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The Effect of Bovine Somatotropin Treatment on Production of Lactating Angora Does with Kids^{1,2,3,4}

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ABSTRACT: Fourteen Angora does (35 ± 2 kg), each with a single kid and in the first month of lactation, were used to determine ongoing (Period 1) and residual (Period 2) effects of chronic bovine somatotropin (bST) treatment. Specifically, we sought to determine whether chronic bST treatment was capable of improving milk yield, and thus kid growth, and mohair production of nursing does. The experiment consisted of a 2-wk pretreatment period, 5 wk of weekly subcutaneous treatment of slow-release bST ($n = 7$; Period 1), and a 4-wk posttreatment period (Period 2). The weekly dose of bST was calculated to release $100 \mu\text{g}/(\text{kg BW}\cdot\text{d}^{-1})$. To estimate milk production, kids were separated from the does daily for 5 h, and their BW was recorded before and after suckling. The difference in BW was taken as milk production for 5 h. Fiber growth was measured by shearing does at the start of the experiment and at

the end of Periods 1 and 2. Dry matter intake and BW of does were not affected by bST ($P > .05$). Average daily gain of kids that were suckling bST-treated does was higher ($P < .05$) than for kids of untreated does during Period 1 (184 vs 139 g/d) but not during Period 2 (140 vs 136 g/d; $P > .10$). Treatment with bST did not affect ($P > .10$) milk composition or clean fleece production in either period. Injection of bST did not affect ($P > .10$) plasma concentrations of glucose (mean = 49.5 mg/dL), urea N (mean = 19 mg/dL), total protein (mean = 72.5 g/d), or NEFA (mean = 122 $\mu\text{Eq/L}$). During the period of bST treatment, plasma concentrations of somatotropin and IGF-I were increased ($P < .05$), concentrations of thyroxine and cortisol were decreased ($P < .10$), and plasma insulin levels were unchanged ($P > .10$) by bST. In conclusion, treatment of Angora dams with bST did not change DMI or mohair growth, but it improved growth of their kids.

Key Words: Goat Breeds, Bovidae, Somatotropin, Milk Production

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Introduction

The galactopoeitic effects of bovine somatotropin (bST) in dairy cattle (Bauman, 1992), sheep (Sandles et al., 1988; Stelwagen et al., 1993), and dairy goats (Mepham et al., 1984; Prosser et al., 1990; Knight, 1992) are well established. The milk yield

response to bST treatment in goats and sheep is more variable than that in cows (Mepham et al., 1984; Davis et al., 1989).

Bovine somatotropin also has been shown to positively affect growth (Early et al., 1990a), carcass composition (Early et al., 1990b; McLaughlin et al., 1993), and wool fiber production (Wynn et al., 1988). Variable results have been obtained for fiber production response to GH treatment. Fiber growth was unchanged, decreased, or increased in sheep during

¹Names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of products, and use of the name by the USDA implies no approval of products to the exclusion of others that may also be suitable.

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GH treatment (Wheatley et al., 1966; Reklewska, 1974; Muir et al., 1983; Johnsson et al., 1985, 1987; Wynn et al., 1988; Zainur et al., 1989). In the recovery period after GH treatment, wool growth was reported to be similar to or greater than that in control sheep (Wheatley et al., 1966; Wynn et al., 1988). To date no studies have been reported on the effect of bST on mohair or milk production in Angora does. In the present study, data were collected to determine whether bST treatment of lactating Angora does would affect preferentially the partitioning of nutrients toward fiber or milk production either during the period of bST treatment or in the period after bST treatment.

Materials and Methods

Animals and Treatments

Multiparous Angora does ($n = 14$; $BW = 30.9 \pm 1.8$ kg) with single kids from the E. (Kika) de la Garza Institute for Goat Research herd were used. All does had kidded during April and were in early lactation (d 10 to 25 postpartum) at the start of the experiment. The experiment was divided into three continuous periods: a 14-d pretreatment period (d 1 to 14), a 35-d treatment period (Period 1; d 15 to 49), and a 35-d posttreatment period (Period 2; d 50 to 79). The goats were housed at ambient temperature in raised, individual stalls indoors under natural lighting and had free access to fresh water. Kids were kept with their dams except during the period of milk production estimation. Does were offered the experimental diet (Table 1) at 0830 daily on an ad libitum basis.

At the end of the pretreatment period, does were blocked according to kidding date, milk production, BW, and initial mohair weight and within block randomly assigned to one of two treatments. The treatments were control ($n = 7$) and bST ($n = 7$), a weekly subcutaneous injection of slow-release bST (Animal Sciences Division, Monsanto Co., St. Louis, MO) calculated to provide $100 \mu\text{g}/(\text{kg BW}\cdot\text{d}^{-1})$ of bST. The bST injection was given in the left scapular region weekly for five consecutive weeks. This dose of bST was selected based on the results of Johnsson et al. (1987), Wynn et al. (1988), and McDowell et al. (1987), who reported significant responses in wool growth and in milk production of sheep.

Feed intake was recorded daily, and BW was measured weekly before feeding. The diet was sampled regularly throughout the trial and analyzed for DM, CP (Technicon Instruments Co., Tarrytown, NY), NDF, and ADF (Goering and Van Soest, 1970).

Milk Production

Milk production was estimated daily for the entire period of the trial by using the weigh-suckle-weigh

Table 1. Composition of experimental diets

Item	Percentage of DM
Ingredient	
Cottonseed hulls	33.0
Ground corn	19.0
Oats	20.5
Soybean meal	15.0
Alfalfa meal	10.0
Trace mineralized salt ^a	1.0
Calcium carbonate	.5
Vitamin premix ^b	.2
Dicalcium phosphate	.8
Chemical composition	
CP, % of DM	14.0
ME, Mcal/kg ^c	2.52
NDF, % of DM	36.6
ADF, % of DM	21.5

^aContained 94 to 95% NaCl, >.2% Mn, >.16% ferrous Fe, >.14% ferric Fe, >.033% Cu, >.10% Zn, >.007% I, and >.005% Co.

^bEach gram contained 2,200 IU of vitamin A, 2,200 IU of vitamin D, and .2 IU of vitamin E.

^cCalculated energy in diet (NRC, 1981).

technique (Williams et al., 1979). At approximately 0800, kids were removed from their dams and placed in an adjacent pen. Following a 5-h separation period, the kids were weighed and then joined with their dams to nurse. After the kids had finished nursing (approximately 15 min), they were reweighed. Milk yield for the 5-h period was taken as the difference in kid weight before and after nursing. To determine milk composition, samples were obtained 1 d each week by milking out the goats by hand before allowing the kids to nurse. The samples were collected into plastic milk sample vials (Capital Vials, Fultonville, NY), preserved with Microtabs (Control Systems, San Ramon, CA), stored at 4°C, and analyzed within 24 h. Milk samples were analyzed for fat, protein ($N \times 6.38$), lactose, and solids-not-fat contents by infrared spectrophotometry (Multispec 2, Multispec, Whel-drake, York, U.K.).

Mohair Fiber Measurements

The does were shorn at the beginning of the pretreatment period (d 1), after the period of bST treatment (d 49), and at the end of the posttreatment period (d 79). A mid-side sample was collected from each fleece, and clean mohair yield and staple length were determined according to the standards of ASTM (1988). Fiber diameter was determined using the Peyer FDA 200 System (Walleran, Switzerland).

Blood Measurements

Jugular blood samples were obtained at regular intervals before feeding during Periods 1 and 2. They were taken via venipuncture into two vacuum tubes containing either sodium heparin or potassium oxalate

and sodium fluoride (Becton Dickinson Vacutainer Systems, Rutherford, NJ). The tubes were immediately chilled in an ice bath and transported to the laboratory, where they were centrifuged at $1,500 \times g$ and 4°C for 20 min. Aliquots of plasma were stored at -20°C pending analysis. The concentration of plasma NEFA was determined with a commercial kit using an enzymatic colorimetric procedure (Wako Pure Chemical Industries, Richmond, VA) as modified by McCutcheon and Bauman (1986). Plasma urea N, total protein, and glucose were quantified colorimetrically using a Technicon Autoanalyzer II System (Technicon Instruments Co.). Plasma insulin, cortisol, and thyroxine concentrations were quantified using commercially available kits from ICN Biomedicals (Costa Mesa, CA) by procedures described by Puchala et al. (1995). Assays for a given hormone were run concurrently. The average intraassay CV (determined from analyses of pooled caprine plasma samples) for cortisol, thyroxine, and insulin were 7.6, 6.6, and 10.3%, respectively. Plasma concentrations of immunoreactive somatotropin and IGF-I were measured using procedures of McCann et al. (1997). Amino acid analyses were performed using an AminoQuant system, precolumn derivatization with α -phthalaldehyde and 9-fluorenylmethyl-chloroformate, and UV detection (Hewlett Packard, San Fernando, CA). For amino acid analysis, plasma (1 mL) with added internal standards (norvaline and sarcosine) was deproteinized with .9 mL of Seraprep (Pickering, Mountain View, CA).

Statistical Analyses

Data were analyzed using the General Linear Models procedure of SAS (1989). Feed intake, BW, and mohair fiber measurements were analyzed as a one-way completely randomized experiment with two treatments. Milk production was analyzed as a split plot in time rather than with repeated measures, because repeated measures resulted in a loss of more than half the data owing to a very small number of missing values. Average milk production for the pretreatment period was used as a covariate. Blood traits were analyzed as a split plot in time.

Results

Production Data

Body weight (Tables 2 and 3) of the does was not affected ($P > .10$) by bST treatment. Does lost weight during the first part of the experiment when they were moving into their peak lactation period. Dry matter intake was not affected ($P > .10$) by bST (Tables 2 and 3). Kids of bST-treated does had higher ADG ($P < .04$) than the kids of control does during the period of bST treatment (Table 2). Following this period, ADG was similar for kids on both treatments (Table 3).

In Period 1 during bST treatment and in the subsequent 8 wk of Period 2 without bST, milk production was similar ($P > .10$) between groups (Table 3). There were no differences in milk composi-

Table 2. Body weight, DMI, and milk and mohair production of lactating Angora does and ADG of their kids during bovine somatotropin (bST) treatment (Period 1; d 15 to 49)

Item	Treatment ^a		SEM	P <
	Control	bST		
Initial BW, kg	35.3	35.9	1.8	.80
Final BW, kg	33.9	35.6	1.6	.47
DMI, kg/d	1.9	2.0	.1	.46
Kid ADG, g/d	139	184	16	.04
Milk				
Production ^b , mL/d	1,051	1,210	91	.35
Fat, %	3.51	3.32	1.25	.75
Protein, %	3.71	3.76	.44	.25
Lactose, %	5.11	5.08	.35	.82
Solids-not-fat, %	9.59	9.85	.67	.33
Mohair fiber ^c				
Grease fleece, g/d	22.6	21.2	1.7	.54
Clean fleece, g/d	18.0	18.1	1.6	.97
Staple length, $\mu\text{m}/\text{d}$	1,166	1,226	53	.44
Diameter, μm	39.0	38.5	1.1	.76

^aDoes ($n = 7$ per treatment) were injected with slow-release bST once weekly for 5 wk (d 15 to 49; Period 1) or received no treatment (control). The bST injection was calculated to deliver $100 \mu\text{g}/(\text{kg BW}\cdot\text{d}^{-1})$ of bST.

^bMilk production was calculated from data obtained daily (d 15 to 49) for production over 5 h.

^cDoes were shorn on d 1, and fleece production was measured by shearing at d 49.

Table 3. Body weight, DMI, milk, and mohair production of lactating Angora does and ADG of their kids after bovine somatotropin (bST) treatment (d 50 to 79; Period 2)

Item	Treatment ^a		SEM	P <
	Control	bST		
Initial BW, kg	33.9	35.6	1.6	.47
Final BW, kg	34.0	35.8	1.7	.45
DMI, kg/d	1.9	1.9	.1	.92
Kid ADG, g/d	136	140	10	.75
Milk				
Production, mL/d ^b	922	1,008	130	.29
Fat, %	3.65	3.54	.92	.75
Protein, %	3.71	3.71	.34	.49
Lactose, %	4.89	4.85	.27	.72
Solids-not-fat, %	9.36	9.54	.67	.55
Mohair fiber ^c				
Grease fleece, g/d	22.2	22.4	1.5	.30
Clean fleece, g/d	18.6	17.6	1.6	.64
Staple length, $\mu\text{m}/\text{d}$	864	841	22	.48
Diameter, μm	38.6	39.1	1.3	.80

^aDoes (n = 7 per treatment) were injected s.c. with slow-release bST once weekly for 5 wk (d 15 to 49; Period 1) or received no treatment (control). The bST injection was calculated to deliver 100 $\mu\text{g}/(\text{kg BW}\cdot\text{d}^{-1})$ of bST.

^bMilk production was calculated from data obtained daily (d 50 to 79) for production over 5 h.

^cFleece production was measured from d 50 to 79.

tion in either Period 1 or 2 (Tables 2 and 3). No effect ($P > .10$) of bST was observed on grease or clean fleece production, staple length, or fiber diameter (Tables 2 and 3).

Blood Metabolites and Hormones

Concentrations of plasma NEFA, total protein, glucose, insulin, urea N, and amino acids were not affected ($P > .10$) by bST treatment (Tables 4, 5, and 6). During the period of bST treatment (Period 1), plasma concentrations of thyroxine and cortisol were decreased ($P < .10$) in bST-treated does (Table 4). Plasma concentrations of immunoreactive somatotropin were greater ($P < .05$) in bST-treated than in control does immediately before injection of the last (fifth) weekly injection of slow-release bST. Plasma levels of somatotropin were increased two- to threefold in treated does in the 1st 72 h after bST injection (Figure 1). Plasma concentrations of IGF-I were greater ($P < .06$) in bST-treated than in control does in the 1st 72 h after bST injection (Figure 2). Levels of IGF-I were not different ($P > .10$) between bST-treated and control does immediately before injection of the last weekly dose of slow-release bST or 72 h after.

Discussion

In this experiment, the weigh-suckle-weigh technique did not give an accurate measure of milk

production. It is apparent from the 32% increase in ADG of kids from the bST-treated does that milk production was increased. A 15% increase in milk production was observed during bST treatment, but, with the high standard error, this increase was not significant. The weigh-suckle-weigh technique has been recommended for measuring milk production in cattle (Williams et al., 1979) and pigs (Lewis et al., 1978). However, Pettigrew et al. (1985) stated that the weigh-suckle-weigh technique suffers several disadvantages. For example, the separation and reunification of mother and offspring may cause an excitement in the mother that inhibits normal milk ejection and in the offspring that may reduce nursing vigor. We observed that several does objected strongly to nursing their kids when their kids were put back into the pen with them after the period of separation. The kids also varied in their suckling; some were very persistent in demanding their milk as soon as they were back with their does, whereas others were passive. Therefore, kid ADG is probably a better indicator of actual milk production, particularly during Period 1 when kids were not consuming any of their dam's feed. No effort was made during the experiment to prevent kids from drinking or eating their dam's water and feed. However, it was only in the latter part of the experiment that kids were observed consuming any of the water and feed available. Sahlu et al. (1992) showed that Angora kids have very low dry feed DMI for the 1st 9 wk of life if milk is offered.

Table 4. Plasma concentrations of metabolites and hormones in Angora does taken before feeding during treatment with bovine somatotropin (bST) (d 15 to 49; Period 1)

Item	Treatment ^a		SEM	P <
	Control	bST		
Glucose, mg/dL	49.5	49.4	6.5	.99
Urea, mg/dL	17.9	20.1	1.2	.23
NEFA, mEq/L	140	104	16	.14
Total protein, g/L	71	74	2.1	.29
Thyroxine, μ g/dL	8.9	7.9	.08	.03
Insulin, μ U/mL	31.9	34.3	4.2	.69
Cortisol, μ g/dL	.83	.53	.06	.10

^aDoes (n = 7 per treatment) were injected s.c. with slow-release bST once weekly for 5 wk (d 15 to 49; Period 1) or received no treatment (control). The bST injection was calculated to deliver 100 μ g/(kg BW·d⁻¹) of bST.

The increase in ADG of the kids on bST-treated does was affected without change in DMI or BW of does. Similar responses in milk yield by lactating dairy cows without corresponding increase in DMI have been reported by Peel and Bauman (1987), Downer et al. (1993), and Bareille et al. (1997). Also, Tyrrell et al. (1988) observed increased milk production of lactating dairy cows treated with bST concomitant with increased BW, attributing increased BW to differences in water retention. The magnitude of milk yield responses to sustained-release formulations of bST generally have been less than those observed with daily injectable formulations when comparisons are done for similar daily bST doses (Bauman et al., 1989; Green et al., 1989; McGuffey et al., 1991). Following cessation of bST treatment, the ADG of kids from does treated with bST was similar to that of kids from untreated does, which indicates no carryover effect of bST on milk production. The lack of carryover effects of bST treatment on milk production has been shown in earlier studies with cattle (Peel et al., 1985), sheep (Sandles et al., 1988), and dairy goats (Knight, 1992).

The lack of change in milk composition in bST-treated goats that we observed is consistent with

previous reports on goats (Nielsen, 1988) and cattle (Dahl et al., 1991; Schams et al., 1991). In some instances, milk fat has been reported to increase in response to bST treatment. McDowell et al. (1987) injected ewes in midlactation daily with 100 μ g/kg BW of bST for 5 d and increased yield of milk and milk fat content. Milk fat content also was increased in dairy cattle treated with bST (McGuire et al., 1992).

The lack of a bST effect on mohair fiber growth has been observed previously (Davis et al., 1995). Those authors reported that 6-mo-old Angora kids responded to bST treatment by increasing ADG but that mohair fiber growth was not affected. However, mature Angora wethers showed no metabolic or mohair production responses to bST treatment (Davis et al., 1994). Studies with nonpregnant and nonlactating sheep showed that bST treatment increased wool growth either during (Johnsson et al., 1985, 1987) or following the period of treatment (Wheatley et al., 1966; Reklewska, 1974; Wynn et al., 1988). Stelwagen et al. (1994) treated pregnant ewes between 97 and 124 d of gestation with daily injections of bST and observed that wool growth was not significantly increased and that maternal gain, gross skeletal measurements, and fetal growth and development were unaffected by bST treatment.

Table 5. Plasma concentrations of metabolites in Angora does before feeding in the period after treatment with bovine somatotropin (bST) (d 50 to 79; Period 2)

Item	Treatment ^a		SEM	P <
	Control	bST		
Glucose, mg/dL	58.0	58.3	2.1	.93
Urea N, mg/dL	18.1	20.8	1.2	.14
NEFA, mEq/L	195	140	29	.20
Total protein, g/L	70	75	2.4	.23

^aDoes (n = 7 per treatment) were injected s.c. with slow-release bST once weekly for 5 wk (d 15 to 49; Period 1) or received no treatment (control). The bST injection was calculated to deliver 100 μ g/(kg BW·d⁻¹) of bST.

Table 6. Plasma amino acid concentrations of lactating Angora does before feeding during the period of treatment with bovine somatotropin (bST; Period 1)

Item	Treatment ^a		SEM	P <
	Control	bST		
	μmol/L			
Essential				
Lys	127	104	16	.14
Met	31	42	6	.21
Val	485	441	20	.61
Ile	184	186	15	.94
Leu	292	249	26	.39
Phe	92	94	8	.90
Thr	210	216	19	.87
Arg	400	399	31	.97
Nonessential				
Ser	124	222	77	.35
Gly	1,099	995	106	.28
Ala	349	382	18	.21
Tyr	106	144	29	.38

^aDoes (n = 7 per treatment) were injected s.c. with slow-release bST once weekly for 5 wk (d 15 to 49; Period 1) or received no treatment (control). The bST injection was calculated to deliver 100 μg/(kg BW·d⁻¹) of bST.

No changes in plasma concentration of glucose, total protein, NEFA, or urea were observed in response to bST treatment. Sechen et al. (1989a) reported that treatment of cows with bST increased milk yield and plasma concentration of NEFA but that there were no changes in plasma concentrations of glucose, insulin, or glucagon. In their study, the increase in milk energy secretion caused the cows to be in negative energy balance, which resulted in a chronic elevation of circulating concentration of NEFA. Changes in plasma concentration and increased oxidation of NEFA have been reported in dairy cows that were in negative energy balance during bST treatment (Bauman et al., 1988; Sechen et al., 1989b). The decreases in plasma concentration of thyroxine and cortisol observed in bST-treated goats in this study are contrary to results of Wynn et al. (1988), who found no consistent changes in plasma concentration of thyroxine or cortisol in response to growth hormone treatment in sheep. The lack of response in plasma concentration of insulin to bST treatment has been observed in goats and sheep by McDowell et al. (1987) and in dairy cattle by Sechen et al. (1989a). No changes in plasma amino acid levels were observed due to bST treatment. In a previous study with Angora kids that were treated with bST (Davis et al., 1995), we observed an increase in ADG with no accompanying change in plasma amino acid concentrations.

Weekly injection of slow-release bST produced a chronic increase in plasma somatotropin but a tem-

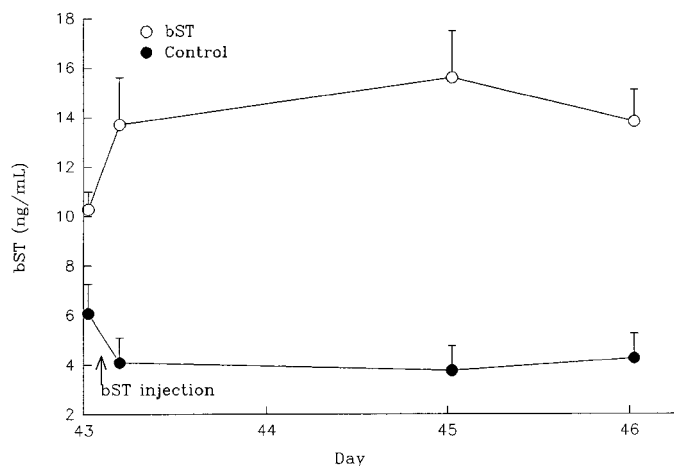


Figure 1. Mean plasma (\pm SE) concentration of somatotropin (bST) in Angora does treated with 0 or 100 μg/(kg BW·d⁻¹) of bST. Samples were obtained before feeding in the fifth week of treatment with bST.

porary (2 to 3 d) postinjection increase in plasma IGF-I in goats in this study. Both plasma somatotropin and IGF-I were elevated chronically when goats were injected daily with 100 μg/kg BW of bST (Davis et al., 1995), an amount equivalent to the presumed daily release rate of bST from the slow-release form of bST used in the present study. The milk yield of goats in this study was unchanged despite an increase in plasma somatotropin and IGF-I. Other workers reported either an increase in milk yield coincident with increased plasma IGF-I (Prosser et al., 1990) or increased plasma IGF-I without change in milk yield (Nielsen et al., 1990).

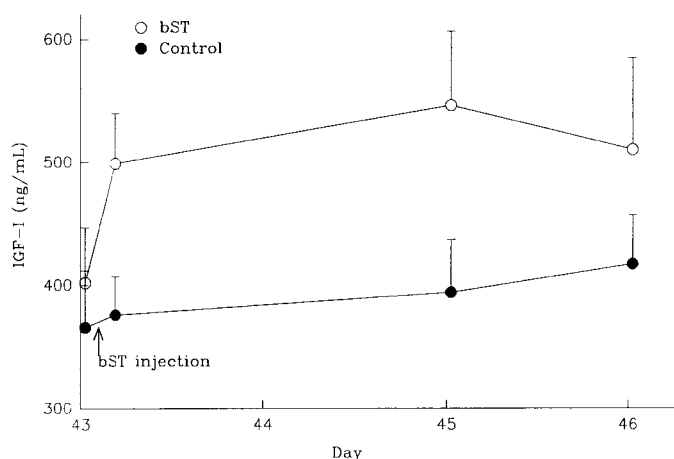


Figure 2. Mean plasma (\pm SE) concentration of IGF-I in Angora does treated with 0 or 100 μg/(kg BW·d⁻¹) of bovine somatotropin (bST). Samples were obtained before feeding in the fifth week of treatment with bST.

Implications

These results do not depict a potential for enhancing mohair production through slow-release bovine somatotropin treatment of Angora does. Growth by suckling kids may be enhanced, although the cost-effectiveness of the treatment is unknown.

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