J. Dairy Sci. 92:4876–4888
doi:10.3168/jds.2008-1675

Postpartum ovarian activity in multiparous Holstein cows treated with bovine somatotropin and fed n-3 fatty acids in early lactation[1]

M. Carriquiry,*[2] C. R. Dahlen,† W. J. Weber,* G. C. Lamb,‡[3] and B. A. Crooker*[4]
*Department of Animal Science, University of Minnesota, St. Paul 55108-6118
†Northwest Research and Outreach Center, University of Minnesota, Crookston 56716-5000
‡North Central Research and Outreach Center, University of Minnesota, Grand Rapids 55744-3361

ABSTRACT

Multiparous cows (n = 59) were blocked by expected calving date and previous 305-d mature-equivalent milk yield and assigned randomly to a 2 × 2 factorial design to determine the effects of bovine somatotropin (bST; Posilac, Monsanto Animal Agricultural Group, St. Louis, MO) and dietary fat on ovarian activity during the first 90 d in milk (DIM). Diets that included whole, high-oil sunflower seeds [SS; 10% of dietary dry matter; rich in linoleic acid (18:2)] or a mixture of Alifet-High Energy and Alifet-Repro [AF; Alifet USA, Cincinnati, OH; 3.5 and 1.5% of dietary dry matter, respectively; protected source of linolenic (18:3), eicosapentaenoic, and docosahexaenoic fatty acids] were provided from calving. Diets were isocaloric at equal intakes, but AF provided more net energy for lactation at actual intakes (1.54 vs. 1.66 Mcal/kg of dry matter). Cows received 0 or 500 mg of bST (N, Y) every 10 d from 12 to 70 DIM and at 14-d intervals from 70 to 280 DIM. Breeding was initiated after 90 DIM. Follicular dynamics, luteal growth and development (15 to 90 DIM), and plasma progesterone concentrations (1 to 90 DIM) were evaluated (3 times per week). Days to first ovulation (33.6 ± 1.4) and incidence of anovulation at 45 or 70 DIM did not differ among treatments. Interovulatory intervals were similar among treatments (22.1 ± 0.9 d). Incidence of estrous cycles with 2 follicular waves was greater for SSY (71.0%) and AFN (80.0%) than for other groups, but more 3-wave cycles occurred with AFY (83.3%). Growth rate of the ovulatory follicle was greater for AF than SS (1.9 vs. 2.2 ± 0.11 mm/d) and diameter of ovulatory follicles was larger for AFN than the other treatments (17.9 vs. 15.7 ± 0.7 mm). Area under the progesterone curve was reduced for SSY (63.2, 48.1, 55.5, and 61.4 ± 5.1 ng·d/mL for SSN, SSY, AFN, and AFY, respectively). The number of class 1 (3 to 5 mm) follicles was decreased and the number of class 2 (6 to 9 mm) follicles was increased by bST. The number of class 2 follicles was reduced by AF. Initiation of bST administration at 12 DIM and dietary n-3 fatty acids altered ovarian activity during the first 90 DIM and could benefit reproductive performance. Dietary n-3 fatty acids interacted with bST administration in early lactation to increase the incidence of estrous cycles with 3 follicular waves. Although these changes could benefit reproductive performance, evaluation with a larger number of cows is needed to determine if these alterations improve fertility.
Key words: somatotropin, n-3 fatty acid, follicular dynamic

INTRODUCTION

Supplementation with dietary fat and administration of bST are management approaches that have the potential to improve the reproductive performance of high-producing dairy cows (Staples et al., 1998; Moreira et al., 2001). Several mechanisms have been proposed to explain the positive effects of supplemental fat on reproductive performance (Beam and Butler, 1997; Staples et al., 1998; Mattos et al., 2002). These include 1) increased LH secretion; 2) increased number and size of total and preovulatory follicles; 3) increased secretion, increased clearance, or increased secretion and clearance of progesterone (**P$_4$**); 4) increased size and lifespan of the corpus luteum (**CL**); and 5) reduced $PGF_{2\alpha}$ synthesis and secretion. The effect of supplemental fats on reproductive function likely depends on the fatty acid composition and extent of ruminal biohydrogenation of the fat source (Staples et al., 1998; Petit et al., 2002, 2004). As milk production and management intensity

Received September 1, 2008.
Accepted June 19, 2009.
[1]This work was supported in part by a Doctoral Dissertation Research Grant from the Graduate School at the University of Minnesota, a Hueg-Harrison Fellowship, and a Sigma Delta Epsilon Fellowship all awarded to M. Carriquiry. Support for the study was also provided by the Agricultural Experiment Station at the University of Minnesota (project number 16-46).
[2]Current address: Facultad de Agronomía, Avda. Garzón 810, 12900 Montevideo, Uruguay.
[3]Current address: University of Florida-NFREC, 3925 Highway 71, Marianna, FL 32446.
[4]Corresponding author: crook001@umn.edu

have increased, feeding systems have evolved toward a greater use of dietary concentrates (rich in n-6), which has increased the dietary n-6/n-3 fatty acid ratio from 0.5 to 6 (Ponter et al., 2006), and this has been associated with reduced reproductive function (Mattos et al., 2002).

Several characteristics of reproductive function are improved when cows are treated with bST. These improvements have been linked with increased circulating concentrations of IGF-I and include an increased number of recruited follicles (Kirby et al., 1997), an increased size of the second largest follicle (De La Sota et al., 1993), an increased number of dominant follicles (Jimenez-Krassel et al., 1999), and increased ovulation rate (Jimenez-Krassel et al., 1999). Administration of bST decreased the interval between follicular waves by an earlier emergence of the second wave of follicular growth (Kirby et al., 1997; Lucy, 2000). In well-managed cows, bST increased pregnancy rates in a timed AI protocol and had a beneficial effect on the development of the preovulatory follicle, oocyte, or both (Moreira et al., 2001).

Our hypothesis was that dietary n-3 fatty acids and bST administration would alter follicular dynamics and that these alterations could help improve reproductive performance. No study appears to have examined the combined effects of source of supplemental fat and bST administration on ovarian activity of early postpartum cows. Therefore, the objective of this study was to evaluate the effects of bST and dietary fat enriched with n-6 or n-3 fatty acids on ovarian activity in early postpartum dairy cows.

MATERIALS AND METHODS

Animals, Experimental Design, and Treatments

Animal care and experimental procedures were approved by the University of Minnesota Institutional Animal Care and Use Committee. Detailed descriptions of the diets, animal management, data and sample collection and analyses, and production responses have been reported (Carriquiry et al., 2009b). Briefly, multiparous cows (n = 59) were fed a dry cow diet beginning 3 wk before the expected calving date. Cows were blocked by expected calving date and previous milk yield (305-d mature-equivalent milk yield) and assigned randomly to 1 of 4 treatments in a 2 × 2 factorial arrangement of bST (0 or 500 mg/injection) and source of supplemental dietary fat. Treatment diets contained either whole, high-oil (42% ether extract) sunflower seeds (**SS**; 10% of dietary DM) as a source of linoleic acid (18:2; dietary n-6/n-3 ratio = 4.6) or a mixture of Alifet-High Energy and Alifet-Repro (**AF**; Alifet USA, Cincinnati, OH; 3.5 and 1.5% of dietary DM, respectively) as a source of n-3 fatty acids (dietary n-6/n-3 ratio = 2.6). Alifet-High Energy is a microcrystallized rumen-inert energy concentrate made from animal fat (99%) rich in saturated fatty acids (57% stearic acid, 18:0; 25% palmitic acid, 16:0). Alifet-Repro is a microcrystallized rumen-inert fat (flaxseed oil and fish oil) that is enriched with the n-3 fatty acids linolenic (18:3; 15.7%), eicosapentanoic (**EPA**, 20:5; 1.3%), and docosahexaenoic (**DHA**, 22:6; 1.3%) acids. Treatment diets were offered from calving, and administration of bST (Posilac, Monsanto Animal Agricultural Group, St. Louis, MO) was initiated on 12 ± 3 DIM and continued at 10-d intervals through 70 ± 3 DIM and at 14-d intervals from 70 to 280 ± 3 DIM. Treatments from the 2 × 2 factorial arrangement of diets (SS, AF) with 0 (**N**) or 500 mg (**Y**) of bST per injection were designated **SSN**, **SSY**, **AFN**, and **AFY**, and there were 15, 16, 15, and 13 cows per treatment, respectively.

Cows were housed in tie stalls and fed individually. Diets were provided as TMR and were formulated to meet the nutritional needs of the cows. Treatment diets, composed primarily of alfalfa haylage, corn silage, high-moisture shelled corn, and soybean meal, were designed to differ primarily in the type of fatty acids they contained and were formulated to contain similar amounts of NE_L (1.68 and 1.71 Mcal/kg of DM, respectively) at a predicted peak DMI of 29.9 kg/d (4.7× maintenance) as described by Carriquiry et al. (2009b). The $NE_{L\text{-Actual DMI}}$ values were 1.54 and 1.66 Mcal/kg of DM for SS and AF, respectively. The SS and AF diets contained 8.6 and 7.7% ether extract and an estimated 7.9 and 7.0% fatty acid (Allen, 2000) on a DM basis, respectively. Dietary content of all other major nutrients differed by <4% and averaged 18.5% CP, 18.5% ADF, and 28% NDF (Carriquiry et al., 2009b). Formulation differences altered the dietary linoleic acid (383 vs. 265 mg/g of fatty acids), EPA (0.4 vs. 2.6 mg/g of fatty acids), and DHA (0.2 vs. 1.8 mg/g of fatty acids) content of the SS and AF diets, respectively (Carriquiry et al., 2009a). The n-3 fatty acids in Alifet-Repro were partially protected (75 to 95%) from metabolism by rumen microorganisms (Carriquiry et al., 2008), which contributed to an increased proportion of these fatty acids in the milk from cows that consumed AF (Carriquiry et al., 2009a).

Cows were milked 2 times per day and BW, backfat thickness, and BCS were measured at weekly intervals from −2 to 4 wk of lactation and at 4-wk intervals from 4 to 40 wk of lactation (Carriquiry et al., 2009b). Amounts of feed offered and refused were recorded daily to determine feed intake. General health records were maintained throughout the study, and cows were treated for illness when warranted. Severity of health