Effects of high concentrate supplementation of Saint Croix sheep during peripartum on neonatal lamb behaviour

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ABSTRACT

The aim of this study was to determine whether increasing concentrate supplementation to ewes during the peripartum would benefit ewe and lamb vigour. Pregnant ewes were randomly assigned to either a maintenance group (MG) or a supplementation group (SG). The diets given covered energy requirements and consisted of pasture, forages and commercial concentrate; however, SG ewes received higher concentrate ration. Body weight and blood metabolites were assessed weekly. Lambs were weighed and their behaviour was observed. Data were analysed using repeated-measures test or ANOVA. During peripartum, the body weight was significantly higher in SG ewes compared with MG ewes ($P = .02$). Indicators of energy metabolism were similar between groups ($P > .05$). Latency to first suck was 10 minutes shorter in SG lambs compared with MG lambs ($P = .005$). Lamb weight was similar between groups, and there was a negative correlation between lamb birthweight and time to first suckle that was independent of diet group. This study demonstrates that high concentrate supplementation of ewes during peripartum results in higher body weight postpartum but does not change metabolic status. Latency to first suck was shorter in lambs born to SG ewes suggestive of enhanced vigour related to supplementation.

Introduction

Neonatal mortality is estimated to be between 10% and 25% in lambs (Mellor and Stafford 2004) and occurs mainly during the first hours of life (Sawalha et al. 2007). The survival of a neonatal lamb is mainly related to vigour (the capacity to stand up and suck milk within a few hours after birth), maternal behaviour and colostrum production. These factors are affected by the ewe’s level of nutrition during late pregnancy (Nowak and Poindrón 2006; Dwyer 2014). Maternal undernutrition and twin or triplet births have been associated with low body weight, low vigour and high mortality in neonatal lambs (Mellor and Stafford 2004, González-Stagnaro 2012). Conversely, it has been shown that supplementation of long-chain fatty acids to pregnant ewes reduces the suckle latency of neonatal lambs (Capper et al. 2006).

During the peripartum period, ruminants commonly suffer nutrient stress that is reflected by increased lipid metabolism (Chilliard et al. 2000). Supplementation of ewes during this period may therefore reduce this metabolic stress. However, the effect of supplementation on both ewe and lamb is controversial. For example, twin- or triplet-bearing ewes that grazed on unrestricted pasture and supplemented with 400 g of concentrate daily per ewe, had lower nutritional stress as evidenced by lower plasma concentrations of non-esterified fatty acids (NEFA) and β-hydroxybutyric acid (BHBA) during the peripartum period and higher lamb birthweight compared to non-supplemented ewes (Kerslake et al. 2010). However, in a similarly designed study, concentrate supplementation had no effect on blood levels of NEFA and BHBA (Kenyon et al. 2010). Another study showed that ewes fed with Sainfoin hay and supplemented with 300 g of concentrate per ewe daily during prepartum had similar concentration of NEFA as non-supplemented ewes (Joy et al. 2014). Therefore, the aim of this study was to evaluate the effect of high-level concentrate supplementation of Saint Croix ewes during the peripartum period on the ewes’ energy balance and neonatal lamb weight and vigour. We hypothesize that high-level concentrate supplementation will reduce ewes’ metabolic stress during the peripartum period and improve lamb birthweight and vigour.

Material and methods

Location of experiment and animals

This study was conducted at the Faculty of Agricultural and Animal Production Sciences, Autonomous University of Morelos in Cuernavaca, Mexico, during the rainy season. A flock of Saint Croix ewes were synchronized by placing a vaginal implant containing 20 mg of fluorogestone acetate (Chronogest® CR, Intervet). At the time of implant removal 12 days after placement, ewes were treated with 500 IU of intra-muscular eCG (Folligon®, Intervet). Pregnancy was confirmed by absence of return to oestrus. At 100 days gestation, 47
pregnant ewes were selected and randomly distributed to either a maintenance Group (MG) or a supplementation Group (SG), which are described below. The ewes had an average parity of 3.6 births and a body condition score of 2.6 ± 0.04 (1–5 scale), and their body weight was 50.1 ± 1.05 kg. There were 11 single and 13 twin births to the MG and 10 single and 13 twin births to the SG ewes. Only one MG lamb died (twin birth).

**Experiment diets**

During gestation, the sheep were managed in a semi-intensive production system. Ewes grazed daily on African star (*Cynodon nlemfuensis*) and Taiwan grass (*Pennisetum purpureum*) paddocks for 6 hours. At 4:00 pm, the ewes were housed indoors and forages and concentrates were offered. Water was offered *ad libitum* throughout the day. The grazing area was 1.5 ha, divided into three paddocks, and it was rotationally grazed, with an average of 10 days for paddocks using temporary sub-divisions when it was required (depending on pasture availability).

The MG diet consisted of grazing for 6 hours in the paddocks described above, after which ewes were housed indoors and offered 322 g/ewe/day of commercial concentrate (13% crude protein, Nu3® brand) in a common feed trough. From lambing until 4 weeks (postpartum), the amount of concentrate offered to the ewes was doubled to 644 g/ewe/day and they were additionally given 240 g/ewe/day of lucerne hay (*Medicago sativa*). The grazing management for the SG was the same as the MG, but the concentrate supplementation was higher and the ewes were fed individually to ensure that the consumption was according to body weight. Thus, during postpartum, the ewes received on average 625 ± 15.50 g/day/ewe of concentrate (range: 500–910 g/day/ewe), and during the first 10 days postpartum, they received 1258 ± 42.87 g/day/ewe (range: 1138–2031 g) of concentrate; thereafter, they received the same amount as the MG ewes at postpartum. During the last third gestation period, the forage to concentrate ratio offered was 60:40 and 30:70 in lactation. The average body weight and blood parameters of the ewes were analysed for all variables. All means are presented with ± SEM. Data were analysed using GenStat 16th edition program.

**Statistical analysis**

The body weight and blood parameters of the ewes were analysed by ANOVA for repeated-measures test. The variables included in the model were the diet type (MG or SG), the gestational period (in weeks) and whether the ewe gave birth to single or twin lambs. The effect of ewe diet on lamb behaviour was analysed using ANOVA, including lamb birthweight as a covariate. The effect of lamb birthweight per se was analysed by ANOVA using a classification into quartiles, where the average ‘small’ lamb weight was 2172.4 ± 77.6 g, the ‘medium’ lamb was 2977.8 ± 36.0 g and the ‘large’ lamb was 3734 ± 59.9 g. Pearson’s correlation coefficients were calculated for some variables. Significance was considered at the *P* ≤ .05 level and the difference between means was evaluated using least square significance difference. The normal distribution was evaluated for all variables. All means are presented with ± SEM. Data were analysed using GenStat 16th edition program.

**Results**

**Effect of diet on ewes**

Before the feeding regime, the SG and MG had similar body weights (*P* > .05; 50.5 ± 1.7 kg and 49.7 ± 1.3 kg, respectively). But 4 weeks after starting supplementation, the SG were heavier than the MG ewes (*P* < .02; 47.7 ± 1.7 kg (SD) and 42.9 ± 1.1 kg, respectively). The weight difference was significant starting 1 week before lambing and until the end of the study, 4 weeks postpartum (*P* < .001) (Figure 1). On average, the difference in body weight for the SG ewes was of 1.33 kg during the last 4 weeks of gestation and 3.31 kg during 4 weeks of lactation, compared with the MG ewes.

Energy metabolism indicators were similar between MG and SG (Figure 2) and not affected by birth type (single or twin) (*P* > .05). The mean values for the MG and the SG were NEFA concentration: 12.99 ± 0.55 and 13.53 ± 0.61 mg/dL (*P* = .411), the glucose concentration: 57.37 ± 0.95 and 57.19 ± 1.02 mg/dL (c111*) was used to measure the concentration of metabolites using commercial kits, NEFA (NEFA kit, Randox®), glucose (Glucose HK kit, Roche®), total proteins (Total proteins 400t kit, Roche®) and albumin (Albumin Gen2 kit, Roche®), following the procedures described by the manufacturer.

Lamb behaviour was evaluated, during the first 3 hours after birth, by an observer positioned 2 m from the pen. When an ewe showed signs of labour, she was separated from the flock to an individual pen. The observer measured the time in minutes that the lamb took to stand up (lamb stands unsupported on four legs for more than 5 seconds), to reach udder (lamb approaches ewe and nudges her in the udder region) and to suck milk (lamb mouth holds teat and suck for more than 5 seconds) (Dwyer et al. 2005). If the lamb did not suck colostrum within an hour and a half after birth, they were assisted and either held to the teat to drink or bottle-fed colostrum. Afterward, the sex and weight of the lamb(s) were registered. The ewe and lamb(s) remained in the individual pen for 3 days before rejoining the flock. At 7 days postpartum, lambs were weighed again.

**Blood samples and behaviour measurement**

During the peripartum period (from 4 weeks before lambing to 4 weeks after), ewes were weighed once weekly, immediately before concentrate supplement was offered. Blood samples were collected from the jugular vein before each weighing, into BD Vacutainer® tubes without anticoagulant for serum collection and with anticoagulant and an inhibitor of glycolysis (sodium fluoride) for plasma collection for subsequent glucose analysis. After collection, blood samples were centrifuged at 3000 rpm for 15 minutes, and then serum and plasma samples were stored in 1.5 mL microtubes at −20°C until analysed. An automated chemistry analyser (Cobos JOURNAL OF APPLIED ANIMAL RESEARCH 721) was used to measure the concentration of metabolites
(P = .764), total protein concentration: 7.22 ± 0.24 and 7.26 ± 0.26 g/dL (P = .89) and albumin concentration: 57.37 ± 0.95 and 57.19 ± 1.02 g/L (P = .63), respectively. In both groups, NEFA concentration was higher prepartum than postpartum (17.83 ± 0.81 and 9.2 ± 0.35 mg/dL, respectively, P < .001) and glucose concentration was lower (48.92 ± 0.72 and 66 ± 0.81 mg/dL, respectively, P < .001). During peripartum, glucose was negatively correlated to NEFA (R = −0.47, P < .001).

**Effect of diet on lambs**

The effect of diet and birth type (single or twin) on the lamb's behaviour is shown in Table 1. Six lambs from the MG reached the udder but were unable to suckle without assistance. In the SG, two lambs required assistance. Latency to first suck for female lambs was 39.3 ± 10.1 minutes and for male lambs was 38.5 ± 10.4 minutes (P > .05).

The effect of diet of the ewe on body weight of the lamb is shown in Table 2. The single birth lambs weighed more (3631 ± 128.2 g) than twin birth lambs (3011 ± 79.0 g) (P < .001), and this difference continued at 1 week after birth (5303 ± 206.0 g and 4130 ± 120.1 g, respectively). Females weighed 2973.4 ± 580.3 g and the males weighed 3057.7 ± 1019.7 g (P > .05).

Independently of the ewe’s diet, the lamb’s weight at birth was negatively correlated to the time for the lamb to suck...
metabolic status of both groups was similar during pregnancy. energy demands are increased but feed intake cannot compensate offered, there was no effect of feed supplementation

- Studies have shown that concentrate supplementation does not change sward or forage consumption (Kenyon et al. 2010, Kerslake et al. 2010, Joy et al. 2014).

- Despite the significant difference of the amount of concentrates offered, there was no effect of feed supplementation on body reserve mobilization. During the peripartum period, energy demands are increased but feed intake cannot compensate with the increased demand and therefore body reserves need to be mobilized (Bell 1995, Duehlmeier et al. 2011). The metabolic status of both groups was similar during pregnancy.

Discussion

The present study investigated the effect of high-level concentrate supplementation during peripartum on ewes and their lambs. Increased supplementation did not affect metabolic stress during peripartum of the ewe, but it did improve lamb vigour at birth.

The SG ewes had higher body weight 1 week before lambing to 4 weeks postpartum. Body weight and metabolites are affected by maintenance energy requirement, feed intake, efficiency of energy and protein utilization and body composition that vary due to physiological state (González-García et al. 2014). In this study, both diets had similar ingredients and were designed to cover the ewes’ energy demands, but the SG ewes received a larger amount of concentrates. Unfortunately, food intake was not recorded, but the higher body weight of the SG ewes is probably due to higher protein intake of supplemented concentrates (Radunz et al. 2011). Studies have shown that concentrate supplementation does not change sward or forage consumption (Kenyon et al. 2010, Kerslake et al. 2010, Joy et al. 2014).

Table 1. The effect of MG or SG diet during pregnancy on neonatal lamb behaviour.

| From birth to standing (min) | MG ± SEM | SG ± SEM | P-value | Diet | Birth | Diet × Birth |
|-----------------------------|----------|----------|---------|------|-------|--------------|
| From birth to udder (min)   | 25.0 ± 2.0 | 24.0 ± 2.2 | ns      | ns   | ns    | ns           |
| Single birth                | 30.6 ± 3.8 | 33.0 ± 4.1 | ns      | ns   | ns    | ns           |
| Twin birth                  | 22.6 ± 2.6 | 24.5 ± 2.6 | ns      | ns   | ns    | ns           |
| From birth to sucking (min) | 41.0 ± 2.4 | 31.0 ± 2.3 | 0.005   | ns   | ns    | ns           |
| Single birth                | 39.3 ± 4.0 | 27.4 ± 4.0 | ns      | ns   | ns    | ns           |
| Twin birth                  | 41.8 ± 3.1 | 32.8 ± 2.8 | ns      | ns   | ns    | ns           |

Before lambing, serum NEFA concentration was high and glucose concentration was low compared with the lactation period in both groups. This is probably due to placental hormones that induce insulin resistance to increase the nutrients available to the placenta and foetal metabolism (Harding 2001). After birth, metabolic requirements change with the onset of lactation (Bell 1995). Glucose is the main source of energy for foetal metabolism and growth. A decrease in blood glucose concentrations leads to lipid mobilization, which is reflected by high concentration of NEFA, which are mobilized in the liver as an alternate energy source (Chilliard et al. 2000, Duehlmeier et al. 2011). Therefore, the negative correlation between glucose and NEFA found in the present study is expected. A similar relationship between glucose and NEFA levels in peripartum sheep was also found by Balikci et al. (2007). In goats with restricted or non-restricted nutrient requirements, low glucose and high NEFA concentrations were found before parturition rather than postpartum (Celi et al. 2008). In dairy cows, the energy demand is greater postpartum, and both glucose and NEFA are higher then, presumably due to the high levels of milk production (Pedernera et al. 2008). In our study, total protein and albumin levels were similar in both groups during peripartum. A similar result was reported in ewes in a similar physiological state (Piccione et al. 2009). The present results indicate that a high-level concentrate supplementation during peripartum in well-fed ewes is not necessary to improve energy balance.

High concentrate supplementation during peripartum does affect lamb vigour. Lambs’ latency to stand and search for the udder was not affected by diet, but latency to first suckling was shorter in SG lambs. A similar finding has been described in other sheep breeds (Dwyer 2003). Commencement of suckling could take more time because MG lambs tend to fall more times compared to SG lambs. Postpartum SG ewes moved and cleaned their lambs more frequently, and depending on their maternal experience this can enhance lamb activity (Dwyer 2008). Lamb strength is influenced by nutritional reserves at birth (amount of brown adipose tissue) and locomotor ability. Brown adipose tissue supplies the lamb with energy for thermoregulation and nutrition from birth until colostrum is consumed (Symonds et al. 2010). Development of the lamb’s central nervous system, and therefore locomotor activity, might be affected by the ewe’s nutrition during gestation (Alamy and Bengelloun 2012). It has been shown that supplementing pregnant ewes with different sources of fatty acids reduces the latency to suckle (Capper et al. 2006). A delay in consuming colostrum can increase the morbidity and mortality of lambs, especially in extensive systems where they cannot be assisted. In the present study, eight lambs (six from MG and two from SG) were unable to nurse colostrum by themselves within 1.5 hours. Without assistance, the lambs might have died from inanition and hypothermia (Dwyer 2008).

Table 2. The effect of MG or SG diet during pregnancy on neonatal lamb body weight.

| Body weight at birth (g) | MG ± SEM | SG ± SEM | P-value | Diet | Birth | Diet × Birth |
|--------------------------|----------|----------|---------|------|-------|--------------|
| Single birth             | 3111 ± 93.2 | 3259 ± 97.3 | ns      | <0.001 | ns    | ns           |
| Twin birth               | 3473 ± 176.8 | 3803 ± 186.3 | <0.001 | ns   | ns    | ns           |
| Body weight at 7 days of age (g) | 4358 ± 143.3 | 4504 ± 150.3 | ns      | <0.001 | ns    | ns           |
| Single birth             | 5074 ± 291.0 | 5555 ± 291.0 | ns      | ns   | ns    | ns           |
| Twin birth               | 4114 ± 164.6 | 4147 ± 175.5 | ns      | ns   | ns    | ns           |
| Daily body weight gain (g) | 178.7 ± 13.1 | 190.7 ± 18.9 | ns      | <0.001 | ns    | ns           |
| Single birth             | 246.4 ± 26.6 | 263.8 ± 26.6 | ns      | ns   | ns    | ns           |
| Twin birth               | 155.7 ± 15.1 | 165.8 ± 16.0 | ns      | ns   | ns    | ns           |

Independent of feeding regime, this study showed that the time to first suckle was related to lamb weight at birth, smaller lambs took longer to start suckling than larger lambs in both nutritional groups. Other studies have also found that lambs with higher body weight at birth can stand up and suckle before lambs with lower weights (Dwyer 2003, González-Stagnaro 2012). Larger lambs have better metabolic and
endocrine metabolism and this is reflected in the vigour of the lamb at birth (Greenwood et al. 2002). Regardless of the way the mother was supplemented, the lambs’ body weight was similar in both groups, but, as expected, twins had lower body weight than the single lambs.

Conclusions

In this study, we found that high concentrate supplementation in pregnant ewes is not necessary to improve the energy balance during peripartum, if appropriate nutrition is provided. However, it reduced the latency of lambs from birth to first suckle, which may lower the risk of mortality from starvation and hypothermia in the extensive system.

Acknowledgements

The authors would like to thank Dr Sara C. García-Jimenez for the support in the analysis of blood samples in the Pharmacy Faculty, and W. Fulkerson and G. Suárez for their contributions to improve this article.

Funding

This project was financially supported by PRODEP, SEP, México.

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