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Effects of bovine somatotropin administration on growth, physiological, and reproductive responses of replacement beef heifers¹

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ABSTRACT: This experiment compared growth, body composition, plasma IGF-I and leptin, and reproductive development of beef heifers receiving or not recombinant bovine ST (BST) beginning after weaning until the first breeding season. Fifty Angus × Hereford heifers (initial BW = 219 ± 2 kg; initial age = 208 ± 2 d), weaned at approximately 6 mo of age, were assigned to the experiment (d 0 to 210). On d 0, heifers were ranked by initial BW and age and assigned to 1) treatment with BST or 2) saline control. Heifers assigned to the BST treatment received subcutaneous (s.c.) injections containing 250 mg of somatotropin zinc whereas control heifers received a 5-mL s.c. injection of 0.9% saline every 14 d. Treatments were initiated on d 14 and last administered on d 196. Heifers were maintained on separate pastures harvested for hay the previous summer according to treatment and received grass and alfalfa hay at a rate to provide a daily amount of 7.0 and 1.0 kg of DM per heifer, respectively. Heifer shrunk BW was collected on d 1 and 211 for heifer ADG calculation. Blood samples were collected weekly from d 0 to 210 for determination of plasma progesterone to estimate puberty attainment as well as plasma concentrations of IGF-I and leptin in selected

samples. On d 0, 63, 133, and 189, heifers were evaluated for intramuscular marbling, LM depth, and backfat thickness via real-time ultrasonography. No treatment effects were detected ($P = 0.27$) for heifer ADG (0.49 vs. 0.51 kg/d for control and BST heifers, respectively; SEM = 0.02). Mean backfat thickness was lesser ($P < 0.01$) in BST heifers compared with control cohorts (3.56 vs. 3.92 mm, respectively; SEM = 0.08). Heifers receiving BST had greater plasma IGF-I concentrations compared with control cohorts 7 d after treatment administration (treatment × day interaction; $P < 0.01$). Mean plasma leptin concentrations were lesser ($P = 0.05$) in BST heifers compared with control cohorts (1.82 vs. 2.03 ng/mL, respectively; SEM = 0.07). Onset of puberty was hastened in BST heifers compared with control cohorts (treatment × day interaction; $P = 0.04$). In summary, a greater proportion of BST heifers reached puberty during the experiment compared with control cohorts, despite lesser plasma leptin concentrations, backfat thickness, and similar ADG. Hence, circulating IGF-I was positively associated with hastened puberty attainment independently of growth rate, circulating leptin concentrations, and body fat content of replacement beef heifers.

Key words: beef heifers, bovine somatotropin, insulin-like growth factor-I, leptin, puberty

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INTRODUCTION

Development of replacement heifers is a critical component within cow–calf production systems (Bagley, 1993). Management that maximizes the number of heifers conceiving by 15 mo of age improves cow–calf profitability because heifers that calve as 2 yr olds wean more and heavier calves

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during their productive lives (Lesmeister et al., 1973). Because conception rates are greater during the third estrus compared with the pubertal estrus (Byerley et al., 1987), replacement heifers should be managed to attain puberty at 12 mo of age so they can conceive by 15 mo of age (Bagley, 1993). Hence, recognition of traits that regulate puberty in beef heifers is essential for optimal production efficiency in cow–calf systems.

Age at puberty in heifers is greatly influenced by plane of nutrition and resultant ADG (Schillo et al., 1992). Moreover, the effects of nutritional status and body development on puberty attainment appear to be modulated, at least partially, by circulating hormones such as IGF-I and leptin (Jones et al., 1991; Garcia et al., 2002). Accordingly, feed intake is positively associated with BW gain, circulating concentrations of IGF-I and leptin (Lents et al., 2005), and hastened onset of puberty in beef females (Schillo et al., 1992). On the other hand, the specific role of each of these hormones within the puberty process still requires further investigation. One alternative to further explore this subject is the administration of bovine ST (BST) to developing heifers, which increases circulating IGF-I concentrations independently of nutrient intake (Buskirk et al., 1996) but also reduces carcass fat deposition (Dalke et al., 1992) and circulating leptin concentrations in cattle (Sauerwein et al., 2004). Based on this rationale, this experiment was conducted to compare growth, body composition, plasma concentrations of IGF-I and leptin, and reproductive development of beef heifers receiving or not receiving BST beginning after weaning until the first breeding season.

MATERIALS AND METHODS

This experiment was conducted at the Oregon State University Eastern Oregon Agricultural Research Center (Burns, OR) from October 2011 to May 2012. All animals were cared for in accordance with acceptable practices and experimental protocols reviewed and approved by the Oregon State University, Institutional Animal Care and Use Committee (number 4260).

Animals

Fifty Angus × Hereford heifers (initial BW = 219 ± 2 kg; initial age = 208 ± 2 d), weaned at approximately 6 mo of age, were assigned to the experiment (d 0 to 210). On d 0, heifers were ranked by initial BW and age and assigned to 1 of the 2 treatments: 1) treatment with BST or 2) saline control. Heifers assigned to the BST treatment were administered subcutaneous (s.c.) injections containing 250 mg of somatotribove zinc (Posilac; Elanco, Greenfield, IN) every 14 d whereas

control heifers concurrently received a 5-mL s.c. injection of 0.9% saline. Treatments were initiated on d 14 and last administered on d 196.

Diets

During the experiment, treatment groups were maintained separately in 1 of 2 meadow foxtail (*Alopecurus pratensis* L.) pastures (6 ha/pasture) harvested for hay the previous summer. Groups were rotated between pastures every 2 wk to account for potential effects of pasture on the variables evaluated herein. Heifers from both treatments received meadow foxtail and alfalfa hay daily at a rate of 7.0 and 1.0 kg of DM per heifer/d, respectively, from d 0 to 253. Throughout the experimental period, pastures had no forage available for grazing whereas both treatment groups always received and entirely consumed the same daily amount of hay. Water and a commercial mineral and vitamin mix (Cattleman's Choice; Performix Nutrition Systems, Nampa, ID) containing 14% Ca, 10% P, 16% NaCl, 1.5% Mg, 6,000 mg/kg Zn, 3,200 mg/kg Cu, 65 mg/kg I, 900 mg/kg Mn, 140 mg/kg Se, 136 IU/g of vitamin A, 13 IU/g of vitamin D₃, and 0.05 IU/g of vitamin E were offered for ad libitum consumption throughout the experiment. Hay samples were collected at the beginning of the experiment and analyzed for nutrient content by a commercial laboratory (Dairy One Forage Laboratory, Ithaca, NY) using wet chemistry procedures for concentrations of CP (method 984.13; AOAC, 2006), ADF (method 973.18 modified for use in an Ankom 200 fiber analyzer, Ankom Technology Corp., Fairport, NY; AOAC, 2006), and NDF (Van Soest et al., 1991; method for use in an Ankom 200 fiber analyzer, Ankom Technology Corp.). Calculations of TDN used the equation proposed by Bath and Marble (1989) whereas NEm and NEg were calculated with the equations proposed by the NRC (1996). Nutritive value (DM basis) of the meadow foxtail and alfalfa hay was estimated at, respectively, 59 and 64% TDN, 64 and 42% NDF, 32 and 25% ADF, 1.20 and 1.37 Mcal/kg of NEm, 0.64 and 0.82 Mcal/kg of NEg, and 5.5 and 22.6% CP.

Sampling. Heifer BW was recorded and blood samples were collected weekly from d 0 to 210. On weeks that treatments were administered, BW and blood samples were collected immediately before treatment administration. Furthermore, heifer shrunk (after 16 h of feed and water restriction) BW was collected on d 1 and 211 for calculation of heifer ADG during the study. Puberty attainment was estimated via plasma progesterone. Heifers were considered pubertal once plasma progesterone concentrations were ≥1.0 ng/mL for 2 consecutive wk (Perry et al., 1991), and puberty attainment was declared at the second week of increased progesterone. Blood samples collected on d 0 and 7,

d 56 and 63, d 126 and 133, and d 182 and 189 were also analyzed for plasma concentrations of IGF-I and leptin. On d 0, 63, 133, and 189, heifers were evaluated for intramuscular marbling, LM depth, and backfat thickness via real-time ultrasonography. Ultrasound measurements were obtained at the 12th to 13th rib interface by an experienced technician using an Aloka 500V (Aloka Co., Ltd., Wallingford, CT) B-mode instrument equipped with a 3.5-MHz, 125 mm general purpose transducer array (UST-5011U-3.5). Images were collected by a single technician with software from the Cattle Performance Enhancement Company (CPEC, Oakley, KS). Estimates of intramuscular marbling, LM depth, and backfat thickness were based on image analysis programming (Brethour, 1994) contained within the CPEC software.

On d 194, heifers from both treatments were assigned to an estrus synchronization + timed-AI protocol (CO-Synch + controlled internal progesterone-release device; Larson et al., 2006). Immediately after the PGF_{2α} injection of the protocol (d 201), heifers were combined into a single pasture and exposed to mature bulls (1:25 bull to heifer ratio) for 48 h after the PGF_{2α} injection and for 50 d beginning 12 h after AI. Heifers were inseminated by the same technician with semen from the same bull at approximately 54 h after the PGF_{2α} injection and received the second GnRH injection of the protocol concurrently with AI (Larson et al., 2006). All bulls used in this experiment were submitted to and approved by a breeding soundness evaluation (Chenoweth and Ball, 1980) before the breeding season. Estrus synchronization rate was evaluated based on plasma progesterone concentrations at timed AI (d 203) and 7 d later (d 210). Only heifers with progesterone concentrations <1.0 ng/mL on d 203 but ≥1.0 ng/mL on d 210 were classified as responsive to the estrus synchronization + timed-AI protocol. Heifer pregnancy status was verified by detecting a fetus via transrectal ultrasonography (5.0-MHz transducer; 500V; Aloka) 33 d after the end of the breeding season. Fetal age and subsequent date of conception were estimated based on the methods described by Curran et al. (1986).

Blood Analysis. Blood samples were collected via jugular venipuncture into commercial blood collection tubes (Vacutainer, 10 mL; Becton Dickinson, Franklin Lakes, NJ) containing 148 United States Pharmacopeia units of freeze-dried sodium heparin, immediately placed on ice, and centrifuged at 2,400 × g for 30 min at 4°C for plasma collection. Plasma was frozen at -80°C on the same day of collection. Concentrations of progesterone were determined according to procedure described by Munro and Stabenfeldt (1984) with modifications described by Galvão et al. (2004). Concentrations of IGF-I were determined using a human-specific

commercial ELISA kit (SG100; R&D Systems, Inc., Minneapolis, MN) with 100% cross-reactivity with bovine IGF-I, previously validated for bovine samples (Cooke et al., 2012). Concentrations of leptin were determined according to procedures described by Delavaud et al. (2000). The intra- and interassay CV were, respectively, 8.4 and 5.4% for progesterone and 5.8 and 7.7% for IGF-I. All samples were analyzed for leptin concentration within a single assay, and the intra-assay CV was 3.9%. Assay sensitivity was 0.05 ng/mL for IGF-I and progesterone and 0.10 ng/mL for leptin.

Statistical Analysis. All data were analyzed using heifer as the experimental unit and heifer(treatment) as random variable. Growth, body composition, and physiological data were analyzed using the MIXED procedure (SAS Inst., Inc., Cary, NC) and Satterthwaite approximation to determine the denominator degrees of freedom for the tests of fixed effects. The model statement used for analysis of BW gain, plasma IGF-I and leptin, and body composition contained the fixed effects of treatment, day, and the resultant interaction. Body composition and physiological data were adjusted covariately to values obtained before the first treatment administration. The specified term used in the repeated statement was day, the subject was heifer(treatment), and the covariance structure used was autoregressive, which provided the best fit for these analyses according to the Akaike information criterion. The model statement used for ADG contained the fixed effect of treatment. Reproductive data were analyzed using the GLIMMIX procedure of SAS with Satterthwaite approximation. The model statement used for puberty and pregnancy analysis contained the fixed effects of treatment, day of the study (puberty analysis) or week of estimated conception (pregnancy analysis), and the resultant interaction. The model statement used for estrus synchronization rate contained the fixed effect of treatment. Results are reported as least square means and separated using LSD. Significance was set at $P \leq 0.05$, and tendencies were determined if $P > 0.05$ and $P \leq 0.10$. Results are reported according to treatment effects if no interactions were significant or according to the greatest-order interaction detected.

RESULTS AND DISCUSSION

No treatment effects were detected ($P = 0.27$; Table 1) for heifer ADG (0.49 vs. 0.51 kg/d for control and BST heifers, respectively; SEM = 0.02). Similarly, no treatment effects were detected for heifer BW change during the study ($P = 0.70$; data not shown). Other authors reported that BST administered at doses similar or greater than used herein increased BW gain in beef heifers due to enhanced feed efficiency parameters

Table 1. Growth, body composition, plasma leptin concentrations, and reproductive performance of beef heifers receiving subcutaneous injections containing 250 mg of bovine ST (BST; sometribove zinc; $n = 25$; Posilac, Elanco, Greenfield, IN) or 5 mL of saline (0.9%; control; $n = 25$)¹

Item	BST	Control	SEM	<i>P</i> -value
Growth variables				
Initial shrunk BW (d 1), kg	207	209	2	0.53
Final shrunk BW (d 211), kg	307	304	4	0.56
ADG, ² kg/d	0.51	0.49	0.02	0.27
Body composition ³				
Backfat thickness, mm	3.56	3.92	0.08	<0.01
LM depth, mm	45.9	46.5	0.6	0.46
Marbling ⁴	456	452	3	0.14
Plasma leptin, ⁵ ng/mL	1.82	2.03	0.07	0.05
Reproductive performance ⁶				
Estrus synchronization rate, %	96	92	5	0.56
Final pregnancy rate, %	96	100	3	0.32

¹Treatments were administered every 14 d beginning on d 14 until d 196 of the experimental period (d 0 to 210).

²Calculated using shrunk BW obtained on d 1 and 211 after 16 h of feed and water deprivation.

³Evaluated via real-time ultrasonography on d 0, 63, 133, and 189 of the experiment. Ultrasound measurements were obtained at the 12th to 13th rib interface using an Aloka 500V (Aloka Co., Ltd, Wallingford, CT) B-mode instrument equipped with a 3.5-MHz, 125 mm general purpose transducer array (UST-5011U-3.5). Images were collected and processed with software from the Cattle Performance Enhancement Company (Oakley, KS) according to Brethour (1994). Least squares means adjusted covariately to values obtained on d 0.

⁴Marbling score: 300 = traces, 400 = slight, 500 = small, and 600 = modest.

⁵Evaluated from blood samples collected on d 0, 7, 56, 63, 126, 133, 182, and 189 of the experiment. Least squares means adjusted covariately to values obtained on d 0 and 7.

⁶Heifers were exposed to an estrus synchronization + timed-AI protocol on d 194 of the experiment (CO-Synch + controlled internal progesterone-release device; Larson et al., 2006) immediately followed by 50-d bull breeding. Estrus synchronization rate was evaluated based on plasma progesterone concentration obtained at AI and 7 d later. Values calculated as pregnant heifers or synchronized heifers divided by total heifers \times 100.

(Schwarz et al., 1993; Buskirk et al., 1996; Carstens et al., 1997). However, these cited studies evaluated developing heifers maintained on planes of nutrition to yield growth rates of ≥ 0.8 kg/d (Schwarz et al., 1993; Buskirk et al., 1996; Carstens et al., 1997). Supporting our findings, Hall et al. (1994) reported that ADG was similar between beef heifers limit fed to gain approximately 0.5 kg/d and receiving or not 350 mg of BST at 14-d intervals. Similarly, Buskirk et al. (1996) and Carstens et al. (1997) reported that 250 or 500 mg of BST administered at 14-d intervals, respectively, did not improve ADG in beef heifers gaining <0.8 kg/d. Hence, these studies corroborate our observations that the dose of BST used in the present experiment does not improve ADG when heifers are limit fed and managed to gain moderate amounts of BW.

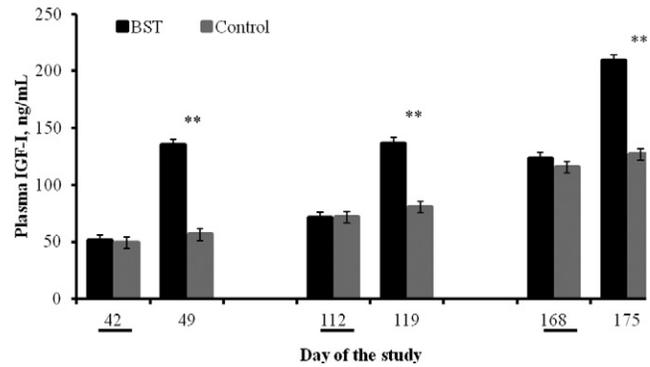


Figure 1. Plasma IGF-I concentrations (\pm SEM) of heifers receiving subcutaneous injections containing 250 mg of bovine ST (BST; sometribove zinc; $n = 25$; Posilac, Elanco, Greenfield, IN) or 5 mL of saline (0.9%; control; $n = 25$). Treatments were administered every 14 d beginning on d 14 until d 196 of the experimental period (d 0 to 210). Values obtained from samples collected on d 0 and 7 served as covariate ($P < 0.01$) but did not differ ($P = 0.35$) between BST and control heifers (50.4 vs. 48.0 ng/mL, respectively; SEM = 1.8). Therefore, results reported are covariately adjusted least squares means. A treatment \times day interaction was detected ($P < 0.01$). Days on which treatments were administered are underlined. Treatment comparison within time: ** $P < 0.01$.

A treatment effect was detected ($P < 0.01$) for backfat thickness but not ($P \geq 0.14$) for LM depth and intramuscular marbling (Table 1). All body composition measurements obtained on d 0 were significant covariates ($P < 0.04$) but did not differ ($P \geq 0.45$; data not shown) between BST and control heifers (3.47 vs. 3.61 mm of backfat thickness, SEM = 0.14; 42.2 vs. 41.4 mm of LM depth, SEM = 0.8; and 400 vs. 401 of marbling score, SEM = 3, respectively). Mean backfat thickness was less ($P < 0.01$) in BST heifers compared with control cohorts (3.56 vs. 3.92 mm, respectively; SEM = 0.08). Supporting our findings, Schwarz et al. (1993) reported that beef heifers receiving 320 mg of BST at 14-d intervals had less carcass fat content but similar marbling score compared with nontreated cohorts. Dalke et al. (1992) reported that feedlot steers receiving 160 mg of BST weekly had less backfat thickness and marbling score but similar LM area compared with nontreated steers. Vestergaard et al. (1995) also reported that prepubertal Friesian heifers receiving 15 mg/d of BST had less backfat thickness but similar LM area compared with cohorts receiving placebo. Accordingly, BST has been shown to inhibit lipogenesis in cattle as well as stimulate lipolytic activity in bovine adipose tissues (Hart et al., 1984; Lanna et al., 1995). Furthermore, BST administration increases protein deposition into body components at the expense of fat accretion (Vestergaard et al., 1993) although BST administrations did not change LM depth herein or LM area in Dalke et al. (1992) and Vestergaard et al. (1995).

A treatment \times day interaction was detected ($P < 0.01$) for plasma IGF-I (Fig. 1). Concentrations of plasma IGF-I on d 0 and 7 were significant covariates ($P < 0.01$) but did not differ ($P = 0.35$; data not

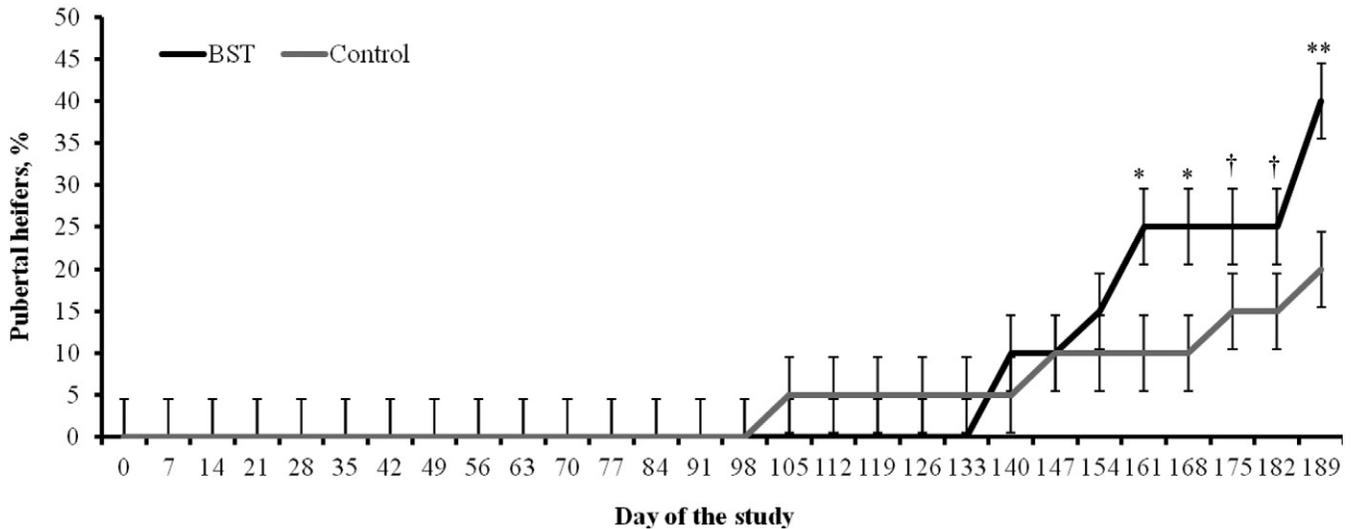


Figure 2. Puberty attainment (\pm SEM) of heifers receiving subcutaneous injections containing 250 mg of bovine ST (BST; sometribove zinc; $n = 25$; Posilac, Elanco, Greenfield, IN) or 5 mL of saline (0.9%; control; $n = 25$). Treatments were administered every 14 d beginning on d 14 until d 196 of the experimental period (d 0 to 210). Heifers were considered pubertal once plasma progesterone concentrations were greater than 1.0 ng/mL for 2 consecutive weeks, and puberty attainment was declared at the second week of increased progesterone. A treatment \times day interaction was detected ($P = 0.04$). Treatment comparison within days: ** $P < 0.01$, * $P = 0.03$, and † $P = 0.10$.

shown) between BST and control heifers (50.4 vs. 48.0 ng/mL, respectively; SEM = 1.8). As expected by the experimental design, BST heifers had greater plasma IGF-I concentrations compared with control cohorts 7 d after treatment administration (Fig. 1). Buskirk et al. (1996) also reported that 250 mg of sometribove zinc administered every 14 d increases IGF-I synthesis and circulating concentrations in replacement heifers. Furthermore, plasma IGF-I concentrations typically increases 3 d after sometribove zinc administration, peaking approximately 7 to 8 d, and begins returning to baseline levels 12 d relative to treatment (Bilby et al., 1999, 2004). A treatment effect was detected ($P = 0.05$) for plasma leptin (Table 1). Concentrations of plasma leptin on d 0 and 7 were significant covariates ($P < 0.01$) but did not differ ($P = 0.89$; data not shown) between BST and control heifers (2.21 vs. 2.19 ng/mL, respectively; SEM = 0.12). Mean plasma leptin concentrations were less ($P = 0.05$) in BST heifers compared with control cohorts (1.82 vs. 2.03 ng/mL, respectively; SEM = 0.07), concurring with treatment effects detected for backfat thickness given that adipose tissues are the main site of leptin synthesis in ruminants (Houseknecht et al., 1998). In addition, BST administration may decrease circulating leptin concentrations in cattle by inhibiting the ability of insulin or corticoids to stimulate leptin synthesis by adipocytes (Houseknecht et al., 2000).

A treatment \times day interaction was detected ($P = 0.04$) for puberty analysis, given that attainment of puberty was hastened in BST heifers compared with control cohorts (Fig. 2). Before breeding (d 189), a greater proportion ($P < 0.01$; Fig. 2) of BST heifers were pubertal compared with control cohorts (40.0 vs. 20.0% of pubertal heifers/total heifers; SEM = 4.5). Although

age at puberty in cattle is greatly determined by nutrient intake, BW, and growth rate (Schillo et al., 1992), BST heifers experienced hastened attainment of puberty compared with control heifers despite their similar nutritional management, ADG, and final BW during the experiment. Similarly, Hall et al. (1994) reported that BST administration increased the number of animals pubertal by 14.5 mo of age within heifers limit fed to gain 0.5 kg/d. This outcome can be attributed, at least partially, to increased plasma IGF-I concentrations in BST heifers compared with control cohorts. Circulating IGF-I plays a major role in gonadotropin secretion and activity required for the first ovulation and subsequent puberty establishment in heifers by influencing hypothalamic-pituitary secretory activity (Butler and Smith, 1989; Schillo et al., 1992) and also amplifying the effects of gonadotropins in ovarian follicular cells (Spicer and Echternkamp, 1995). It can be speculated that BST administration also modulated plasma concentrations of other metabolites and hormones expected to influence puberty but not evaluated herein, including NEFA, glucose, and insulin (Hess et al., 2005). The effects of BST administration on these metabolic indicators have been variable, either increasing (de la Sota et al., 1993; Armstrong et al., 1995; Chase et al., 2011), decreasing (Armstrong et al., 1995; Azza et al., 2010), or not altering (Neathery et al., 1991; Schwarz et al., 1993; Cooke et al., 2012) their circulating concentrations in cattle. However, increased glucose and insulin concentrations on BST administration may be associated with insulin resistance rather than enhanced metabolic status (Dunshea et al., 1995). Moreover, previous research from our group reported that plasma IGF-I concentrations were greater whereas ADG and

plasma insulin and glucose concentrations were similar in replacement Brahman \times Angus heifers that reached puberty as yearlings compared with nonpubertal cohorts (Cooke et al., 2007).

Results from this experiment also indicate that circulating leptin concentrations and potentially body fat content are not independent determinants of puberty establishment in heifers. Circulating leptin has also been positively associated with GnRH and gonadotropin synthesis in females (Maciel et al., 2004b). However, chronic administration of recombinant ovine leptin effectively increased plasma leptin concentrations but failed to increase pulse frequency and circulating LH concentrations and did not anticipate puberty in replacement beef heifers (Maciel et al., 2004a). Hence, it has been postulated that leptin is not a trigger for puberty but may serve as a permissive signal that allows puberty to occur (Barb and Kraeling, 2004). Consequently, one can also speculate that BST administration in the present study was not sufficient to reduce plasma leptin concentrations to concentrations that would halt puberty attainment whereas the greater leptin concentrations in control heifers were not sufficient to hasten their puberty attainment. Nevertheless, it is important to note that puberty attainment was hastened in BST heifers compared with control cohorts despite differences reported in plasma leptin, backfat thickness, and similar ADG, supporting the rationale that increased circulating IGF-I can hasten puberty establishment independently of growth rate, body fat content, and circulating leptin concentrations.

No treatment effects were detected for estrus synchronization rate ($P = 0.56$; Table 1), pregnancy attainment ($P = 0.94$; data not shown), and final pregnancy rate ($P = 0.32$; Table 1). The lack of treatment effects on these reproductive outcomes could be attributed, at least partially, to the estrus synchronization protocol used herein given that exogenous GnRH and progesterone may stimulate puberty attainment in heifers (Patterson et al., 2000; Madgwick et al., 2005). In addition, previous research reported that BST administration as well as plasma concentrations of IGF-I and leptin influence pregnancy rates in beef females (Ciccioli et al., 2003; Cooke et al., 2007; Albuquerque et al., 2012). However, heifers in the present experiment did not receive treatments during the breeding season, which may also explain the lack of treatment effects on pregnancy outcomes (Table 1).

The main goal of the present experiment was to further evaluate the impact of circulating IGF-I and leptin on puberty attainment in beef heifers. As previously mentioned, both hormones are positively associated with some of the factors responsible for puberty establishment in cattle, including nutrient intake

and BW gain (Ciccioli et al., 2003; Lents et al., 2005) as well as synthesis and activity of GnRH and gonadotropin (Butler and Smith, 1989; Schillo et al., 1992; Maciel et al., 2004b). Administration of BST has been shown to increase plasma IGF-I concentrations independently of nutrient intake and BW gain in heifers managed to attain moderate ADG (Buskirk et al., 1996) as well as decrease plasma leptin concentration by reducing body fat content and synthesis by adipose tissues (Dalke et al., 1992; Houseknecht et al., 1998, 2000). Hence, the present study used BST administration as an experimental approach to compare reproductive development of beef heifers growing with different plasma IGF-I and leptin profiles. Similarly, Garcia et al. (2003) supplemented CLA to replacement heifers with the intent of reducing body fat deposition and consequently circulating leptin concentrations and compared puberty attainment with that of nonsupplemented cohorts. However, CLA supplementation did not impact body fat content, circulating leptin, or puberty attainment whereas authors concluded that their model did not contribute to the understanding of the roles of adiposity and leptin in sexual maturation of beef heifers (Garcia et al., 2003). In the present study, however, our BST-based experimental approach was effective in increasing plasma IGF-I concentrations with no impact on ADG and decreasing backfat thickness and plasma leptin concentrations in the evaluated heifers.

In conclusion, results from this experiment indicate that heifers with elevated circulating IGF-I concentrations experience hastened puberty establishment independently of growth rate, nutritional plane, body fat content, and circulating leptin concentrations. Hence, management and nutritional alternatives that enhance circulating IGF-I concentrations are expected to maximize the number of replacement heifers pubertal by 12 mo of age and consequently optimize production efficiency in cow-calf systems.

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