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Effects of bovine somatotropin and thyroid hormone status on hormone levels, body weight gain, and mohair fiber growth of Angora goats^{1,2}

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ABSTRACT: Forty-eight Angora goats (24 wethers and 24 doelings; 5 mo old; 16 ± 0.5 kg initial BW) were used in an experiment with a 2×3 factorial treatment arrangement ($n = 8$) to evaluate effects of recombinant bovine somatotropin (bST) administration and thyroid hormone status (euthyroid, hypothyroid, and hyperthyroid) on hormone levels, ADG, and mohair fiber growth. The bST was a slow-release zinc-based suspension, with sustained delivery ($100 \mu\text{g}/[\text{kg BW}\cdot\text{d}]$) over a 14-d period. Hyperthyroidism was maintained by daily treatment with thyroxine (T_4 ; $150 \mu\text{g}/[\text{kg BW}\cdot\text{d}]$), and hypothyroidism was achieved by feeding $6 \text{ mg}/(\text{kg BW}\cdot\text{d})$ of propylthiouracil. The experiment was conducted in July to September and consisted of a 2-wk pretreatment period and 8 wk of bST treatment. Goats were given ad libitum access to a diet with 15% CP and 2.54 Mcal/kg ME (DM basis). Concentrations of T_4 and T_3 were greatest ($P < 0.01$) among treatments for hyperthyroid-bST and hyperthyroid-control (T_4 : 38.6 and 38.0 $\mu\text{g}/\text{dL}$; T_3 : 406 and 385 ng/dL, respectively); similar among euthyroid-control, euthyroid-bST, and hypothyroid-bST (T_4 : 11.1, 11.5, and 9.8 $\mu\text{g}/\text{dL}$, respectively; T_3 : 232, 252, and 226 ng/dL, respectively); and lowest ($P < 0.01$)

for hypothyroid-control (T_4 : 5.1 $\mu\text{g}/\text{dL}$; T_3 : 144 ng/dL). Plasma concentration of insulin-like growth factor-I was greatest ($P < 0.01$) for euthyroid-bST (596 ng/mL) and hypothyroid-bST (618 ng/mL); however, concentration for hyperthyroid-bST was similar to those for euthyroid-control, hypothyroid-control, and hyperthyroid-control (188, 178, 187, and 191 ng/mL, respectively). Dry matter intake was greatest ($P < 0.05$) for euthyroid-bST (794 g/d), similar among hypothyroid treatments (693 and 703 g/d for control and bST, respectively) and euthyroid-control (681 g/d), and lowest for hyperthyroid groups (554 and 518 g/d for control and bST, respectively); ADG for hyperthyroid goats (11 g/d) was lower than with hypothyroidism and euthyroidism (72 and 73 g/d, respectively); and mohair fiber growth was greater ($P < 0.01$) for hyperthyroidism (0.133 g/[100 $\text{cm}^2\cdot\text{d}$]) than for hypothyroid and euthyroid goats (0.102 and 0.104 g/[100 $\text{cm}^2\cdot\text{d}$], respectively). Hyperthyroidism also increased mohair length growth rate by 15% and decreased fiber diameter by 7.8% ($P < 0.01$). These results demonstrate interactions between growth hormone administration and thyroid hormone status, although these influences had limited effects on ADG and mohair fiber growth.

Key Words: Angora, Goat Breeds, Somatotropin, Thyroid Hormones

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Introduction

Thyroidectomy has depressed wool growth (Ferguson et al., 1965) and thyroxine administration has had positive effects (Hart, 1957), although the exact mode of action of thyroid hormones is unknown and comparable effects on mohair fiber growth by Angora goats have not been established. Growth hormone (GH) and bovine somatotropin (bST) have had variable effects on wool

growth. For example, Wynn et al. (1988) reported that wool growth was depressed during a period of GH administration. In contrast, Reklewska (1974) and Johnson et al. (1985, 1987) noted markedly greater wool growth during periods of bST injection. Our previous research with Angora goats (Davis et al., 1999a,b) showed that mohair fiber growth was unaffected by treatment with GH or recombinant bST, but ADG was increased. Variations in responses have been ascribed to differences in genotype, age, nutrition, and type of bST/GH used.

Indirect growth-promoting actions of GH are mediated by the generation of insulin-like growth factors (IGF). Philpott et al. (1994) found that IGF-I stimulates in vitro hair follicle growth. In vivo, there is a complex relationship between the thyroid and pituitary GH/IGF axes. Hence, the lack of effect of bST on mohair fiber

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growth by Angoras noted by Davis et al. (1999a,b) may be attributable to interaction or antagonism between IGF and thyroid hormones.

Miell et al. (1994) investigated effects of both withdrawal and reinstatement of thyroid hormones on circulating IGF and IGF-binding protein concentrations in humans. Mean IGF-I, IGF-II, and IGF-binding protein-I concentrations decreased 5 wk after cessation of thyroxine treatment and returned to normal 3 wk after the start of replacement treatment. Relationships between thyroid hormones and GH/IGF appear important in anabolic actions of the GH/IGF system. Therefore, our objective was to investigate effects of thyroid hormone status and bST treatment on hormone levels, ADG, and mohair fiber growth in Angora goats.

Materials and Methods

Animals and Treatments

Forty-eight Angora goats (24 wethers and 24 doelings; 5 mo old; 16 ± 0.5 kg initial BW) were used in an experiment with a 2×3 factorial arrangement of treatments ($n = 8$, 4 wethers and 4 doelings) to determine effects of recombinant bST administration (0 and 100 $\mu\text{g}/[\text{kg BW}\cdot\text{d}]$) and thyroid hormone status (euthyroid, hypothyroid, and hyperthyroid) on hormone levels, ADG, and mohair fiber growth. The bST was a slow-release zinc-based suspension designed for sustained delivery of 100 $\mu\text{g}/[\text{kg BW}\cdot\text{d}]$ of bST over a 14-d period. The bST was administered at 2-wk intervals by subcutaneous injection at 1000. Hyperthyroidism was maintained by daily subcutaneous injection of thyroxine (150 $\mu\text{g}/[\text{kg BW}\cdot\text{d}]$); and hypothyroidism, by dietary supplementation with propylthiouracil (6 mg/[kg BW·d]). The level of thyroxine (T_4) administered was based on work of Weekes (1992) with daily T_4 administration of 150 $\mu\text{g}/\text{kg BW}$ to sheep and of Fowles et al. (1997) with daily T_4 levels of 125 to 500 $\mu\text{g}/\text{kg BW}$ to ducks. The daily propylthiouracil level was chosen based on work with sheep by Achmadi and Terashima (1995) and Sokkar et al. (2000) with levels of 4 to 8 and 5 mg/kg BW, respectively.

The experiment was conducted in July to September and consisted of a 2-wk pretreatment period and 8 wk of bST treatment. Goats were given ad libitum access to a 15.0% CP and 2.54 Mcal/kg ME diet (DM basis; Table 1) and were housed in elevated, individual indoor stalls under ambient temperature and lighting. Propylthiouracil was given during the entire 10-wk period, whereas thyroid status and bST treatments were applied in the 8 wk following the pretreatment period.

Sampling and Analyses

Feed intake was recorded daily, and BW was measured weekly prior to feeding. The diet was sampled throughout the trial and analyzed for DM (100°C), CP (Technicon Instrument Co., Tarrytown, NY), and ADF

Table 1. Composition of the diet consumed by Angora goats

Item	Concentration
Ingredient, % DM	
Cottonseed hulls	33.0
Ground corn	19.0
Oats	20.5
Soybean meal	15.0
Alfalfa meal	10.9
Trace mineralized salt ^a	0.5
Calcium carbonate	0.9
Vitamin premix ^b	0.2
Nutrient composition	
CP, % DM	14.96
ADF, % DM	25.3
ME ^c , Mcal/kg DM	2.54

^aContained 94 to 95% NaCl and > 0.2% Mn, 0.16% ferrous Fe, 0.14% ferric Fe, 0.033% Cu, 0.10% Zn, 0.007% I, and 0.005% Co.

^bContained 2,200 IU/g vitamin A, 2,200 IU/g vitamin D, and 0.2 IU/g vitamin E (air-dry basis).

^cCalculated (NRC, 1981).

(Goering and Van Soest, 1970). Goats were shorn at the beginning of the pretreatment period and at the end of the experiment. A fleece sample from the mid-side was collected, and clean mohair yield and staple length were determined according to ASTM (1988) standards, with fiber diameter determined using the Optical Fibre Diameter Analyzer (BSC Electronics, Myaree, Australia). Blood samples were obtained before feeding via jugular venipuncture at 2-wk intervals throughout the trial; tubes were immediately chilled in an ice bath, transported to the laboratory, and centrifuged for 20 min at $1,500 \times g$ and 4°C. Aliquots of plasma were stored at -20°C until analysis. 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 and glucose were measured colorimetrically using a Technicon Autoanalyzer II System (Technicon Instruments, Tarrytown, NY). Plasma concentrations of insulin and thyroid hormones were determined with kits from ICN Biomedicals, Inc. (Costa Mesa, CA) validated for goats. The radioimmunoassay for IGF-I was carried out using a kit from Diagnostic System Laboratories (DSL-5600, Webster, TX). Insulin-like growth factor-I was separated from binding proteins using an ethanolic HCl method. Intraassay coefficients of variation were 5.9% for triiodothyronine (T_3), 6.2% for T_4 , 6.9% for insulin, and 7.3% for IGF-I. Amino acid analyses were performed using a Hewlett Packard AminoQuant system (Wilmington, DE; Puchala et al. 1995).

Statistical Analyses

Data were initially analyzed as a $2 \times 2 \times 3$ factorial arrangement of treatments and a completely randomized design using the GLM of SAS (SAS Inst. Inc., Cary, NC). The model included gender (wether and female),

bST level (0 and 100 $\mu\text{g}/[\text{kg BW}\cdot\text{d}]$), thyroid status (euthyroid, hypothyroid, and hyperthyroid), and their interactions. Effects of gender and interactions involving gender were nonsignificant ($P > 0.05$) and, thus, were dropped from the model. Blood parameters were analyzed as a split plot in time; however, there were no significant interactions of sampling time ($P > 0.05$). When the effect of thyroid status or the interaction between bST level and thyroid hormone status was significant ($P < 0.05$), means were separated by least significant difference procedures.

Results

There were interactions ($P < 0.01$) between bST and thyroid hormone status in plasma concentrations of T_4 , T_3 , and IGF-I (Table 2). Concentrations of T_4 and T_3 were greatest ($P < 0.01$) among treatments for hyperthyroid-bST and hyperthyroid-control; similar among euthyroid-control, euthyroid-bST, and hypothyroid-bST; and lowest ($P < 0.01$) for hypothyroid-control. Plasma IGF-I concentration was greatest ($P < 0.01$) among treatments for euthyroid-bST and hypothyroid-bST, but IGF-I was similar among hyperthyroid-bST and the three control treatments.

There were no treatment effects on plasma NEFA, glucose, or urea concentrations (Table 3). Thyroid status influenced plasma concentrations of some amino acids. Plasma Glu, Ser, Gly, and Phe concentrations were greater, and Arg and Lys levels were lower for hyperthyroid groups vs euthyroid and hypothyroid groups ($P < 0.05$).

Thyroid status influenced ($P < 0.05$) ADG, mohair fiber growth, and DMI (Table 4). Average daily gain was lower ($P < 0.01$) for hyperthyroid than for hypothyroid and euthyroid goats. Mohair fiber growth and mohair length growth rate were greater ($P < 0.01$) for hyperthyroid than for hypothyroid and euthyroid goats. Mohair diameter was lower ($P < 0.01$) for hyperthyroid than for hypothyroid and euthyroid goats. Dry matter intake was greatest ($P < 0.05$) among treatments for the euthyroid-bST, similar among hypothyroid treatments and euthyroid-control, and lowest ($P < 0.01$) for hyperthyroid treatments.

Discussion

Plasma Constituent Concentrations

Because propylthiouracyl decreased T_4 and T_3 concentrations without but not with bST, the bST prevented propylthiouracyl from blocking iodination of thyroglobulin and(or) systemic conversion of T_4 to T_3 . However, increased pituitary gland production of thyroid-stimulating hormone in response to GH treatment is also possible (Iglesias et al., 2000). In the present experiment, hypothyroidism did not affect IGF-I concentration regardless of bST administration. Similarly, Elsasser et al. (1993) noted that propylthiouracyl increased plasma thyroid-stimulating hormone and decreased plasma T_4 and T_3 , but had no influence on IGF-I with Hereford steers. Conversely, De Gennaro-Colonna et al. (1991) observed that thyroid hormone deficiency in young rats reduced plasma GH and IGF-I concentrations, and they concluded that low plasma IGF-I concentrations are related to thyroid hormone deficiency.

The lack of an effect of bST on IGF-I in the hyperthyroid state also reflects interrelationships of thyroid status and GH status/bST administration. In this regard, T_4 administration may have increased GH excretion; Murao et al. (1994) observed greater urinary GH levels in hyperthyroid patients than in those maintained in euthyroid or hypothyroid states. However, nutritional status is an important regulator of circulating concentrations of IGF-I as well. Reduced feed intake by lactating cows decreased serum IGF-I (McGurie et al., 1995). Therefore, lower feed intake by hyperthyroid goats than for goats in euthyroid or hypothyroid states may have contributed to the lack of response in IGF-I to bST.

Similar to results of the present experiment, Achmadi and Terashima (1995) decreased plasma concentrations of T_4 and T_3 in sheep treated with propylthiouracyl, but neither insulin function nor plasma concentrations of insulin or glucose were affected. Therefore, changes in circulating T_4 and T_3 concentrations may not interfere with the ability of insulin to stimulate tissue uptake of glucose or suppress endogenous glucose release.

Table 2. Effects of bovine somatotropin (bST) administration and thyroid hormone status on plasma concentrations of thyroxine (T_4), triiodothyronine (T_3), insulin-like growth factor-I (IGF-I), and insulin in Angora goats

Item	Euthyroid		Hypothyroid ^a		Hyperthyroid ^a		SE	Effect, <i>P</i> -value		
	Control	bST ^a	Control	bST	Control	bST		Thyroid status	bST	Interaction
T_4 , $\mu\text{g}/\text{dL}$	11.1 ^c	11.5 ^c	5.1 ^d	9.8 ^c	38.0 ^b	38.6 ^b	0.7	0.001	0.003	0.01
T_3 , ng/dL	232 ^c	252 ^c	144 ^d	226 ^c	406 ^b	385 ^b	12	0.001	0.01	0.01
IGF-I, ng/mL	178 ^c	596 ^b	187 ^c	618 ^b	191 ^c	188 ^c	15	0.01	0.01	0.01
Insulin, $\mu\text{U}/\text{mL}$	28.6	38.5	37.8	40.6	34.6	32.6	7.4	0.99	0.59	0.42

^aHyperthyroidism: daily subcutaneous injection of thyroxine (150 $\text{g}/[\text{kg BW}\cdot\text{d}]$); hypothyroidism: dietary supplementation with propylthiouracyl (6 $\text{mg}/[\text{kg BW}\cdot\text{d}]$); bST: slow-release zinc-based suspension designed for sustained delivery of 100 $\mu\text{g}/[\text{kg BW}\cdot\text{d}]$.

^{b,c,d}Within a row, means lacking a common superscript letter differ ($P < 0.05$).

Table 3. Effects of bovine somatotropin (bST) administration and thyroid hormone status on plasma concentrations of NEFA, glucose, urea, and amino acids in Angora goats

Item	Euthyroid		Hypothyroid ^a		Hyperthyroid ^a		SE	Effect, <i>P</i> -value		
	Control	bST ^a	Control	bST	Control	bST		Thyroid status	bST	Interaction
	NEFA, mEq/L	123	125	119	121	97		112	9	0.08
Glucose, mg/dL	60.1	62.2	61.1	62.5	60.5	58.7	2.2	0.63	0.73	0.67
Urea, mg/dL	9.4	8.7	9.3	8.5	8.1	7.9	0.7	0.10	0.20	0.87
Amino acids, μ M										
Glu	282 ^c	270 ^c	266 ^c	282 ^c	359 ^b	340 ^b	19.1	0.01	0.58	0.12
Ser	210 ^c	210 ^c	219 ^c	202 ^c	274 ^b	252 ^b	12.0	0.05	0.11	0.79
Gly	742 ^c	759 ^c	797 ^c	795 ^c	1,025 ^b	992 ^b	48.1	0.01	0.26	0.71
Arg	185 ^b	196 ^b	174 ^b	178 ^b	130 ^c	122 ^c	11.6	0.01	0.76	0.75
Phe	46 ^c	46 ^c	42 ^c	45 ^c	52 ^b	52 ^b	2.1	0.01	0.22	0.58
Lys	95 ^b	107 ^b	91 ^b	109 ^b	66 ^c	59 ^c	9.7	0.01	0.32	0.44
Met	24	28	23	28	25	25	2.5	0.83	0.16	0.47
Val	215	218	224	219	206	213	17.3	0.11	0.18	0.45
Ileu	74	78	79	82	70	76	6.6	0.07	0.37	0.51
Leu	113	114	115	112	103	105	10.7	0.24	0.42	0.74
Thr	98	102	103	103	106	109	8.8	0.53	0.44	0.89
His	65	73	61	63	70	61	4.2	0.33	0.90	0.11

^aHyperthyroidism: daily subcutaneous injection of thyroxine (150 g/[kg BW·d]); hypothyroidism: dietary supplementation with propylthiouracil (6 mg/[kg BW·d]); bST: slow-release zinc-based suspension designed for sustained delivery of 100 μ g/(kg BW·d).

^{b,c,d}Within a row, means lacking a common superscript letter differ ($P < 0.05$).

DMI and ADG

The administration of bST has not affected the DMI of Angora goats (Davis et al., 1999a,b), whereas recently bST decreased the DMI of beef cattle (Holzer et al., 2000). Treatment with thyroid hormones usually increases feed intake (Hart, 1957; Abid et al., 1999), although feed intake was lower for hyperthyroid than euthyroid broiler chickens (Decuyper et al., 1987). In the present experiment, bST administration increased DMI only in euthyroid goats, and T₄ treatment decreased intake regardless of bST administration. The effect of hyperthyroidism on intake may have involved the combination of increased metabolic rate, with consequent greater heat production and unusually high ambient temperature during the experiment (Leng, 1990; Hahn, 1995); the average daily high temperature during the 8-wk experimental period was 35.4°C.

In accordance with the tendency for increased ADG with bST administration to euthyroid and hypothyroid goats, Davis et al. (1999a,b) increased the ADG of Angoras by bST administration. The trend for an effect of bST on the ADG of euthyroid goats corresponds to the increase in DMI. Conversely, the tendency for greater ADG by hypothyroid goats with than without bST was not associated with increased intake. Hence, it appears that bST treatment of hypothyroid goats improved the efficiency of feed utilization. Although concentrations of T₃ and T₄ did not differ significantly between euthyroid-bST and hypothyroid-bST, levels were numerically lower for hypothyroid-bST. Thus, it is possible that there were corresponding differences in metabolic heat production and energy used for maintenance. However, any such effect of propylthiouracil administration was not evident without bST. Wagner and Veenhuizen (1978) also failed to stimulate lamb growth rate through

Table 4. Effects of bovine somatotropin (bST) administration and thyroid hormone status on DMI, ADG, and mohair fiber growth in Angora goats

Item	Euthyroid		Hypothyroid ^a		Hyperthyroid ^a		SE	Effect, <i>P</i> -value		
	Control	bST	Control	bST	Control	bST		Thyroid status	bST	Interaction
	DMI, g/d	681 ^c	794 ^b	693 ^c	703 ^c	554 ^d		518 ^d	38.3	0.01
ADG, g/d	63.3 ^b	80.9 ^b	63.9 ^b	80.8 ^b	18.6 ^c	4.0 ^c	8.17	0.01	0.24	0.11
Mohair fiber growth, g/(100 cm ² ·d)	0.103 ^c	0.106 ^c	0.105 ^c	0.100 ^c	0.134 ^b	0.133 ^b	0.0053	0.01	0.85	0.84
Mohair length growth rate, μ m/d	804 ^c	752 ^c	799 ^c	773 ^c	914 ^b	923 ^b	30.1	0.01	0.31	0.56
Fiber diameter, μ m	26.6 ^b	27.6 ^b	27.4 ^b	26.4 ^b	24.4 ^c	25.0 ^c	0.53	0.01	0.48	0.14

^aHyperthyroidism: daily subcutaneous injection of thyroxine (150 g/[kg BW·d]); hypothyroidism: dietary supplementation with propylthiouracil (6 mg/[kg BW·d]); bST: slow-release zinc-based suspension designed for sustained delivery of 100 μ g/(kg BW·d).

^{b,c,d}Within a row, means lacking a common superscript letter differ ($P < 0.05$).

the administration of exogenous thyroid hormones, and Thrift et al. (1999) depressed the ADG of Brahman heifers by T₃ administration.

Lower ADG for hyperthyroid vs euthyroid and hypothyroid states appeared to be primarily a function of lower feed intake and is not explained by greater mohair fiber growth. In support, based on whole-body mohair fiber production calculated by applying a surface area equation for Merino sheep (surface area, $m^2 = 0.094 \times BW^{0.67}$; Bennett, 1973), assuming 90% of the surface area to be fiber-producing and the use of initial BW, mohair fiber growth for hyperthyroid goats was approximately 7 g/d. Based on NRC (1981), a difference in DMI of 165 g/d yields an expected ADG difference of approximately 55 g/d. These differences are similar to those between hyperthyroid, euthyroid, and hypothyroid states.

Mohair Fiber Growth

As observed in present study and in our previous study (Davis et al., 1999a,b), mohair fiber growth was not influenced by bST administration and elevated plasma IGF-I. An in vitro study by Philpott et al. (1994) suggested that IGF-I might be an important physiological regulator of hair growth and possibly the hair growth cycle. Philpott et al. (1994) observed that IGF-I did not affect hair follicle growth when maintained in the presence of insulin. However, in the absence of insulin, both IGF-I and IGF-II stimulated hair follicle growth in a dose-dependent manner. Insulin-like growth factor-I was more potent than either insulin or IGF-II in stimulating maximum rates of hair follicle growth. Edwards et al. (1995) observed that skin infusion with a variant of IGF-I, long-Arg3-IGF-I (LR3IGF-I), reduced plasma concentrations of glucose, oxygen, and amino acids (especially tyrosine, valine, and lysine) in well-fed castrated Romney sheep. In addition, blood flow and oxygen uptake were elevated, and total uptake of phenylalanine for skin protein synthesis, measured using [³H]phenylalanine uptake, was increased after 24 h of infusion. However, after 21 d of infusion, there was no effect of LR3IGF-I on wool follicle bulb cell mitotic rate, bulb diameter, or wool production. The authors suggested that this lack of change in wool production resulted from down-regulation of type-I IGF-I receptors in the follicle. However, the lack of long-term effect also can be attributed to changes in thyroid hormone concentrations (Deyssig et al., 1993).

Insulin-like growth factor-I elicits biological activity (differentiation, growth) by binding to specific membrane-bound receptors; the affinity of type-I IGF receptors is generally as follows: IGF-I > IGF-II > insulin. The affinity of type-II IGF receptors is greater for IGF-II than for IGF-I, without binding of insulin (Baumrucker et al., 1994). Nixon et al. (1997) observed that, in the skin of Wiltshire sheep, IGF-I binding increased in late anagen/early catagen and was highest in catagen. This may have contributed to why in experiments

such as the present one and that of Davis et al. (1999a,b), conducted in anagen, elevated IGF-I did not improve mohair fiber growth. In skin perfusion experiments with Angora goats, Pierzynowski et al. (1997) and Puchala et al. (1995) observed that skin has a high capacity to bind insulin; therefore, it is possible that insulin may also bind to IGF-I receptors, not allowing IGF-I to elicit biological effects. Observations of Philpott et al. (1994) support the concept that the presence of insulin in the incubation media blocked the effect of IGF on hair follicle growth. In addition, Murphy et al. (1988) suggested that IGF-I is also very sensitive to prolactin, one of the key hormones regulating fiber growth. Prolactin receptors have been identified in sheep skin (Choy et al., 1995) in locations similar to IGF-I immunoreactivity. Hence, prolactin could act directly on the follicle to trigger follicular cycles, and IGF-I may mediate the cellular growth response.

The magnitude of impact of hyperthyroidism on mohair fiber growth was appreciable, particularly considering relatively low feed intake and ADG. Increased mohair fiber growth in hyperthyroid goats was due to increased length growth; however, fiber diameter was reduced. Therefore, it is possible that hyperthyroidism also increased the number of active fiber follicles. Thyroid hormones influence not only the maturation of follicles (Ferguson et al., 1956; Hopkins and Thorburn, 1972) but also the rate of fiber production in adult animals (Hart, 1957; Labban, 1957; Ferguson et al., 1965). Thyroidectomy depressed wool growth by approximately 60%, largely by decreased fiber length growth (Ferguson et al., 1965). Likewise, the administration of T₄ to intact sheep elevated wool growth as a consequence of increased fiber length (Hart, 1957). The mode of action of T₄ on wool growth is unclear, although Hynd (1989) indicated that thyroidectomy decreased cell division with no change in the dimension of fully keratinized cortical cells. There is no information available concerning the mode of action of thyroid hormones in mohair follicles; however, the role of these hormones in other tissues suggests involvement in protein accretion or energy metabolism (Bender, 1984). Puchala et al. (1998), using a skin perfusion technique with Angoras, observed that thyroid hormones decreased concentrations of free amino acids in blood leaving the perfused area, suggesting increased amino acid uptake by skin tissue.

Implications

Bovine somatotropin has been shown to be active in goats. There is a complex interaction between exogenous growth hormone administration and thyroid hormone status in Angora goats. Treatment with bovine somatotropin blocked the effects of propylthiouracyl, allowing maintenance of normal concentrations of thyroid hormones. Also, treatment with thyroxine prevented an increase in insulin-like growth factor-I plasma concentration due to bovine somatotropin. Ex-

ogenous growth hormone administration does not appear to influence mohair fiber growth, regardless of thyroid hormone status, and, thus, its effects may differ from those on other tissues and organs. The substantial effect of thyroxine administration on mohair fiber growth, despite decreased feed intake and live weight gain, implies a major role of thyroid hormone status.

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