Effects of Body Condition and Bovine Somatotropin on Endocrine and Follicular Dynamics of Postpartum Brahman-influenced Cows


Introduction

Growth hormone (GH) may serve as an endocrine mediator of nutritional status on reproduction (Hess et al., 2005) through direct or indirect mechanisms. A direct effect of GH is possible because the GH receptor is located within large cells of the corpus luteum of ruminants (Yuan and Lucy, 1996). An indirect effect of GH on ovarian function is through insulin-like growth factor-I (IGF-I) secretion (Lucy et al., 1999) that stimulates ovarian development (Armstrong and Benoit, 1996). Nutrient restriction uncouples the positive relationship of the GH-IGF-I axis with increased concentrations of GH and reduced IGF-I (Butler et al., 2003). Britt (1992) estimated 60 to 80 d for a bovine follicle to grow from the early pre-antral stage to the mature stage ready for ovulation. Thus, alterations of endocrine function affecting follicular development in cows would begin several weeks prior to ovulation. Effects of body condition score (BCS) and bovine somatotropin (bST) on ovarian and endocrine function in beef cattle remains to be elucidated. Objectives were to evaluate the effects of body condition (BC) and bST on number of small and large follicles, diameter of the largest follicle, and concentrations of growth hormone (GH), insulin-like growth factor-I (IGF-I), triiodothyronine (T$_3$), thyroxine (T$_4$), and prolactin in postpartum Brahman-influenced cows.

Experimental Procedures

Spring-calving crossbred (1/4 to 3/8) multiparous Brahman-influenced cows were managed to achieve low or moderate BC at parturition. Cows grazed stockpiled and spring-growth, endophyte-infected tall fescue (Festuca arundinacea Schreb.) pastures to obtain desired BC at a stocking rate of either 1 cow/0.8 acres (low BC) or 1 cow/2 acres (moderate BC) for approximately 162 d prior to initiation of treatment. Mean BCS of low (n = 50; mean BW = 931.0 ± 34.8 lb) and moderate (n = 49; mean BW = 1,168.9 ± 35.3 lb) BC cows was 4.3 ± 0.1 and 6.1 ± 0.1 (1 = emaciated to 9 = obese), respectively.

Beginning 32 ± 2 d postpartum, cows within each BC were randomly assigned to treatment with or without bST in a 2 x 2 factorial arrangement. Control cows received no treatment, and treated cows were administered bST (500 mg, s.c.; Posilac, St. Louis, Mo.) on d -35, -21, and -7. On d -7, all cows received a controlled internal drug-releasing (CIDR, 1.38 g of progesterone [P$_4$]; Pharmacia & Upjohn Co., Kalamazoo, Mich.) device. On d 0 (start of 70-d breeding season), CIDR were removed, and all cows received prostaglandin F$_{2α}$ (PGF$_{2α}$) 25 mg, i.m.; Lutalyse, Pharmacia & Upjohn Co., Kalamazoo, Mich.). Calves were maintained with cows at all times.

Ultrasonography (Aloka SSD 500 V ultrasound scanner equipped with a 7.5 MHz linear array transrectal transducer; Aloka Co. Ltd., Wallingford, Conn.) was performed on d 1 after CIDR removal and PGF$_{2α}$ to determine number of small (2 to 9 mm) and large (>10 mm) follicles and diameter of the largest follicle. Blood samples were obtained from cows at bST treatment (d -35, -21, and -7) and d -28 and 0. Serum concentrations of hormones were determined in duplicate aliquots using radioimmunoassay procedures. Serum samples, collected on d -35, -28, and -21, were analyzed for concentrations of P$_4$ to determine the percentage of anestrous cows at the initiation of treatment. Cows were classified as either cyclic (concentrations of P$_4$ ≥ 1 ng/mL in 2 consecutive weekly blood samples) or anestrous (concentrations of P$_4$ < 1 ng/mL in 2 consecutive weekly blood samples).

Story in Brief

Influence of body condition (BC) and bovine somatotropin (bST) on number of follicles, diameter of largest follicle, and concentrations of growth hormone (GH), insulin-like growth factor-I (IGF-I), triiodothyronine (T$_3$), thyroxine, and prolactin were examined in postpartum Brahman-influenced cows. Cows (n = 99) were managed for low (BCS = 4.3 ± 0.1) or moderate (BCS = 6.1 ± 0.1) BC at parturition and treated with bST every 2 wk for 6 wk beginning at 35 d prior to breeding (d 0) or no bST (control). Blood was collected on d -35, -28, -21, -7, and 0. Cows received a controlled internal drug releasing (CIDR) device on d -7. On d 0, CIDR were removed, and cows received prostaglandin F$_{2α}$ (PGF$_{2α}$). Ultrasound was performed on d 1 to determine diameter of largest follicle. Cows treated with bST had increased (P < 0.05) GH on d -28, -21, -7, and 0. Cows treated with bST in low BC had increased (P < 0.05) IGF-I vs. control-low BC cows on d -28, -21, -7, and 0. Prolactin and T$_3$ were greater (P < 0.05) in moderate BC vs. low BC cows. Diameter of largest follicle was correlated with IGF-I (r ≥ 0.18; P ≤ 0.08), T$_3$ (r ≥ 0.17, P ≤ 0.10), and prolactin (r ≥ 0.20, P ≤ 0.05). Somatotropin increased IGF-I in low BC cows, and IGF-I was correlated with diameter of the largest follicle. Endocrine influences on follicular dynamics may be mediated by BC, GH, and (or) IGF-I.

1 Names are necessary to report factually on available data; however, the USDA does not guarantee or warrant the standard of the product, and the use of the name by the USDA implies no approval of the product to the exclusion of others that may be suitable. This work was supported in part by USDA, Agricultural Research Service cooperative agreement #58-6227-8-040.

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Results and Discussion

Eighty-eight percent (87/99) of cows were anestrous at the initiation of bST treatment. Number of small and large follicles 1 d following CIDR removal and PGF$_{2\alpha}$ was not influenced (P > 0.10) by treatment and (or) BC. Diameter of the largest follicle 1 d following CIDR-PGF$_{2\alpha}$ was influenced (P = 0.06) by a treatment x BC interaction. Diameter of the largest follicle was greater for control-moderate BC (17.5 ± 1.0 mm), bST-moderate BC (17.0 ± 1.0 mm), and bST-low BC (16.2 ± 1.0 mm) cows vs. control-low BC (13.0 ± 1.0 mm) cows. Our observations agree with Lucy (2000) that treatment with GH influences ovarian follicular development.

Serum concentrations of GH were influenced (P = 0.01) by a treatment x BC x day interaction (Fig. 1A). Following bST treatment, low and moderate BC cows had increased concentrations of GH with bST-low BC cows having greater concentrations of GH than bST-moderate BC cows. Administration of bST increases concentrations of GH in beef cattle (Bilby et al., 1999).

Serum concentrations of IGF-I were influenced (P = 0.001) by a treatment x BC x day interaction (Fig. 1B). On d -28, -21, -7, and 0, bST-moderate BC cows had greater concentrations of IGF-I compared with bST-low BC, control-moderate BC, and control-low BC cows. However, bST-low BC cows had greater concentrations of IGF-I than control-low BC cows on d -28, -21, -7, and 0, indicating the GH/IGF axis may have been re-coupled in low BC cows treated with bST. Recently, Lake et al. (2006) reported that beef cows with a BCS of 4 at parturition had increased GH and decreased IGF-I during early lactation compared with cows with a BCS of 6, suggesting that regulation of IGF by GH may have been uncoupled in thin cows. In the present study, treatment of low BC cows with bST prior to initiation of the breeding season increased concentrations of IGF-I, suggesting that regulation of IGF-I synthesis by GH may be influenced by bST administration in thin beef cows.

Serum concentrations of IGF-I at d -28 (r = 0.18; P = 0.08), -7 (r = 0.22; P = 0.03), and 0 (r = 0.19; P = 0.07) were positively correlated with the diameter of the largest follicle 1 d following CIDR-PGF$_{2\alpha}$. This may further explain why the diameter of the largest follicle of bST-low BC cows was similar to the diameter of the largest follicle of control-moderate BC and bST-moderate BC cows.

Serum concentrations of T$_3$ were influenced by a BC x day interaction (P = 0.001; Fig. 1C). On all sample dates, moderate BC cows had greater concentrations of T$_3$ compared with low BC cows. Serum concentrations of T$_4$ were influenced by a treatment x day (P = 0.001; Fig. 1D) and BC x day (P = 0.001; Fig. 1E) interaction. On d -28 and 0, bST-treated cows had increased concentrations of T$_3$ vs. control cows. Concentrations of T$_4$ were greater in moderate BC cows on d -28, -21, -7, and 0 vs. low BC cows. Direct effects of thyroid hormones on ovarian function are unclear. Spicer et al. (2001) reported direct stimulatory effects of T$_3$ and T$_4$ on thecal cell steroidogenesis which may result in increased estrogen production by the follicle. In the present study, concentrations of T$_3$ on d -35 (r = 0.24; P = 0.02), -28 (r = 0.18; P = 0.09), -21 (r = 0.25; P = 0.01), -7 (r = 0.17; P = 0.10), and 0 (r = 0.23; P = 0.03) were positively correlated with diameter of the largest follicle 1 d following CIDR-PGF$_{2\alpha}$. Prolactin is important for the maintenance and secretory activity of the corpus luteum in rodents (Freeman et al., 2000); less is known of prolactin effects on follicular dynamics in beef cattle. To our knowledge, this is the first report describing relationships among concentrations of prolactin prior to breeding and diameter of the largest follicle following CIDR-PGF$_{2\alpha}$ in beef cattle.

Implications

Increased concentrations of GH and IGF-I of thin cows suggest the nutritional and endocrine status prior to breeding may be influenced by treatment with bST. The positive relationships among IGF-I, T$_3$, and prolactin, and diameter of the largest follicle may be components of the complex hormonal milieu mediating nutritional effects on ovarian function in cattle.

Literature Cited

Fig. 1. Serum concentrations of growth hormone (GH), insulin-like growth factor-I (IGF-I), triiodothyronine (T$_3$), thyroxine (T$_4$), and prolactin of low (BCS = 4.2 ± 0.1) and moderate (BCS = 6.1 ± 0.1) body condition (BC) Brahman-influenced cows treated with or without bovine somatotropin (bST). Cows were control (no bST) or treated with bST every 2 wk for 6 wk prior to the initiation of the breeding season (d 0). Serum was collected at bST treatment (d -35, -21, and -7) and on d -28 and 0.

Means without common superscripts differ (P < 0.05).