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Metabolic and endocrine profiles and hepatic gene expression in periparturient, grazing primiparous beef cows with different body reserves

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ABSTRACT

The objective was to determine effects of prepartum BCS on metabolic/endocrine profiles and hepatic gene expression and their associations with cow and calf performance in grazing suckled-primiparous beef cows from −49 to 49 days postpartum (DPP). Twenty crossbred cows selected according to expected calving date, were classified at −35 DPP into thin (BCS < 4.5) or moderate (BCS ≥ 4.5) BCS groups and blocked by calving date. Blood samples were obtained weekly for metabolite and hormone analyses and liver biopsies were collected at −11, 7, 31, and 49 DPP. Cow BW and BCS were greater in moderate than thin cows throughout the period. Estimated energy intake was greater in moderate than thin cows Moderate BCS cows produced more milk than thin cows at 35 DPP and calves from moderate BCS cows had greater BW and average daily gain than calves from thin cows. Serum leptin tended to be greater while adiponectin was less in moderate than thin BCS cows. Overall serum insulin was less in moderate than thin cows while serum IGF-I during the prepartum was greater in moderate than thin BCS cows. Growth hormone receptor (*GHR*) mRNA was 2-fold greater at −11 DPP while *GHR1A* and *IGF1* mRNA were 2.5-fold less at 49 DPP in moderate than thin BCS cows. The I*GFBP2* mRNA decreased in moderate but increased in thin BCS cows from −11 to 49 DPP. These results were associated with changes in body reserves during prepartum and may indicate that prepartum differences in BCS lost can affect nutrient partitioning towards the mammary gland, and subsequent milk production and calf weight.

1. Introduction

The adaptability of ruminants to periods of nutritional restriction depends on the capacity of their endocrine and metabolic mechanisms to maintain homeostasis (Chilliard et al., 1998). Rangeland cows that calve in winter or early spring experience moderate to severe nutritional restrictions during the last months of gestation due to the reduced quantity and quality of pastures which decreases energy intake and increases the energy costs of grazing (Soca et al., 2013). This determines the onset of a prepartum negative energy balance and loss of BCS (Quintans et al., 2010) to help meet the greater energy demands of the developing fetus and mammary gland (Bell, 1995). Greater pre and postpartum body reserves BCS increased milk yield and calf performance in grazing conditions (Quintans et al., 2010)

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and increased the overall profits from cow–calf operations. In contrast, in primiparous beef cows grazing grasslands, a small difference in BCS at calving (3.5 vs. 4.0, scale 1–8) increased probability of cyclicity and early pregnancy (0.2 to 0.7 of probability) when cows maintained BCS during the postpartum but it did not affect calf weaning weight (Soca et al., 2013).

Adaptive mechanisms during periods of dietary restriction and/or negative energy balance include increased blood concentrations of GH, which in turn stimulates a state of insulin resistance in the peripheral tissues that increases fat mobilization (increased NEFA) and redirects nutrients – especially glucose – to the fetus and/or milk production (Bell, 1995; Bauman, 2000). This increased GH is accompanied by reduced insulin concentrations, which are believed to be part of the consequence of uncoupling of the GH–IGF axis, and the reduced IGF-I concentrations (Lucy, 2008). Reduced IGF-I concentrations in dairy cows during early lactation are associated with reduced expression of the liver-specific GH receptor-1A (*GHR1A*), *IGF1* and *IGFBP3* mRNA expression (Kobayashi et al., 1999; Loor et al., 2005; Carriquiry et al., 2009). However, in beef cows, hepatic expression of *GHR1A* and *IGF1* mRNA did not change after calving in ad libitum-fed (Jiang et al., 2005) or grazing (Schneider et al., 2010) cows, indicating that this mechanism could be related to the genetic potential for milk production.

Leptin and adiponectin, two of the best-characterized adipokines, are signals from adipose tissue that regulate metabolic, endocrine and behavioral adaptations to changes in energy balance and alter energy intake and expenditure, carbohydrate and lipid metabolism, and insulin sensitivity/resistance (Chilliard et al., 2005; Guerre-Millo, 2008; Galic et al., 2010). However, leptin concentrations increased while adiponectin concentrations decreased with increased adiposity (Chilliard et al., 2005; Guerre-Millo, 2008; Galic et al., 2010). While circulating leptin concentrations decreased from pre to postpartum in dairy cows (Meikle et al., 2004; Thorn et al., 2008), leptin concentrations they have been reported to be less (Gentry et al., 2002) or unchanged (Strauch et al., 2003) in pregnant vs. lactating beef cows. Thorn et al. (2008) reported greater hepatic mRNA expression of both short and long isoforms of leptin receptor in early postpartum than in the prepartum period in dairy cows, which was associated with reduced plasma insulin and leptin and with increased plasma growth hormone. Few reports of bovine plasma adiponectin profiles are available but adiponectin concentrations increased during the first month postpartum in dairy cows (Ohtani et al., 2012).

Beef cows with different BCS have distinctive productive and reproductive performances (Lake et al., 2006; Soca et al., 2013). Lake et al. (2006) reported elevated GH and reduced IGF-I concentrations in serum from postpartum beef cows managed nutritionally during gestation to achieve a low rather than a high BCS (4 vs. 6 on a 1 to 9 unit scale) at calving. However, it appears that there are no reports of simultaneous insulin, IGF-I, leptin and adiponectin profiles and/or changes in hepatic gene expression during the peripartum of beef cows calving with moderate vs. thin BCS. Improved better understanding of the mechanisms that regulate nutrient partitioning could help improve nutritional management of the beef cow.

We hypothesized that the differential energy reserves at calving in terms of BCS (moderate vs. thin BCS) in primiparous grazing beef cows will be reflected in a distinct nutritional partitioning (in terms of metabolic and endocrine profiles and hepatic gene expression) which may explain differences in their productive responses (milk production and calf performance). The objectives of this study were to determine (1) relationships among metabolic and endocrine profiles and hepatic expression of genes associated with the somatotropic axis and the full-length leptin receptor (*LEPR-b*) and (2) associations among these components with changes in BCS, milk production, and calf performance in grazing, suckled, primiparous beef cows during the peripartum period.

2. Materials and methods

The experiment was carried out at Palo a Pique Experimental Unit of the Instituto Nacional de Investigación Agropecuaria (Treinta y Tres, Uruguay; 33°S, 56°W) from May to November 2007. Animal procedures were approved by the Animal Experimentation Committee of Universidad de la Republica (UdelaR, Montevideo, Uruguay).

2.1. Animals and experimental design

Twenty primiparous crossbred Aberdeen Angus x Hereford cows (449 ± 6.5 kg of BW and 30 ± 1.8 month of age) were selected from a group ($n=64$; managed together as a contemporary group since the breeding period in November 2006 and with a similar BCS in May 2007) according to expected calving date (all expected calvings were within a 28 ± 3 days period) for the study. Cows were classified at -35 days postpartum (DPP) according to BCS (scale from 1.0 (very thin) to 8.0 units (very obese); Soca et al., 2013) into thin (BCS < 4.5; 4.2 ± 0.05) or moderate (BCS ≥ 4.5; 4.8 ± 0.05) BCS groups and blocked by calving date. A BCS of 4.5 has been reported as the critical BCS at calving because subsequent reproductive performance of primiparous cows is reduced if their BCS at calving is < 4.5 (Soca et al., 2013). Differences in BCS were not due to dietary treatments, because all 20 cows were managed together in the same pasture. All cows and calves were from the same herd (similar genetic background) and in a good sanitary status from the beginning of the study.

During the study (pre and postpartum periods), cows grazed together in the herd of 64 cows a native pasture paddock (60 ha) with good access to water. Available forage mass was determined by cutting squares (0.3×0.3 m, $n=60$; every 28 ± 3 days from -49 to 49 ± 9 DPP). Forage provided 453 ± 34 kg dry matter (DM)/ha with 132 ± 19 g of crude protein (CP) and 244 ± 6 g of acid detergent fiber (ADF) per kg DM during the prepartum (-49 to 0 ± 9 DPP) and 552 ± 86 kg DM with 144 ± 7 g of CP and 251 ± 1 g of ADF per kg DM during the postpartum (0 to 49 ± 9 DPP) periods. Due to low forage mass available during the early postpartum period (from 17 to 28 ± 9 DPP), all cows were offered an additional 4.7 kg DM/cow/day of pasture hay (137 g/kg DM of CP and 300 g/kg DM of ADF) during 12 days. Calves were managed with their dams and did not receive any supplementation during the study.