Small Ruminant Research 97 (2011) 21–27

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Effects of dam size and nutritional plane during pregnancy on lamb performance to weaning

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ARTICLE INFO

Article history:
Received 10 August 2010
Received in revised form
15 December 2010
Accepted 12 January 2011
Available online 2 February 2011

Keywords:
Maternal nutrition
Ewe size
Growth
Glucose
GGT
Udder size

ABSTRACT

This study examined the effects of dam size and plane of nutrition during pregnancy on dam udder size, lamb colostrum intake, and lamb liveweight gain (LWG). The study also attempted to quantify the effects of a number of dam and offspring parameters on lamb LWG. Two hundred and fifty-five heavy (H) (60.8 ± 0.18 kg) and 255 light (L) (42.5 ± 0.17 kg) Romney dams were allocated to *ad libitum* (A) or maintenance (M) nutritional regimens, under New Zealand pastoral grazing conditions – from day 21 to day 140 post-insemination. One week prior to lambing, all dams and offspring were managed as one group and provided with *ad libitum* feeding. Udder dimensions were measured at day 140 of pregnancy in a sub-group of 313 dams. Lambs were weighed within 24 h of birth (L0) and at L21, L45, L80 and L100 and the lamb liveweight gains calculated. From a sub-group of 167 lambs, blood was sampled at 24–36 h of age to determine the glucose and gamma-glutamyltransferase (GGT) concentrations. During pregnancy, the M-dams gained less live weight than the A-dams and gave birth to lighter lambs – which resulted in a reduced LWG, until L21. From L21 onwards, the LWG of the lambs born to M-dams did not differ from lambs born to A-dams. Udders of the LA-dams were bigger than those of LM-dams. Lambs born to A-dams recorded a higher blood glucose concentration than lambs born to M-dams. Dam size and nutrition did not affect the GGT concentrations of the lamb. Heavy (H) dams remained heavier than the L-dams throughout pregnancy and gave birth to heavier lambs, than the L-dams. Lambs born to H-dams recorded greater LWG than lambs born to L-dams during early, mid and late lactation. Modelling of the results showed that only a small part of the variation (±35%) of LWG of the lambs could be explained by the measured variables (e.g., birth weight, dam live weight, sire, udder dimension, nutrition). The largest single variable explained less than 5% of the variation in LWG. In conclusion, this study showed that lamb liveweight gain in early lactation is affected by both dam size and plane of nutrition and could likely be explained by differences in the lactational performance of the ewes. Interestingly, modelling of the results showed that a considerable proportion of lamb liveweight gain was not explained by the variables measured.

1. Introduction

In New Zealand, the feeding level of pregnant ewes in winter is often a compromise between herbage availability and nutritional demand (Matthews et al., 1999), which

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doi:10.1016/j.smallrumres.2011.01.004

can lead to periods of sub-optimal nutrition. Many studies have shown that ewe nutrition during pregnancy affects growth, development and health of the offspring (Robinson et al., 1999; Bertram and Hanson, 2001; Redmer et al., 2004; Wu et al., 2006; Gardner et al., 2008). So for example, sub-optimal nutrition can negatively affect birth weight (Oliver et al., 2002; Wu et al., 2006; Kenyon, 2008; Tygesen et al., 2008) and consequently early postnatal growth (Ford et al., 2007; Jaquiery et al., 2007). In addition, exposure of the dam to a prolonged period of sub-optimal nutrition may affect her lactational performance, resulting in reduced colostrum and/or milk availability for the offspring, affecting growth and lamb survival to weaning (Banchero et al., 2006; Cafe et al., 2006; Pulina et al., 2006; Tygesen et al., 2008). Size of the dam can also affect lamb birth weight and/or postnatal growth through the size of the placenta (Mellor, 1983). Dam size has also been shown to affect milk production (Gardner and Hogue, 1966; Hansen, 2000), as a larger body size enables the animal to have greater energy intakes and greater tissue reserves – which can be reflected in more precursors for milk synthesis reaching the mammary gland, resulting in a greater milk yield (Rattray et al., 2007).

Recently, Kenyon et al. (2009) showed that 'light' ewes fed a "conceptus-free" maintenance diet from day 21 to day 140 of pregnancy gave birth to lighter lambs, which remained lighter at 100 days of age, compared to lambs born to 'heavy' ewes fed *ad libitum*. The nutritional level of the dam during pregnancy has been shown to have a greater effect on birth weight of the twin-born lambs, than in singleton-born counterparts (Kenyon et al., 2009). However, this study did not examine the effect of dam size and nutrition on ewe udder size in late pregnancy, indices of lamb colostrum intake or aspects of lamb liveweight gain (LWG) during either early or late lactation. Nor was there any attempt to identify factors associated with lamb LWG during the lactation period. Therefore, the present trial examines the effects of dam size and plane of nutrition from day 21 to day 140 of pregnancy, and the potential interactions with ewe udder size, lamb colostrum intake (as measured by lamb blood glucose and GGT concentrations), and LWG during early, mid, and late lactation of lambs which survived to weaning. This study also statistically evaluates the effects of several dam and offspring parameters on lamb LWG.

2. Materials and methods

The study was conducted at the Massey University Keeble Sheep and Beef farm, 5 km south of Palmerston North, New Zealand. The study and all animal handling procedures were approved by the Massey University Animal Ethics Committee, Palmerston North, New Zealand.

2.1. Dams

In 2005, 255 'heavy' (H) (60.8 ± 0.18 kg) and 255 'light' (L) (42.5 ± 0.17 kg) Romney ewes, bred via AI with Suffolk semen and bearing either a single (n = 230) or twin fetuses (n = 280), were randomly allocated, to either *ad libitum* (A) or maintenance (M) nutritional regimens – under New Zealand pastoral grazing conditions, from day 21 (P21) until day 140 (P140) post-insemination (Kenyon et al., 2009). The aim of the M-nutritional regimen was to ensure sufficient pasture herbage – such that total dam live weight increased during pregnancy, at a level similar to that of the expected conceptus mass. The aim of the A-regimen was to provide unrestricted intake of the same herbage under grazing conditions, by careful manipulation of the stocking rates. The mean pre- and post-grazing pasture herbage masses during the period P21–P140 were respectively 1330 ± 140.0 and 804.0 ± 133.4 kg DM/ha for the M-regimen, and 2304.0 ± 156.8 and 1723.3 ± 149.7 kg DM/ha for the A-regimen (Kenyon et al., 2009). From day 140 of pregnancy until weaning of the lambs, all of the ewes were mixed and provided with *ad libitum* feeding. The present study analyses utilised the data from the 510 ewes (H: n = 255; L: n = 255; A: n = 242; M: n = 268), which gave birth to 441 lambs (H: n = 252; L: n = 189; A: n = 211; M: n = 230). Interactions between dam size and plane of nutrition is abbreviated as HA (heavy-*ad libitum*), HM (heavy-maintenance), LA (light-*ad libitum*) and LM (light-maintenance) groups, respectively.

2.2. Udder dimensions

Udders were measured at day 140 of pregnancy in a sub-group of 313 dams (H: n = 161; L: n = 152; A: n = 145; M: n = 168). The udder dimensions used for analysis were the mean of three measurements from the posterior to the anterior margin of the udder along the midline and parallel to the midline immediately medial to each teat (Mellor and Murray, 1985).

2.3. Lamb offspring

Lambs were tagged and identified to their dams, their sex defined and weighed within 24 h following birth (L0). Lambs were weighed at day 21 of age (±2.1; SD) (L21) at L45 (±2.1; SD), at L80 (±2.1; SD) and at L100 (±2.1; SD, weaning). Based on these live weights, individual lamb liveweight gains (LWG), between L0–L21, L21–L45 and L45–L100, of lambs which survived to weaning were calculated. Kenyon et al. (2009) previously reported that neither dam nutrition nor size affected lamb survival to weaning.

A sub-group of 167 lambs (H: n = 74; L: n = 93; A: n = 92; M: n = 75), was used to sample blood at 24–36 h of age, which subsequently included lambs that did or did not survive to weaning. The 5 mL jugular venous blood samples (Lithium heparin, Becton, Vacutainer Systems, USA) were immediately placed on ice until centrifugation at 1006 × G for 15 min. Blood plasma and serum was collected and frozen until determination of glucose and gamma-glutamyltransferase (GGT) concentrations, by respectively a hexokinase assay (Roche Diagnostics Ltd.) and a RIA diagnosis kit (Roche Diagnostics Ltd., Mannheim, Germany).

2.4. Statistical analyses

Dam live weight, udder dimensions, lamb live weight and LWG were analysed using the MIXED procedure (SAS, 2006), with a linear model that included the fixed effects of dam nutrition, dam size, pregnancy/birth or rearing rank, and lamb sex plus the two- and three-way interactions between these effects. Date of lambing was fitted as a covariate (P < 0.05). Non-significant two- or three-way interactions were removed from the final analyses, except for the interaction of dam nutrition and dam size, to allow for the experimental design. Pregnancy ranking was included in the analysis of dam live weight and udder dimensions. Birth rank was fitted in the analysis of birth weight. Rearing ranking (defined as S: singleton born and reared; TT: twin born and reared; TS; twin born but singleton reared) was fitted in the analysis for lamb LWG and live weights from L21 and onwards. To determine if differences in lamb LWG were independent of live weight, birth weight or live weight at the start of each period were fitted as a covariate in the analysis of lamb LWG. Similarly, to determine if differences in lamb live weight were independent of weight at birth, birth weight was fitted as a covariate. Only lambs that survived until weaning were used in the analyses for lamb live weights and LWG.

Glucose and GGT data were log-transformed to normalize the data and back-transformed to be presented as least square means with a back-transformed 95% confidence level, and analysed using the MIXED procedure (SAS, 2006), with a linear model that included the fixed effects of dam nutrition, dam size, the interaction of dam nutrition by dam size, birth rank, lamb sex and the two- and three-way interactions between these effects. The analyses of glucose and GGT included lambs that did and did not survive to weaning. Date of birth was fitted as a covariate and birth weight was found to be a non-significant (P > 0.05) covariate and removed from the final analysis. The effects on blood GGT and glucose concentrations on survival rate were not analysed, as only 9 lambs