of this study was to determine if dam age (i.e., being born to a ewe-lamb vs. mature adult ewe) affected the productive performance and efficiency of singleton ewe offspring to four years of age. Live weight was recorded every two months from birth to four years of age for singleton ewe progeny born to either ewe-lamb dams or adult ewes (ewe-lamb progeny: ELP, n = 20; adult-ewe progeny: AEP, n = 25). The number of lambs born and weaned, and weight (kg) of lamb born and weaned were determined for each ewe for each productive year and as a combined total. Ewe production efficiency was calculated for each year and as a combined total. Results show that AEP were heavier at birth and remained heavier until one year of age ($P<0.05$). Live weight was again greater ($P<0.05$) for AEP in mid-pregnancy in 2010 and at weaning in 2011. The number of lambs born and weaned and the weight of lamb born and weaned per ewe did not differ in any of the three productive years or for the combined total. Ewe production efficiency was not affected by dam age, with similar efficiencies reported for ELP and AEP. The results from this study show that despite experiencing a weight penalty, the productive performance and efficiency of singleton ewe progeny born to ewe-lamb dams, if conventionally bred themselves as 18 months of age, appears to be similar to that of singleton ewe progeny born to mature adult ewes.

Keywords: dam age; developmental programming; ewe offspring; reproductive performance

Introduction

Each year in New Zealand, approximately one-third of ewe-lambs are bred at 8-9 months of age (Loureiro et al. 2012). A potential advantage of breeding ewe-lambs is an increase in genetic gain through a reduction in generation interval, by selecting ewe progeny born to ewe-lamb dams to be kept as breeding replacements (Kenyon et al. 2004). However, there is some concern about the long-term productive performance of progeny born to young ewes. Studies in sheep have shown that, compared to progeny born to mature adult ewes, progeny born to ewe-lamb dams are lighter and smaller at birth (Annett and Carson 2006; Gardner et al. 2007), at weaning (Safari et al. 2005; Loureiro et al. 2011) and up to 12 months of age (Loureiro et al. 2011). It has been demonstrated that altered nutrient partitioning in ewe-lamb dams during pregnancy may be responsible (Wallace et al. 2001). In mature females, nutrient partitioning during pregnancy will generally favour the conceptus at the expense of the mother, thus, ensuring optimal fetal growth (Bell 1993; Owens 1991). In contrast, studies have shown that the pattern of nutrient partitioning during pregnancy in adolescent sheep can be altered at the expense of the developing fetus (Wallace et al. 2001), thus creating an environment where the fetus may be exposed to suboptimal levels of nutrition. At various stages of gestation, developmental events occur in the female fetus, such as steroidogenesis, gonad development, and folliculogenesis (Rhind 2004; Rhind et al. 2001). These events are susceptible to perturbation in response to the level of nutrients supplied to the gravid uterus by the dam, and thus, the reproductive development and performance of offspring later in life may be affected (Bell 2006; Rhind 2004; Rhind et al. 2001). It has been reported that ewe offspring born to undernourished mature dams had decreased ovulation rates (Rae et al. 2002). Ewes born to mature dams undernourished in mid-to-late pregnancy and lactation, gave birth to fewer multiple-born lambs (Gunn et al. 1995). Therefore, it might be expected that ewe progeny born to ewe-lamb dams, exposed to potentially sub-optimal nutrient delivery during gestation, could display reduced reproductive performance. The study reported here aimed to examine the longer-term effects of dam age on the reproductive performance and efficiency of singleton ewe offspring to four years of age.

Materials and methods

This study was conducted at Massey University's Keeble farm (latitude 41°10' S, longitude 175°36'E) 5 km south of Palmerston North, New Zealand, during the period September 2007 to January 2012. The study was conducted with the approval of the Massey University Animal Ethics Committee.

Experimental design

The present study utilised 44 singleton Romney ewes born to either primiparous ewe-lambs or multiparous adult ewes, creating two progeny groups: ewe-lamb progeny (ELP, n=20) and adult-ewe progeny (AEP, n=25). These dams were randomly selected from a larger study, which comprised 296 Romney ewe-lamb dams (8 - 9 months of age at breeding, live weight 40.6 ± 2.14 kg) and 307 Romney adult ewe dams (3-7 years of age at breeding, live weight 63.6 ± 2.08 kg) that were progesterone synchronised (CIDR, Pharmacia & Upjohn, New Zealand) and naturally bred as one group with mature Romney rams over an interval of 22 days (Mulvaney et al. 2013). These ewe groups were managed together under commercial New Zealand grazing conditions with a minimum post-grazing cover of 1000 kg DM/ha during gestation and 1200 kg DM/

ha during lactation (Mulvaney et al. 2013). In the overall study, of which the present ewe progeny were a cohort, the mean birth weight and weaning weights of singleton ELP and AEP were 4.04 ± 0.14 kg vs. 5.3 ± 0.14 kg and 16.8 ± 0.56 kg vs. 21.6 ± 0.57 kg, respectively (Mulvaney et al. 2013).

In 2009, 2010 and 2011, ELP (n = 20) and AEP (n = 25) were progesterone synchronised (CIDR, Pharmacia & Upjohn, New Zealand) and bred with Romney rams for a total of 22 days. ELP and AEP were pregnancy diagnosed 50 days after the end of joining, via trans-abdominal ultrasound using a real time B-mode scanner with a 5-MHz linear probe (Aloka SSD-500, Aloka Co. Ltd, Tokyo, Japan). Each year, pregnancy diagnosis determined ewes as being non-pregnant or bearing single-, twin- or triplet-fetuses. Lambing and milk production data from 2009 and 2010 are reported by Loureiro et al. (2012).

Experimental measures

The ewe progeny (ELP and AEP) were weighed within 12 hours of their birth (day 1, d1) and subsequently approximately every two months until four years of age.

Ewe progeny production was determined as the yearly (2009, 2010 and 2011) and combined totals (2009 to 2011) of number of lambs they gave birth to, number of lambs they weaned and the total weight (kg) of lambs they gave birth to and the total weight (kg) of lambs they weaned. All ewes were present for the entire study (2009 to 2011) and either gave birth (1, 2 or 3 lambs) or not (0 lamb) each year. Ewes were not removed from the study if they failed to lamb.

Ewe progeny efficiency was calculated as the total weight (kg) of lamb weaned per estimated total maintenance metabolisable energy (MJME) consumed by each ewe for each year (2009, 2010 and 2011) and the combined total (2009 to 2011). Estimated maintenance MJME requirements per year of each ewe was calculated as 0.52 MJME/kg $W^{0.75}$ (Nicol & Brookes 2007); where W is a weighted average live weight of the animal in a given year. A weighted average live weight for each ewe for 2009, 2010 and 2011 was calculated using four live weights estimated for each of those years. Average mating live weight was calculated as the live weight from February to April, average mid-pregnancy live weight as the weight from May to July, average pre-lambing live weight as the weight from August to September and average weaning live weight as the weight from October to January for each year.

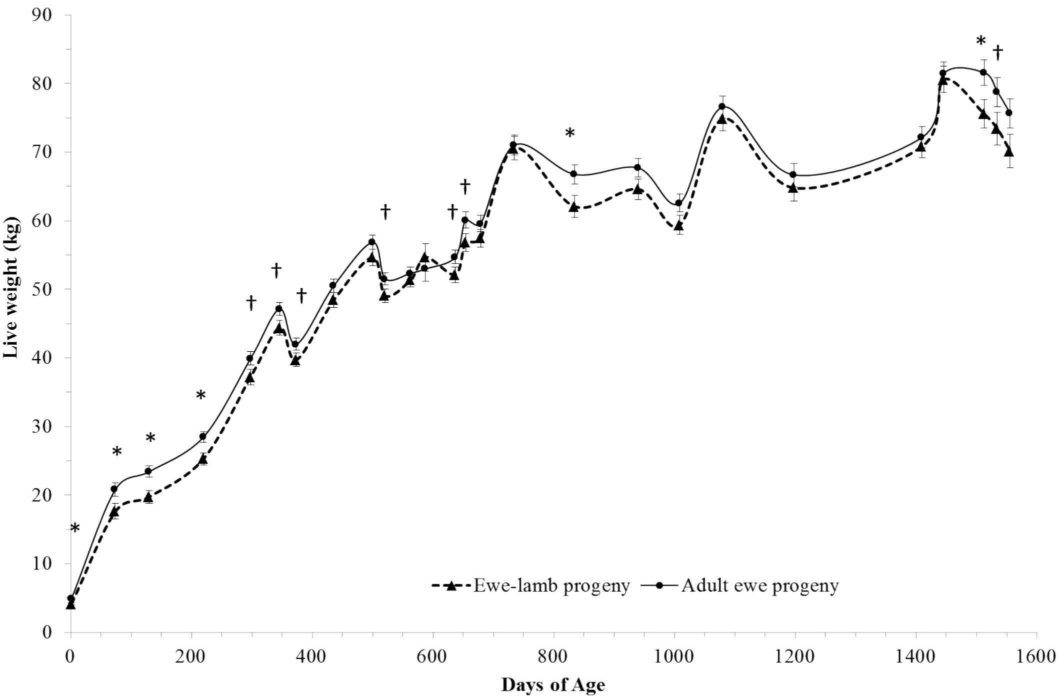
Statistical analysis

All statistical analyses were performed with Minitab® (version 16, Minitab Inc, Cary NC, USA) using the General Linear Model (GLM) repeated measures procedure with dam type (ewe-lamb vs. adult ewe) as a fixed effect. Ewe progeny date of birth was used as a covariate for analyses of live weight.

Results

ELP were lighter (P<0.05) at birth and remained lighter (P<0.05) than AEP until approximately one year of age (Figure 1). Live weight of ELP tended (P<0.1) to continue to be lighter until two years of age and was again lighter (P<0.05) than AEP in mid-pregnancy of their second parity (2010) and at weaning of their lambs in their third parity (2011).

Figure 1 Live weight (kg) of ewe-lamb progeny (n = 20) and adult-ewe progeny (n = 25) from birth (one day of age) to four years of age (1556 days of age). Data presented as least square means ± standard error of the mean (SEM). * indicates values that significantly differ (P<0.05) and † indicates values that tend to differ (P<0.1).



The number of lambs born and weaned and the weight of lamb born and weaned per ewe did not differ (P>0.05) for any of the productive years assessed or the combined total.

Table 1 The number of lambs born, number of lambs weaned, weight (kg) of lamb born and weight (kg) of lamb weaned of ewe-lamb progeny and adult-ewe progeny for their first three parities (2009: two years of age, 2010: three years of age and 2011: four years of age) as a well as the combined total over the three years (2009-2011). Data presented as least square means ± standard error of the mean (SEM).

	Production traits of:	
	Ewe-Lamb Progeny (n = 20)	Adult-Ewe Progeny (n = 25)
No. lambs born:		
2009	1.0 ± 0.16	0.9 ± 0.14
2010	1.3 ± 0.19	1.6 ± 0.17
2011	1.1 ± 0.17	0.9 ± 0.15
2009-2011 combined	3.4 ± 0.40	3.4 ± 0.36
No. lambs weaned:		
2009	1.0 ± 0.16	0.8 ± 0.14
2010	1.0 ± 0.17	1.4 ± 0.15
2011	1.0 ± 0.16	0.8 ± 0.15
2009-2011 combined	2.9 ± 0.35	3.0 ± 0.31
kg lamb born: *		
2009	5.1 ± 0.72	4.5 ± 0.64
2010	8.0 ± 1.00	8.2 ± 0.89
2011	6.8 ± 1.02	5.5 ± 0.91
2009-2011 combined	19.8 ± 2.18	18.3 ± 1.95
kg lamb weaned: *		
2009	27.8 ± 4.17	23.7 ± 3.73
2010	35.5 ± 5.22	40.1 ± 4.67
2011	38.4 ± 6.88	27.8 ± 6.15
2009-2011 combined	101.7 ± 11.41	91.6 ± 10.20

* this value includes a combination of singleton, twin and triplet lambs.

Estimated ewe maintenance energy requirements tended to be affected ($P \leq 0.1$) by dam age. Estimated total yearly maintenance energy requirements for ELP and AEP for 2009 were 3973 ± 57.9 *vs.* 4103 ± 51.8 MJME (P=0.1), respectively. Estimated total yearly maintenance energy requirements for ELP and AEP for 2010 were 4312 ± 72.3 *vs.* 4488 ± 64.7 MJME (P<0.1), respectively. Estimated total yearly maintenance energy requirements for ELP and AEP for 2011 were 4590 ± 82 *vs.* 4792 ± 73 MJME (P<0.1), respectively. Estimated total maintenance energy requirements for ELP and AEP for the combined 2009 to 2011 period were 12875 ± 198 *vs.* 13384 ± 177 MJME (P<0.1), respectively. Ewe production efficiency was not affected by dam age, with similar efficiencies reported for ELP and AEP for each year and for the combined total.

Table 2 Production efficiency (total kg lamb weaned/total maintenance metabolisable energy (MJME) consumed) of ewe-lamb progeny and adult-ewe progeny for their first three parities (2009: two years of age, 2010: three years of age and 2011: four years of age) as a well as the combined total over the three years (2009-2011). Data presented as least square means ± standard error of the mean (SEM).

	Production efficiency of:	
Year	Ewe-Lamb Progeny *($x10^{-3}$)* (n = 20)	Adult-Ewe Progeny *($x10^{-3}$)* (n = 25)
2009	7.0 ± 1.0	6.0 ± 0.9
2010	9.0 ± 1.2	9.0 ± 1.1
2011	9.0 ± 1.5	6.0 ± 1.3
2009-2011 combined	8.0 ± 0.9	7.0 ± 0.8

Discussion

The aim of this study was to compare the productive performance of ewe offspring born to either primiparous ewe-lambs or mature multiparous adult ewes from birth to four years of age. The data reported here showed that ELP were lighter until approximately 12 months of age and were lighter on occasion up to four years of age. This finding is supported by other studies in which offspring born to young mothers were reported to be lighter at birth (Annett & Carson 2006; Gootwine et al. 2006, 2007) and up to 12 months of age (Loureiro et al. 2011). Gootwine et al. (2007) and Wu et al. (2006) suggested that it was not parity that restricted fetal growth but rather the maturity of the dam and her capacity to appropriately partition nutrients to the fetus, that affected birth weight of the offspring.

Despite this liveweight penalty, the number of lambs born and weaned and the weight of lamb born and weaned per ewe did not differ at any point in the three productive years assessed here. In the same cohort of ewe-lamb progeny and adult-ewe progeny as that examined here, Loureiro et al. (2012) found no difference in regards to pregnancy rate and number of fetuses in their first two parities. Loureiro et al. (2012) also reported that milk production and milk composition did not differ between ewe-lamb progeny and adult-ewe progeny, which may explain the lack of difference observed in the study reported here in regards to weight of lamb weaned. Loureiro et al. (2011, 2012) further demonstrated both in this cohort of animals (Loureiro et al. 2012) and in an additional study using a different cohort of animals (Loureiro et al. 2011), that puberty attainment is unaffected by dam age.

The consistent difference in live weight between the ewe groups meant that estimated lifetime ewe maintenance ME requirements for ELP were approximately 13% lower compared to AEP. However this did not affect ewe production efficiency, with similar efficiencies estimated for ELP and AEP.

In conclusion, although differences in live weight were observed until approximately 12 months of age, there were no long-term effects on reproductive efficiency. This indicates that progeny born to ewe-lambs which are retained as replacement ewes, maintained appropriately and conventionally bred themselves as 18 months of age, do not have impaired reproductive performance compared to progeny born to mature adult ewes. It should be noted, however, that due to the small number of animals used in this study, it would be of value to confirm these findings using larger flocks.

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References

Annett RW, Carson AF 2006. Effects of plane of nutrition during the first month of pregnancy on conception rate, foetal development and lamb output of mature and adolescent ewes. Animal Science 82: 947-954.

Barker D 2001. Fetal and infant origins of adult disease. Monatsschrift Kinderheilkunde 149: S2-S6.

Bell AW 1993. Pregnancy and fetal metabolism. In: Quantitative Aspects of Ruminant Digestion and Metabolism. Eds JM Forbes and J France. CAB International, Oxford, pp 405-431.

Bell AW 2006. Prenatal programming of postnatal productivity and health of livestock: a brief review. Australian Journal of Experimental Agriculture 46: 725-732.

Gardner DS, Buttery PJ, Daniel Z, Symonds ME 2007. Factors affecting birthweight in sheep: maternal environment. Reproduction 133: 297-307.

Gootwine E, Rozov A, Bor A, Reicher S 2006. Carrying the FecB (Booroola) mutation is associated with lower birth weight and slower post-weaning growth rate for lambs, as well as a lighter mature bodyweight for ewes. Reproduction, Fertility and Development 18: 433-437.

Gootwine E, Spencer TE, Bazer FW 2007. Litter-size-dependent intrauterine growth restriction in sheep. Animal 1: 547-564.

Gunn RG, Sim D, Hunter EA 1995. Effect of nutrition in utero and in early life on the subsequent lifetime reproductive performance of Scottish Blackface ewes in two management systems. Animal Science 60: 223-230.

Kenyon PR, Pinchbeck GL, Perkins NR, Morris ST, West DM 2004. Identifying factors which maximise the lambing performance of hoggets: a cross sectional study. New Zealand Veterinary Journal 52: 371-377.

Loureiro MFP, Pain SJ, Kenyon PR, Peterson SW, Blair HT 2012. Single female offspring born to primiparous ewe-lambs are lighter than those born to adult multiparous ewes but their reproduction and milk production are unaffected. Animal Production Science 52(7): 552-556.

Loureiro MFP, Paten AM, Asmad K, Pain SJ, Kenyon PR, Pomroy WE, Scott I, Blair HT 2011. The effect of dam age and lamb birth rank on the growth rate, faecal egg count and onset of puberty of single and twin female offspring to 12 months of age. Proceedings of the New Zealand Society of Animal Production 71: 83-85.

Mulvaney FJ, Morris ST, Kenyon PR, Morel PCH, West DM, Viñoles C, Glover KMM 2013. Comparison between the reproductive performance of ewe hoggets and mature ewes following a progesterone-based oestrus synchronization protocol. New Zealand Journal of Agricultural Research 56(4): 288-296.

Nicol AM, Brookes IM 2007. The metabolisable energy requirements of grazing livestock. In: Pasture and Supplements for Grazing Animals. Eds: PV Rattray, IM Brookes, AM Nicol. New Zealand Society of Animal Production Occasional Publication 14, pp. 151-172.

Owens JA 1991. Endocrine and substrate control of fetal growth: placental and maternal influences and insulin-like growth factors. Reproduction Fertility and Development 3: 501-517.

Rae MT, Kyle CE, Miller DW, Hammond AJ, Brooks AN, Rhind SM 2002. The effects of undernutrition, in utero, on reproductive function in adult male and female sheep. Animal Reproduction Science 72(1-2): 63-71.

Rhind SM 2004. Effects of maternal nutrition on fetal and neonatal reproductive development and function. Animal Reproduction Science 82-83: 169-181.

Rhind SM, Rae MT, Brooks AN 2001. Effects of nutrition and environmental factors on the fetal programming of the reproductive axis. Reproduction 122: 205-214.

Safari E, Fogarty NM, Gilmour AR 2005. A review of genetic parameter estimates for wool, growth, meat and reproduction traits in sheep. Livestock Production Science 92: 271-289.

Scholl TO, Hediger ML, Belsky DH 1994. Prenatal care and maternal health during adolescent pregnancy: a review and meta-analysis. The Journal of Adolescent Health 15: 444-456.

Wallace JM, Bourke DA, Da Silva P, Aitken RP 2001. Nutrient partitioning during adolescent pregnancy. Reproduction 122: 347-357.

Wu G, Bazer FW, Wallace JM, Spencer TE 2006. BOARD-INVITED REVIEW: intrauterine growth retardation: implications for the animal sciences. Journal of Animal Science 84: 2316-2337.