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Effect of nutrition around the time of breeding and during pregnancy on yearling liveweight change, pregnancy loss and live weight and survival of their offspring

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ABSTRACT

This experiment investigated the effects of differing nutritional levels on yearling pregnancy loss, and the live weight and survival of their offspring to weaning. Yearlings were offered either Medium or *Ad-libitum* levels of herbage from four days prior to breeding (P-4) until P145. Nutrition during pregnancy had no effect on pregnancy loss or lamb live weight from Day 0 of lactation (L0) until L55. Lambing percent was higher ($P < 0.05$) in the *Ad-libitum* treatment compared to the Medium treatment. Single born lambs were heavier ($P < 0.05$) than twin born lambs at L0 and at L55. *Ad-libitum* treatment yearlings were heavier ($P < 0.05$) than Medium treatment yearlings at L55. Modelling of the live weight trends indicated that from P-4 until P145 the pregnant yearlings in the Medium and *Ad-libitum* treatment groups consumed 8.1 and 14.4 kg DM/kg of lamb live weight at L55. This indicates that the greater yearling live weight gain in the *Ad-libitum* group utilised more herbage during the yearling's first winter without any increase in the performance of their offspring. The extra 9 kg gained by the yearlings fed *Ad-libitum* may have positive effects on future performance as they will gain a suitable live weight for breeding as a two year old earlier.

Keywords: sheep; hogget; reproduction; pregnancy loss; lamb survival.

INTRODUCTION

Under current New Zealand pastoral conditions, only 30 % of the yearlings (7 to 9-months-old) wintered are put with the ram achieving a lambing percentage of less than 60% (Statistics New Zealand, 2008). In comparison adult ewe lambing percentage averaged 121% (Statistics New Zealand, 2008). This identifies the potential to lift the lambing percentage of yearlings considerably. A major reason for the low proportion of yearlings joined is a perceived negative effect on subsequent live weight as two year olds (Kenyon *et al*., 2008), and hence their future reproductive performance (Kenyon *et al*., 2004).

Under housed conditions in the United Kingdom, utilising concentrate diets, Wallace *et al*. (1996, 1997a, 1997b) have consistently shown that young (5 to 7 months of age) and well grown (43.7 to 47.4 kg) yearlings at the time of breeding fed to achieve extreme liveweight gains of 234 to 301 g/d during pregnancy have increased pregnancy loss, and reduced lamb birth weight and survival rates. One New Zealand study under pastoral grazing condition reported pregnancy loss as a result of a relatively high liveweight change of 210 to 230 g/d during pregnancy with 35% of the pregnant *ad-libitum* fed yearlings losing a pregnancy (Mulvaney *et al*. 2008). However, there was no effect on lamb birth or lamb survival. In contrast, the studies of Morris *et al*. (2005) and Kenyon *et al*. (2008) where yearlings achieved 210 to 230 g/d did not report an effect on pregnancy loss. It is probable that the pregnancy losses reported in the study of Mulvaney *et al*. (2008) were associated with *Neospora caninum* infection (West *et al*., 2006; Howe *et al*., 2008). Therefore, it is worthwhile to re-investigate the effects of *ad-libitum* levels of nutrition under pastoral conditions. Further, to the authors' knowledge, there are no data on the effects of different nutritional regimens starting prior to ram introduction on yearling performance. The studies of Kenyon *et al*. (2008) and Mulvaney *et al*. (2008) began after a five-day synchronised breeding period, while Morris *et al*. (2005) began after 21 days of breeding.

The aim of this experiment was to investigate the effects of differing nutritional levels, starting four days prior to ram introduction on yearling pregnancy loss and live weight and the live weight and survival of their offspring to weaning.

MATERIALS AND METHODS

Experimental design and animals

The experiment was conducted from the 1 July to 21 December in 2006 at Massey University's Keeble Farm (latitude 41º10'S), near Palmerston North, New Zealand, and was approved by the Massey University Animal Ethics Committee.

Three-hundred-and thirty Romney yearlings (34.7 ± 0.3 kg) were offered one of two nutritional treatments (Medium vs. *Ad-libitum*) from four days prior to ram introduction (Day of pregnancy (P) -4) to P145. The aim of the Medium treatment group (n = 165), was to achieve a total liveweight change of 100 g/d from P-4 to P145. A live weight change of 100 g/d was used as a mid-point between maintenance and *ad-libitum* and has been used in previous publications (Morris *et al*., 2005; Kenyon *et al.*, 2008; Mulvaney *et al*., 2008)). The *Ad-libitum* nutritional treatment group (n = 165) were offered *ad-libitum* pasture. To achieve these conditions, the herbage of Medium yearlings was maintained between 1,000 and 1,400 kg DM/ha as previously utilised by Mulvaney *et al.*, (2008) and the *Ad-libitum* yearlings were offered herbage with a minimum of 1,800 kg DM/ha. The yearlings grazed a total area of 19 ha of mixed perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). The size of the grazing area and the grazing interval for both nutritional treatments were based on the recorded liveweight change and herbage availability adjusted to ensure live weight targets were met.

All yearlings were bred over a 34 day period (P1 to P34) using crayon harnessed mature Romney rams at a ratio of one ram to 30 yearlings. Yearlings that did not have a crayon rump mark at P34 were removed from the remainder of the study. Pregnancy status as to whether each yearling was carrying no, one or two fetuses, was determined via real time abdominal ultrasound on P64. Eighty-three (50% pregnant) Medium and 105 (64% pregnant) *Ad-libitum* yearlings were diagnosed pregnant at P64 to the 34 day breeding period. Only their data are presented here. Among the pregnant yearlings in the Medium treatment group 81 were single-bearing (98% of those pregnant) and two were twin-bearing (2% of those pregnant), while in the *Ad-libitum* group 69 were single-bearing (66% of those pregnant) and 36 were twin-bearing (34% of those pregnant). Two further ultrasound scans took place on Days P109 and P145 to determine if any yearlings had lost their pregnancy. Yearlings diagnosed as not pregnant at either P64, P109 or P145 were removed from their treatment group for the remainder of the study. Due to an inability to accurately detect the number of fetuses at this late stage of pregnancy, the number of fetuses was not recorded. The present study only reports data collected from P64 until L55.

At P145, yearlings that conceived during their first cycle in the first 17 days of the breeding period, were combined from each nutritional treatment and offered *ad-libitum* levels of pasture at seven yearlings per ha from P145 to 55 days after the first lamb was born (Day of lactation (L) 55). Yearlings that conceived during their second cycle during the second 17 days of the breeding period, remained on their respective nutritional treatments until their predicted P145 day and were then managed as described for the 1st cycle yearlings until L55.

Animal measurements

Yearlings were weighed within one hour off pasture on days P-4, P7, P15, P22, P29, P36, P50, P64, P80, P92, P126, P145, L41 and L55.

Determining pregnancy loss

Pregnancy loss was assumed to occur if a yearling was identified as pregnant via a real-time ultrasound scanner at P64 but later diagnosed as not pregnant at either P109 or P145.

Lamb measurements

Newborn lambs were tagged within 12 hours of birth on day L0, identified to their dam, and their date of birth, sex, litter size and live weight recorded. In addition, crown rump length (CRL), thoracic girth circumference (GRT), rear limb length from the hip to the tip of the hoof (RL), and fore limb length from the shoulder to the tip of the hoof (FL) were measured and recorded. All lambs were re-weighed unfasted at L41 and L55.

Data analysis

Dam live weight and lamb live weight, and the lamb dimensions were analysed using a generalised linear model (SAS, 2005). In the models for dam live weight, fixed effects of litter size and dam nutritional treatment and their interaction were tested for each parameter. Non-significant ($P > 0.05$) interactions were removed and the model re-run. Note in the models for dam live weight the numbers changed at each time point when non-pregnant animals were removed. Similarly in the models for lamb live weight and lamb dimensions, fixed effects of yearling nutritional treatment and litter size were fitted and non-significant ($P > 0.05$) interactions were removed and the model re-run. Date of birth, birth weight and sex of lamb was used in the model as a covariate for live weight at L0, L41 and L55 and lamb dimensions.

Pregnancy rate at P64 was calculated as the number of yearlings diagnosed pregnant at P64 divided by the number of yearlings at the start of the breeding period. Pregnancy loss between P64 and P109 was calculated as the number of yearlings pregnant at P64 less the number of yearlings pregnant at P109 divided by the number of yearlings pregnant at P64, and pregnancy loss between P109 and P145 was calculated as the number of yearlings pregnant at P109 less the number of yearlings pregnant at P145 divided by the number of yearlings pregnant at P109. Lamb survival to L55 was calculated as the total number of lambs born on L0 less the number of lambs alive at L55 divided by the number of lambs born. These data were analysed using the GENMOD procedure for binomial data (SAS, 2005). Fixed effects of yearling nutritional treatment were fitted into the model.

Lambing percentage calculated as the number of lambs present at L55 divided by the number of yearlings joined with the ram, was analysed using the GENMOD procedure for categorical data (SAS, 2005). Fixed effects of yearling nutritional treatment were fitted into the model.

Modelling of live weight data

Conceptus-free live weight for each treatment group was assumed to be the predicted conceptus weight, including the weight of the fetus(es), membranes and fluids, minus the average yearling live weight at P145. The conceptus mass was estimated using the equation from Nicol and Brookes (2007). The *Ad-libitum* treatment group contained a larger proportion of twin-bearing yearlings, therefore, to calculate the estimated conceptus mass for the treatment a single-bearing yearling was given a weighting factor of 0.7, while a twin-bearing yearling was allocated a weighting factor of 0.3. The conceptus free liveweight change was assumed to be yearling live weight at the start of the study (34.7 kg) minus the conceptus free yearling live weight at P145.

The pasture dry matter intake was calculated in two sections. The first section involved estimating the metabolisable energy (MJ ME) that would be required to achieve the conceptus free liveweight gain for each treatment group. The liveweight gain was divided into 5 kg sub categories of 35 to 39, 40 to 44 and 45 to 49 kg, to align with the information provided in Rattray (1986). The MJ ME requirement was calculated using the mean liveweight change during the pregnancy period for each treatment group at each live weight category. The second section involved the summation of each sub-category provided an estimation of the MJ ME intake to achieve the respective liveweight change in each treatment group. It was assumed each kilogram dry matter of herbage contained 11 MJ ME (The New Zealand Sheep Council, 2002).

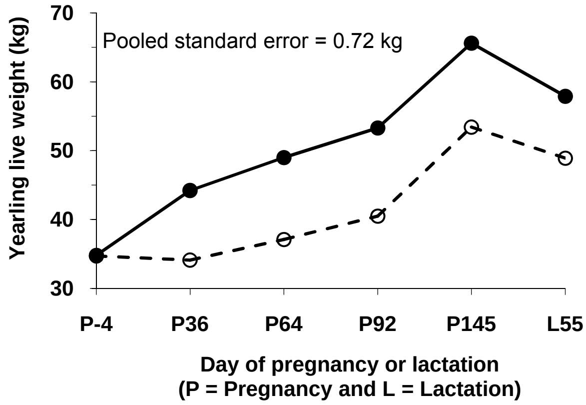
The efficiency of the system was then calculated as kilograms of dry matter intake from P-4 to P145 divided by kg lamb live weight at L55.

RESULTS

Yearling live weight

At P-4, live weight did not differ (P >0.05) between nutritional treatments. However, by P7 and until L55, *Ad-libitum* treatment yearlings were heavier (P <0.05) than their Medium counterparts (Figure 1). The liveweight change was lower than the target until P36 for the Medium treatment yearlings. At P145, the Medium and *Ad-libitum* treatment yearlings were 53.4 ± 0.5 and 65.6 ± 0.5 kg, respectively with the average daily liveweight changes of 125 ± 9 and 206 ± 11 g/d, including the conceptus, respectively (P <0.05). At L55, the Medium and *Ad-libitum* yearlings were 48.9 ± 0.7 and 57.9 ± 0.7 kg, respectively (P <0.05).

FIGURE 1: The effect of yearling nutrition (--o-- = Medium and -●- = *Ad-libitum*) beginning four days prior to breeding until 145 days of pregnancy (P145) on yearling live weight. L55 = 55 days into lactation.



Pregnancy rate and pregnancy loss

Pregnancy rate at P64 was higher (P <0.05) in the *Ad-libitum* treatment with 105 yearlings pregnant out of 165 yearlings joined (logit value 0.53 ± 0.16, back transformed percentage 63 %) than the Medium treatment with 83 yearlings pregnant out of 165 yearlings joined (logit value 0.01 ± 0.16, back transformed percentage 50 %).

Nutrition of the yearling dam had no impact (P >0.05) on pregnancy loss from P64 to P109 with 7% versus 11% for Medium and *Ad-libitum* treatment yearlings respectively, from P109 to P145 with 6% versus 9% for Medium and *Ad-libitum* treatment yearlings respectively and from or from P64 to P145 with 14% versus 19 % for Medium and *Ad-libitum* treatment yearlings respectively.

Lamb live weight, dimensions and survival and lambing percentage

Lamb live weight at L0, L41 and L55 was not affected (P >0.05) by dam nutrition (Table 1).Single born lambs were heavier (P <0.05) at L0, L41 and L55 than their twin born counterparts.

Nutrition of the dam during pregnancy had no affect (P >0.05) on lamb CRL, GRT and FL. However, lambs born to the *Ad-libtum* treatment yearlings had a longer (P <0.05) RL than lambs born to the Medium treatment yearlings (Table 2). Single born lambs had a larger (P <0.05) CRL, GRT and a longer (P <0.05) FL and RL compared to twin born counterparts.

Lamb survival was not affected (P >0.05) by dam nutrition being 84% and 77 % for the Medium and *Ad-libitum* groups respectively. Lamb litter size was also not affected (P >0.05) by dam nutrition

TABLE 1: The effect of yearling nutrition (Medium and *Ad-libitum*) beginning four days prior to breeding until 145 days of pregnancy (P145) on the mean ± standard error, of lamb live weight (kg) at lambing (L0) and 41 (L41)and 55 (L55) days into lactation. Within columns, means with different superscripts differ significantly (P<0.05).

Effect	Days into lactation					
	L0		L41		L55	
	Number of lambs	Lamb live weight (kg)	Number of lambs	Lamb live weight (kg)	Number of lambs	Lamb live weight (kg)
Nutrition						
Medium	82	4.1 ± 0.1	69	12.8 ± 0.3	68	13.5 ± 0.5
Ad-libitum	139	4.0 ± 0.1	107	12.1 ± 0.4	103	14.6 ± 0.4
Litter size						
Single	147	4.6 ± 0.1^{b}	121	14.3 ± 0.3^{b}	119	15.8 ± 0.3^{b}
Twin	74	3.5 ± 0.1^{a}	54	10.6 ± 0.5^{a}	54	12.3 ± 0.6^{a}

TABLE 2: The effect of yearling nutrition (Medium and *Ad-libitum*) beginning four days prior to breeding until 145 days of pregnancy (P145) on the mean ± standard error of lamb body dimensions at birth. Within columns, means with different superscripts differ significantly (P <0.05).

Effect	Number of lambs	Crown rump length (cm)	Girth(cm)	Fore leg length (cm)	Rear leg length (cm)
Nutrition					
Medium	82	50.9 ± 0.6	37.1 ± 0.5	29.5 ± 0.4	33.5 ± 0.4^{x}
Ad-libitum	139	51.4 ± 0.4	37.6 ± 0.3	29.7 ± 0.2	34.6 ± 0.3^{y}
Birth rank					
Single	147	53.1 ± 0.4^{b}	39.1 ± 0.3^{b}	30.5 ± 0.2^{b}	35.2 ± 0.2^{b}
Twin	74	49.1 ± 0.6^{a}	35.5 ± 0.5^{a}	28.2 ± 0.4^{a}	32.8 ± 0.4^{a}

being 82% and. 76% for single- and twin-born lambs respectively.

The lambing percentage was higher (P <0.05) in the *Ad-libitum* (62 %) compared to the Medium (41%) treatment yearlings.

Modelling of the live weight results

The estimated conceptus mass being the weight of the fetus, membranes and fluids, was 7.9 versus 8.5 kg and the conceptus free live weight of the dams was 45.3 versus 57.1 kg, for the Medium and *Ad-libitum* treatments, respectively. Conceptus free live weight change was 11.1 versus 22.4 kg for the Medium and *Ad-libitum* treatment yearlings, respectively. The pregnant Medium and *Ad-libitum* treatment yearlings required 1,210 versus 2,442 MJ ME or 110 versus. 222 kg DM to achieve their respective conceptus free liveweight change between P-4 and P145. Therefore, the Medium treatment yearlings consumed 8.1 kg DM/kg of lamb live weight at L55 and the *Ad-libitum* treatment yearlings consumed 15.2 kg DM/kg of lamb live weight at L55.

DISCUSSION

The present study utilised yearlings diagnosed pregnant at P64 to investigate the effect of two differing nutritional regimens beginning four days prior to breeding, on pregnancy loss and live weight of the dam and her offspring to L55. This study did not examine the effects of the nutritional regimens on yearling breeding performance which will be published elsewhere. Yearling liveweight change from P-4 until P145 of the *Ad-libitum* yearlings were similar to previous studies (Morris *et al*., 2005; Kenyon *et al*., 2008; Mulvaney *et al*., 2008) on the same farm during a similar period of the year. The liveweight change of the Medium treatment group from P-4 until P36 was lower than the target while the liveweight change of both treatment groups during the last trimester were similar.

Extreme liveweight gain under indoor U.K. conditions has invariably shown an increase in nutrition associated with pregnancy loss (Wallace *et al*., 1996; 1997a; 1997b) however; only one New Zealand study (Mulvaney *et al*., 2008) has replicated these results. Other New Zealand pastoral grazing studies (Morris *et al*., 2005; Kenyon *et al*., 2008) undertaken during the same time period on the same farm reported no effect on pregnancy loss. Infectious disease has been identified as a cause of loss of pregnancy in yearlings (West *et al*., 2006; Howe *et al*., 2008), hence the results of Mulvaney *et al*. (2008) should be interpreted with caution.

The U.K. studies have consistently shown elevated liveweight gain during the pregnancy period has reduced mean lamb birth weight. New Zealand studies, on the other hand, have not led to a reduction in mean birth weight. It has been suggested that this difference may be due to different utilisation and partitioning affecting conceptus growth and development in a different manner in the New Zealand studies (F.J. Mulvaney, Unpublished data). Also, the hoggets in the UK studies were younger, heavier (Wallace *et al*., 1996; 1997a; 1997b) and utilised embryo transfer techniques rather than natural mating.

In the present study, lamb survival was similar between nutritional treatments and similar to the previous New Zealand studies (Morris *et al*., 2005; Kenyon *et al*., 2008; Mulvaney *et al*., 2008) and could primarily be due to similar lamb birth weights between the nutritional regimens.

The conceptus free live weight at P145 of the *Ad-libitum* treatment yearlings was substantially higher than that of the Medium treatment yearlings and was close to the target two year old breeding live weight of 60 kg (Rattray, 2002). If the 9 kg difference in live weight can be maintained until breeding as a two year old, an enhanced ewe reproductive performance will be observed (Keane 1974; Baker *et al*., 1981; McMillan & McDonald, 1983). Also, for the Medium treatment yearlings to achieve the target live weight suggested by Rattray (2002) they would require a more intensive management system over the challenging summer period. However, this apparent benefit needs to balanced against the reduced efficiency in terms of kg DM required/ kg lamb live weight at L55, of the *Ad-libitum* treatment yearlings. This indicates that total yearling liveweight gain during pregnancy in the *Ad-libitum* treatment group, costs more herbage during a yearlings first winter without any increase in the performance of their offspring to L55 compared to a system in which the total yearling gain is 125 g/d.

CONCLUSION

Allowing yearlings *ad-libitum* levels of pasture beginning four days prior to breeding did not affect pregnancy loss, lamb survival or subsequent lamb live weight, although the *Ad-libitum* ewes themselves were heavier at L55. When the results were modelled, the Medium treatment group consumed less herbage during the pregnancy period to produce a similar lamb live weight at L55. The *Ad-libitum* treatment yearlings were 9 kg heavier at L55. This could have positive effects on their performance as a two year old if this difference could be maintained, or alternatively they will need to consume less herbage over the summer period to achieve the recommended breeding live weight targets. Further experiments are required to determine if the superior live weight of the *Ad-libitum* yearlings would be carried over to two year old breeding live weight and the potential effects on the subsequent number of lambs identified at the next pregnancy diagnosis.

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