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Fertility of Lactating Dairy Cows Administered Recombinant Bovine Somatotropin During Heat Stress

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ABSTRACT

Administration of recombinant bovine somatotropin (bST) to lactating dairy cows during heat stress increases milk yield, but it also can increase body temperature and may therefore compromise fertility. However, it is possible that bST treatment could increase fertility during heat stress because it has been reported to increase fertility in lactating cows. In addition, bST increases secretion of insulin-like growth factor-I (IGF-I) that promotes embryo survival. The purpose of this study was to determine effects of bST on reproductive function in lactating dairy cows during heat stress. The experiment was conducted in southern Georgia from July to November 2005 using lactating Holstein cows (n = 276 for reproductive traits). For first service timed artificial insemination (TAI), cows were presynchronized with 2 injections of $PGF_{2\alpha}$ given 14 d apart followed by a modified Ovsynch protocol (GnRH and insemination at 72 h following $PGF_{2\alpha}$). Pregnancy was diagnosed by using ultrasonography on d 29 and reconfirmed by palpation between d 45 and 80 post-TAI. Nonpregnant cows were resynchronized with the modified Ovsynch protocol and received a second TAI. Treatment with bST started 1 wk before the start of Ovsynch and continued at 2-wk intervals. Blood samples were collected from a subset of cows to determine IGF-I profiles immediately before the first bST injection, 1 wk later, and at d 35 of bST treatment. Rectal temperatures were assessed on d 29 of bST treatment. Pregnancy rates (d 45 to 80 post-TAI) did not differ between bST and control cows for first- (16.7 vs. 15.2%) or second-service TAI (14.8 vs. 17.2%). Plasma concentrations of IGF-I and milk yield were greater for bST-treated cows following the initiation of bST treatment and bST increased rectal and vaginal temperatures. Body condition score was less for bST-treated cows. In conclusion, treatment with bST during heat stress increased IGF-I concentrations, milk yield over time, and rectal and vaginal temperatures without affecting first- or second-service pregnancy rates. Thus, at least under certain housing conditions, bST can be used to improve milk yield during heat stress without compromising fertility.
Key words: dairy cow, bovine somatotropin, fertility, heat stress

INTRODUCTION

Treatment of lactating cows exposed to heat stress with bST can increase milk yield (West et al., 1990b; Elvinger et al., 1992). One consequence of bST treatment during heat stress is an increase in body temperature (Elvinger et al., 1992; Cole and Hansen, 1993) and some of this increase in body temperature may be independent of a lactational effect (Elvinger et al., 1992; Cole and Hansen, 1993). Given the fact that elevated body temperature compromises fertility in lactating cows (e.g., a 0.5°C increase in uterine temperature on the day of insemination resulted in a 12.8% decrease in fertility; Gwazdauskas et al., 1973), it is possible that bST treatment during heat stress could compromise fertility. However, fertility-promoting effects of bST may overcome adverse effects of increased hyperthermia on fertility. Indeed, treatment of dairy cows with bST increased fertility (Moreira et al., 2000b, 2001; Santos et al., 2004).

Treatment with bST also may increase cellular resistance to elevated temperature, either directly or indirectly. Lymphocytes harvested from heifers treated with bST were more resistant to heat shock in vitro compared with lymphocytes from nontreated heifers (Elvinger et al., 1991). Insulin-like growth factor-I, whose secretion is induced by bST (Bilby et al., 1999), reduced the effects of heat shock on development and apoptosis in preimplantation bovine embryos (Jousan and Hansen, 2004, 2006).

Given the fertility promoting and thermoprotective actions of bST, the hypothesis of this study was that administration of bST to lactating Holstein cows during summer would increase pregnancy rates compared with lactating nontreated Holstein cows.

MATERIALS AND METHODS

Animals, Housing, and Feeding

The experiment was conducted from July 4 to November 7, 2005, at a commercial dairy near Quitman, GA

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(30°47′5″ N, 83°33′39″ W) utilizing 285 lactating Holstein cows (94 were primiparous and 191 were multiparous). The University of Florida Institutional Animal Care and Use Committee approved the experimental protocol. During the study period, cows were housed in a free-stall barn equipped with fans and a sprinkler system. Hourly dry-bulb temperature and relative humidity measurements were recorded at a height of 3 m inside the free-stall barn from July 18 to November 7, 2005, using a data logger (HOBO Pro RH/Temp Data Logger, Onset Computer Co., Bourne, MA); results are depicted in Figure 1.

All cows were fed as a group twice daily. The diet was a TMR containing corn silage and ryegrass silage as the main ingredients and with 0.80 Mcal of NE_L/kg and 17.18% CP on a DM basis. Cows were milked thrice daily (0000, 0800, and 1600 h) and milk yields were recorded for individual cows once monthly during the official Georgia DHIA test.

Experimental Design

A diagram of the experimental protocol is displayed in Figure 2. For first-service timed AI (**TAI**), estrous cycles in cows at an average of 44 d postpartum (range 41 to 47 d) were presynchronized with 2 injections of 25 mg of $PGF_{2\alpha}$, i.m. 14 d apart, followed 14 d later by the initiation of a modified Ovsynch protocol (100 μg of GnRH, i.m. followed 7 d later with 25 mg of $PGF_{2\alpha}$, i.m., and a second injection of GnRH (100 μg) given 72 h following $PGF_{2\alpha}$ coincident with TAI; Portaluppi and Stevenson, 2005). All cows received an additional 100-μg injection of GnRH, i.m., 1 wk before pregnancy diagnosis was conducted by using ultrasonography on d 29 post-TAI. Estrous cycles in cows diagnosed nonpregnant were resynchronized with the continuation of the modified Ovsynch protocol and received TAI. Pregnancy for first and second service was confirmed by palpation per rectum between d 45 and 80 post-TAI.

Cows were enrolled in the experiment each week (during an 8-wk period) and were assigned randomly to receive bST or serve as controls within each week block. Overall, an equal number of primiparous cows were assigned per treatment (n = 47), whereas 103 and 88 multiparous cows were assigned to bST treatment and control, respectively. Treatment with bST (500 mg, s.c.; Posilac, Monsanto Co., St. Louis, MO) was initiated 1 wk before the start of the modified Ovsynch protocol and continued at 2-wk intervals throughout the experiment. Treatment was administered initially in the depression on the right side of the tail head with subsequent injections being alternated between the cow's left and right side tail head depression. Control cows received no injection.

Body condition score using a scale of 1 to 5 in 0.25 increments (Edmonson et al., 1989) was recorded for bST-treated and control cows at each bST treatment. Each week, a subset of 3 cows per treatment was fitted with a temperature data logger (HOBO Water Temp Pro v1, Onset Computer Co.) attached to a blank control internal drug release (CIDR) insert (Pfizer Animal Health, New York, NY) that was inserted into the vagina. The data logger recorded vaginal temperature at 15-min intervals beginning at 1200 h on d 11 post-TAI for 1 wk starting at d 28 of bST treatment. A new subset of cows was enrolled each week so that vaginal temperatures were recorded from 21 bST and 20 control cows in total. In addition, rectal temperatures were taken between 1600 and 2000 h on d 11 post-TAI (d 29 of bST treatment) for all cows, using a digital thermometer (M525/550 Hi-Performance Digital Thermometer; GLA Agricultural Products, San Luis Obispo, CA). Rectal temperatures were recorded following the milking that occurred at 1600 h, when the cows had been washed in preparation for milking and kept under fans while in the milking parlor.

Blood Sample Collection and IGF-I Immunoradiometric Assay

Blood samples were collected from a subset of cows (n = 27) to determine IGF-I concentrations immediately before the first bST injection, 1 wk later, and at d 35 of bST treatment. Blood samples were collected by coccygeal venipuncture into evacuated heparinized 10-mL tubes (Becton Dickinson, Franklin Lakes, NJ). Following collection, blood samples were placed in an ice chest until further processing at the laboratory (within approximately 4 to 6 h). Blood samples were centrifuged at 2,000 × *g* for 20 min at 4°C. Plasma was separated and stored at –20°C until assayed for IGF-I concentration, which was determined using the ACTIVE NonExtraction IGF-I IRMA kit (DSL-2800; Diagnostic Systems Laboratories, Inc., Webster, TX) according to the manufacturer's protocol. The assay had a sensitivity of 2.06 ng/mL (2 standard deviations below the 0 ng/mL IGF-I standard) as determined by the manufacturer. The assay was validated for parallelism by using different dilutions of a plasma sample. All samples were assayed at the same time and the intraassay coefficient of variation was 7%.

Statistical Analysis

Nine cows were excluded from the statistical analysis (3 control cows, 2.2%; and 6 bST cows, 4.0%) because they were removed from the herd before pregnancy diagnosis at d 29 post-TAI, thereby leaving 276 total cows [n = 132 control cows (46 first-lactation cows and 86