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ScienceDirect
Theriogenology 72 (2009) 1202–1214
Theriogenology
www.theriojournal.com

Influences of diet during gestation on potential postpartum reproductive performance and milk production of beef heifers

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Received 1 May 2009; received in revised form 25 June 2009; accepted 5 July 2009

Abstract

The influences of nutritional protein and energy during early and mid pregnancy on milk production and postpartum reproductive parameters were determined in 70 beef heifers of two composite breeds (*Bos indicus X Bos taurus*). At artificial insemination (AI), heifers were divided into four dietary treatment groups identified by the level of protein, and to a lesser extent energy, fed during the first and second trimesters: high/high (HH), high/low (HL), low/high (LH), and low/low (LL). Milk production was lower in the heifers receiving high treatment in first trimester than that in heifers receiving the low treatment (P = 0.01). Milk production was negatively associated with dam body condition score (BCS; P = 0.01), nonesterified fatty acids (P = 0.001), and leptin (P = 0.02) and positively associated with urea ($P < 0.001$) concentrations during lactation. Increased dietary protein in the first trimester increased or decreased concentrations of colostral protein dependent upon genotype (P = 0.03). Colostral protein was positively associated with bovine pregnancy associated glycoprotein from late gestation (P = 0.007). Milk fat was negatively associated with BCS (P = 0.007) and influenced by genotype (P = 0.003). Dietary treatment did not affect the postpartum reproductive performance of beef heifers. Gestation length ($P < 0.001$) and the postpartum interval to first estrus (PPI; P = 0.02) were positively associated with calf size. Placental size was negatively associated with placental expulsion time ($P < 0.01$). Prepartum BCS of the heifers was negatively associated with PPI (P = 0.01). Overall, high levels of nutrition during early gestation are detrimental to milk production in beef heifers.

Keywords: Beef heifer; Gestation length; Milk; Placenta expulsion; Postpartum estrus

1. Introduction

For optimal beef breeder production, a calving interval of 1 yr must be maintained; thus, the resumption of estrus after parturition needs to occur within 80 to 85 d from parturition. Calving interval comprises both gestation length and postpartum interval to conception, which in turn is largely related to the postpartum interval to first estrus (PPI). The duration of PPI is affected primarily by the degree of calf suckling (which is influenced by milk yield [1] and calf size [2]), parity, level of maternal nutrient intake, genetic variation [3], and retained fetal membranes (RFMs) [4]. Restricted prepartum nutrient intake is detrimental to the PPI length in heifers [5].

The limiting factor controlling PPI is the delay in luteinizing hormone (LH) secretion after calving and ovulation of the dominant follicle [1]. Resumption of LH pulsatility is affected by body condition score (BCS), placental steroid hormones, metabolic hormones, urea and nonesterified fatty acids (NEFAs) levels [6–8] all of which are susceptible to reduced prepartum nutrient intake [4,9–13]. Delays in placental expulsion postpartum are also associated with an increased duration of PPI [14] and are attributed to

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0093-691X/$ – see front matter
doi:10.1016/j.theriogenology.2009.07.016

failures of placenta loosening and uterine contractility associated with reductions in estrone sulfate (ES) and elevations of progesterone (P4) [15].

Milk yield affects the profit potential of the beef breeder enterprise via increased meat yields from heavier calves at weaning [16]. Differences in beef cow milk yield are attributed to genetics [17] and environment. Increased placental lactogen (PL) secretion stimulates increased milk production [18] associated with increased mammary gland weight [19]. In ruminants, leptin helps to maintain lactation [20]; however, lactation itself, induces a negative energy balance, such that plasma leptin levels are lower in higher milk producing cows [12]. Reports on the effects of nutrition on milk production in the beef cow are contradictory. Concentrations of bovine PL (bPL), bovine pregnancy associated glycoprotein (bPAG) and leptin are influenced by prepartum nutrition [21,22]. Improved cow condition, as indicated by weight-to-height ratio, is related to decreased milk production [23], yet improved prepartum nutrition [24] and subsequently increased BCS [25] has no effect on milk production. Conversely, beef cows fed increased levels of prepartum energy [11] and protein [26] had increased milk yields. Milk fat percentage is positively correlated with decreasing energy deficit [27]. Factors that influence the protein composition of milk are similar to those that affect milk production and include breed and nutrition [28,29].

There have been few studies on the impact of maternal prepartum nutrition on postpartum reproduction or milk production in beef heifers, particularly where the level of dietary protein has been altered. In northern Australia rangeland pastures, during the gestation period of the cow, protein is often deficient [30] with the majority of replacement beef heifers requiring protein supplementation [31]. Therefore, we tested the hypothesis that, in heifers, prepartum dietary treatment would affect gestation length, PPI, placental expulsion time, body reserves, and the volume, fat, and protein content of milk produced. We also investigated the known relationships between these parameters and their associations with genotype, calf size, placenta size, BCS, and concentrations of metabolites and metabolic and placental hormones.

2. Materials and methods

2.1. Animals, management, and treatments

The project was approved by The University of Queensland Animal Ethics Committee (Approval No. SVS/716/06/MLA/AACo). One hundred twenty beef heifers (*Bos indicus X Bos taurus*) were held on a feedlot in southwest Queensland, Australia (28°52′S, 150°33′E). The heifers were of two composite crosses (BeefX and CBX) in equilibrium and differed in genotype by 12.5%. With respect to genotype, 35% of the heifers were BeefX (Senepol, 1/4 Brahman, 1/8 Charolais, 1/8 Red Angus) and 65% were CBX (Senepol, 1/4 Brahman, 1/4 Charolais). Heifers were individually stall fed throughout gestation and acclimatized for 45 d to the new environment and management practices. Heifers were divided into treatment groups at artificial insemination (AI; Day 1) according to stratification by body weight and genotype. The 23-mo-old heifers (range, 21.6 to 24.6 mo) were synchronized for AI using a 10-d progesterone-based estrus synchronization program. Progesterone-releasing devices (Eazi-breed CIDR Cattle Device, 1.9 g intravaginal; Pfizer Animal Health, West Ryde, New South Wales, Australia) and estradiol benzoate (Ciderol, 1 mg im; Genetics Australia, Bacchus Marsh, Victoria, Australia) were administered on Day –12 followed by prostaglandin (Lutalyse, 25 mg im; Pfizer Animal Health) on Day –5. Intravaginal devices were removed on Day –2, and heifers were mass artificially inseminated with semen from 1 Senepol bull on Day 0 and again on Day 1 for any heifers still showing signs of estrus (n = 6).

The four treatment groups determined the levels of protein and energy fed to each heifer for first and second trimesters of gestation i.e. high/high (HH = higher levels of protein and energy for first and second trimesters), high/low (HL = higher levels of protein and energy for first trimester and lower levels of protein and energy for second trimester), low/high (LH = lower levels of protein and energy for first trimester and higher levels of protein and energy for second trimester), and low/low (LL = lower levels of protein and energy for first and second trimesters). First trimester was defined as Day 1 to Day 92 and second trimester from Day 93 to Day 179. For third trimester (Day 180 to parturition), all heifers were fed at the same level of protein. Details on composition of rations and timing of ration changes are presented in Table 1. Of the 120 heifers, two were removed for temperament-related problems, 41 because they were found to be not pregnant at Day 39 and 6 because they aborted. This left a total of 71 heifers distributed across treatment groups at calving as follows: HH = 16, HL = 19, LH = 17, and LL = 19.

Feed rations consisted of cotton seed meal (*Gossypium* spp.), cracked sorghum seed (*Sorghum* spp.), Bambatsi hay (*Panicum coloratum*), or barley straw (*Hordeum* spp.) and a vitamin and mineral premix. The premix contained 17 g calcium, 9 g phosphorous, 2.91 g