INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
18F–008/2018/20–4–921–925
DOI: 10.17957/IJAB/15.0617
http://www.fspublishers.org

Full Length Article

Correlation Analysis of Cashmere Growth and Serum Levels of Thyroid Hormones in Hexi Cashmere Goats

Xiaoping Sun, Jianbin Liu, Yunxia Wei and Yaqin Gao*
Lanzhou Institute of Husbandry and Pharmaceutical Sciences of the Chinese Academy of Agricultural Sciences, Lanzhou 730050, China
*For correspondence: gaoyaqin@caas.cn

Abstract

The purpose of this study was to investigate the correlation between Cashmere growth and the changes of serum thyroid hormone levels in Hexi Cashmere goats in Western China. Forty (half male half female) six-month-old Hexi Cashmere goats with average body weight of 15.21 kg±0.61 kg were studied. The root of the wool was dyed black. Wool samples and blood samples were collected monthly. The thyroid hormones in the blood samples were measured by radioimmunoassay. Results showed shown that the Cashmere started growing in August and stopped in December. August was found to be the fastest growing month for Cashmere (accounting for 28.0% of the annual growth). Cashmere growth from August through November accounted for 91.0% of the annual growth. Cashmere growth gradually declined after August and had completely stopped by January. Assessments of serum thyroid hormone concentration showed that the concentration of T_3 exhibited seasonal variation. It started to rise each year in February and peaked in September (7.52 ng/mL ± 1.24 ng/mL). Then it gradually declined until the following February, when it reached the lowest value (3.77 ng/mL ± 0.85 ng/mL) and the cycle was repeated. The serum T_3 concentration was lowest in winter, moderate in spring and fall, and highest in summer. The T_3 concentration was significantly higher in summer than in winter (P<0.01). The average T_3 concentration was positively correlated with Cashmere growth during its peak period from August to December (r=0.955, P=0.011), which suggested that thyroid hormones are important for the germination and growth of Cashmere. © 2018 Friends Science Publishers

Keywords: Western China; Hexi Cashmere goat; growth and development; thyroid hormones; correlation study

Introduction

Hexi Cashmere goats live in China's Hexi Corridor, in areas with desert, semi-desert steppe, and the Gobi ecological conditions. It is an ancient and precious local variety that has gone through natural selection and artificial breeding. It is one of China's major Cashmere goat species, and the earliest named outstanding local variety. Most Hexi Cashmere goats are usually black or white. Their wool, meat, and hides all have practical uses. They are mainly distributed in Hexi Corridor in Gansu Province, Western China. They are allowed to graze in pastoral areas and are fed manually in agricultural areas. They are strongly adaptable within alpine climates and are resistant to crude feed and have strong resilience and other characteristics very useful in Cashmere goats. Hexi Cashmere goats have sound constitution and compact, well-proportioned bodies. They look rectangular from the side, with slightly higher hindquarters than the front and handsome faces. The male goats all have horns, which are thick and cross-shaped. Some female goats have horns. These are small and extended upwards. Female goats have straight forelimbs and mostly x-shaped hind limbs. Their coats consist of coarse hair and soft undercoat. Most goats are white in color (90%), but some are black, blue, brown, or mottled.

Cashmere growth is a complex physiological process that is affected by environment, nutrition, and metabolism. Many studies have focused on this matter. However, there is still a lack of convincing mechanistic studies on the regulation of Cashmere growth. The cyclical growth of Cashmere goat varies across different species and individuals, which indicates that genetics is the most important player in regulating Cashmere growth. Endocrine factors also play an important role in Cashmere growth. Environment and nutrition exert their function through changing the *in vivo* physiological conditions, i.e., gene expression and its downstream targets. Among them, melatonin, prolactin, thyroid hormone, and insulin-like growth factor-I play direct and indirect roles in regulating hair follicle activities. However, due to the complexity of hormone physiology in animals, the details of the mechanism underlying how hormones regulate Cashmere growth are still elusive (Villar *et al.*, 2000; Wei, 2008). In this way, investigating the mechanism underlying Cashmere growth and improving its production have become a hot topic.

To cite this paper: Sun, X., J. Liu, Y. Wei and Y. Gao, 2018. Correlation analysis of Cashmere growth and serum levels of thyroid hormones in Hexi Cashmere goats. *Int. J. Agric. Biol*., 20: 921−925

Thyroid hormones are secreted by the thyroid gland. They consist of thyroxine (also known as tetraiodothyronine, T_4) and triiodothyronine (T_3), both of which are low-molecular iodine amino acids. T_4 can be converted to T_3 by removing its 5′ iodine. Both T_3 and T_4 are biologically active, but the biological activity of T_3 is generally three to five times higher than that of T_4. It has been shown that thyroid hormones exert their function through the interaction of T_3 and nuclear receptor. It is still unknown how thyroid hormones impact Cashmere growth. Duan *et al.* (2015) study of the relationship between seasonal Cashmere growth and serum hormone secretion has shown that gender has no significant effect on Cashmere length. Blood thyroid hormone concentrations have been found to be higher in summer than in winter, and they have no regulatory effect on the cyclical growth of Cashmere. Another study by Corssac *et al.* (2016) has shown that thyroid hormones have no impact on the quality of Cashmere. However, Rhind *et al.* (1995) found that a positive correlation between Cashmere growth rate and plasma thyroid hormone (T_3, T_4) concentration. In the late 1990s, Villar *et al.* (1998) confirmed that Cashmere goat skin contains deiodinase (MD), and the follow-up study showed goat skin to be the major location of thyroid hormone metabolism. Thyroid hormone metabolism is directly correlated with MD activity. The controversies concerning these studies involve the complexity of hormone regulation. For this reason, the present study, which was aimed at investigating the correlation between Cashmere growth and serum thyroid hormone concentration in Hexi Cashmere goats, assessed the mechanism underlying Cashmere growth. These findings provide a reliable theoretical basis for improving Cashmere production.

Materials and Methods

Time and location: The investigation time spanned from June 25, 2010 to May 25, 2011 (the time between Cashmere germination and shedding). The test site was in Sunan County, Western Gansu Province, which has a 1400−5564 m altitude and 4−6°C average annual temperature.

Experimental animals and feeding strategy: Forty six-month-old Hexi Cashmere goats (20 male, and 20 female, average body weight 15.21 kg ± 0.61 kg) were tested. Natural light was maintained at the test site. Natural pastures and artificial supplements were both used to feed the goats.

Reagent: A hormone assay kit (i.e., RIA kit) was purchased from Beijing Northern Biotechnology Institute (China). This kit was designed to measure human serum and plasma hormone.

Sample collection: Before the beginning of the test (June 25), the Cashmere root on the central flank of the test goats was dyed black (approximately 10 cm × 10 cm). During the test, Cashmere samples were collected monthly on the 25^{th}. At the same time, around 9:00 a.m. to 10:00 a.m. on the 25^{th} of every month, 10 mL blood samples were collected by venipuncture. EDTA anticoagulant was added to the blood sample, and centrifuged at 4000 rpm/min for 15 min. Serum was aliquoted into two tubes and stored at -20°C.

Cashmere length: The samples were mixed thoroughly. Approximately 150 mg fiber was randomly drawn from both sides using a multi-point method (no fewer than 40 points) and evenly divided into three potions. Two potions were used for parallel testing and one potion was reserved for backup. The original Cashmere was washed and the length was measured by hand caliber according to GB18267-20005 <Goat Cashmere>.

Determination of hormone content and statistical analysis: Radioimmunoassay (RIA) was used to determine hormone concentration. The test was performed in Quality Supervising, Inspecting and Testing Center for Animal Fiber, Fur, Leather and Products (Lanzhou), Ministry of Agriculture in China. Data were analyzed using SPSS 11.5 and variance analysis using the Duncan method.

Results

Cashmere Growth

The growth rates of myelinated hair and Cashmere were different in different seasons. The current test showed that Cashmere in Hexi Cashmere goats started to grow in August and stopped growing in December. August is the fastest growing month for Cashmere (accounting for 28.0% of annual growth). The Cashmere growth from August through November accounted for 91.0% of the annual growth. Cashmere growth gradually declined after August and had completely stopped by January. The data are shown in Table 1 and Fig. 1.

Cashmere growth cycle is related with daylight cycle (Mcdonald *et al.,* 2001). When the daylight hours became shorter, Cashmere started to grow. While when the daylight hours became longer, Cashmere gradually stopped growing which was consistent with goat breeding cycle. In this study, the natural sunlight time gradually reduced from August to November, thus Cashmere growth gradually slowed down from August to November. Sunlight became longer after the winter solstice in December; Cashmere growth rate was decreased and came to a complete stop. Short sunlight time stimulated Cashmere growth. The Cashmere growth pattern was consistent with previous report; however, both the fast-growing time and peak growing time were advanced by 1−2 months compared to the pre-existing finding, which may be due to nutrition and factors other than sunlight.

Serum T_3 Concentration Variation in Cashmere Goat

Table 2 showed that average annual serum T_3 concentration in rams and ewes were 5.52 ng/mL ± 1.83 ng/mL, 5.42 ng/mL ± 2.09 ng/mL, respectively. Though the T_3 level was higher in rams, the difference was not significant (P>0.05). Because there was no variation across gender within the same month, data from rams and ewes were combined.

Table 1: Cashmere growth in Hexi Cashmere goats

Date	Actual Cashmere length (mm)	Increase of Cashmere length	
		Absolute increase of Cashmere length (mm)	Relative increase of Cashmere length (%)
2010-06-25	growth		
2010-07-25	slight growth		
2010-08-25	12.2 ± 4.8	12.2	28.3
2010-09-25	22.6 ± 6.7	10.4	24.1
2010-10-25	31.8 ± 9.3	9.2	21.2
2010-11-25	39.6 ± 12.4	7.8	18.1
2010-12-25	43.5 ± 11.3	3.9	9.0
2011-01-25	43.3 ± 10.6	−0.2	−0.4
2011-02-25	43.3 ± 4.2	0	0
2011-03-25	43.3 ± 4.2	0	0
2011-04-25	43.3 ± 4.2	0	0
2011-05-25	Shedding	0	0
Total		43.1	100

Table 2: Thyroid hormone concentration in Hexi Cashmere goat during difference months (ng/mL)

Month	Thyroid in ram	Thyroid in ewe	Total thyroid
6	6.17 ± 1.12	6.25 ± 1.86	6.21 ± 1.87^{ABb}
7	6.63 ± 1.76	6.22 ± 1.88	6.43 ± 1.51^{ABCDabc}
8	6.72 ± 1.41	6.79 ± 2.31	6.75 ± 2.33^{ABCabc}
9	7.78 ± 0.98	7.25 ± 1.45	7.52 ± 1.24^{Aa}
10	4.32 ± 1.28	4.96 ± 1.69	4.64 ± 1.49^{BCDEbcd}
11	4.71 ± 1.26	4.52 ± 1.71	4.61 ± 1.47^{BCDEcd}
12	4.09 ± 0.56	4.94 ± 1.66	4.52 ± 1.28^{CDEcd}
1	3.87 ± 0.89	3.99 ± 1.43	3.93 ± 1.16^{DEd}
2	3.76 ± 0.65	3.77 ± 1.04	3.77 ± 0.85^{Ed}
3	4.96 ± 1.54	5.30 ± 2.07	5.13 ± 1.85^{BCDabc}
4	5.68 ± 1.73	5.86 ± 2.88	5.77 ± 1.78^{Bab}
5	6.80 ± 2.04	5.90 ± 2.08	6.35 ± 2.06^{ABb}
Average	5.52 ± 1.83	5.42 ± 2.08	5.47 ± 1.96

Note: In the table, data in the same column with different capital letters indicated highly significant differences (P<0.01), data with different lowercase letters indicated significant differences (P<0.05), data with the same case letters indicate no significant differences (P>0.05)

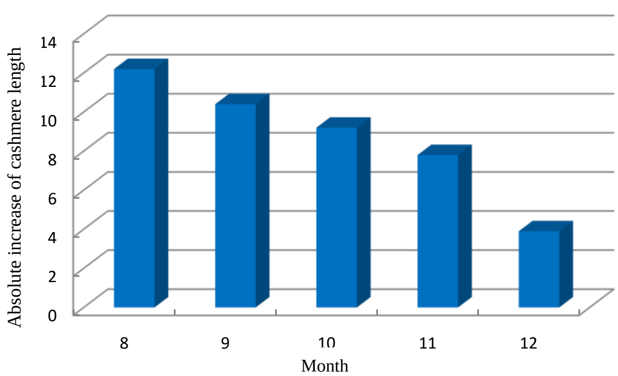

Fig. 1: Absolute increase of cashmere length in Hexi Cashmere goat

The results showed that T_3 concentration differed significantly across different months and different seasons (P<0.05, P<0.01). As shown in Fig. 2, starting from February, the concentration of T_3 began to rise and it peaked in September (7.52 ng/mL ± 1.24 ng/mL).

It gradually declined and reached the lowest in February (3.77 ng/mL ± 0.85 ng/mL), which completed the secretion cycle. T_3 concentration was the lowest in winter, moderate in spring and fall, and highest in summer. T_3 concentration in September were highly significantly higher than in January, February, March, April, October, November, or December (P<0.01) and was significantly higher than in May, June, and July (P<0.05). However, T_3 concentration in September showed no difference from that in August (P>0.05). The T_3 concentration in January, February, and December was very significantly lower than in May, June, July, August, or September (P<0.01). T_3 concentration in March and April was also lower than in June, July, and August (P<0.05). The seasonal trend showed T_3 concentration in summer to be very significantly higher than in winter (P<0.01) (Table 2). However, T_3 concentrations during the same season showed no significant difference (P>0.05).

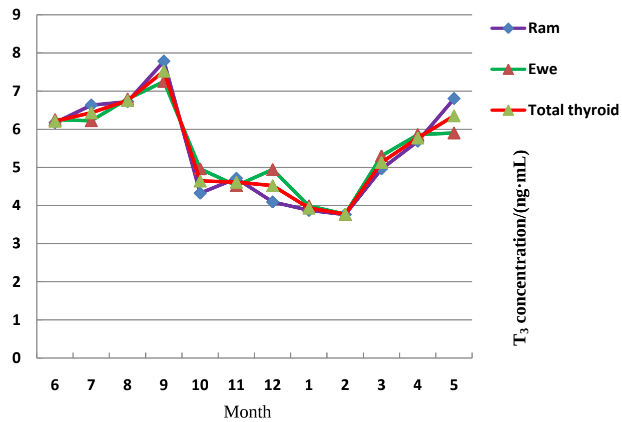

Fig. 2: Thyroid hormone concentration in Hexi Cashmere goat during difference months (ng/mL)

Thyroid Hormone (T_3) Concentration Change and Analysis of its Correlation with Cashmere Growth

Results showed that T_3 concentration began to rise after cessation of Cashmere growth. When Cashmere growth entered the fast-growing period, T_3 concentration reached its highest level, after which it started descending and hit its lowest the following February. It exhibited wavy changes. Five measures of Cashmere growth and the average T_3 concentration data were analyzed and a positive correlation was observed between T_3 concentration and Cashmere growth (r= 0.955, *P* =0.011).

Discussion

It is generally believed that as long as the supply of dietary nutrients exceeds the animal's subsistence needs, and the goat is a little overweight, the Cashmere production will be well maintained. Studies from former Soviet scholars on Orenburg goats showed that, Cashmere growth started in August, and was the fastest from October to December, and stopped growing by the end of December. The Cashmere production from August to November accounted for 88.6% of the total annual production. The Cashmere length increase from October to December accounted for 86% of the total Cashmere length. Observations in Hexi Cashmere goats showed that their Cashmere growth was similar to that in Orenburg goats. The Cashmere growth mainly occurred in fall and winter. Niu *et al. (*2005) found that, with the decline of the nutritional value of forage and diminishing of sunlight, Cashmere growth in Inner Mongolia Cashmere goats was gradually increased (from 0.5 cm to 3.5 cm) from August to November under grazing condition and natural sunlight (2000). It decreased to 1.6 cm in December. The primary growing season was from late September to early December. The peak period was in November (3.5 cm), which suggested that the Cashmere growth in Inner Mongolia Cashmere goats also exhibited a slow-fast-slow pattern. Reducing sunlight was found to promote Cashmere growth, so the fast-growing period shifted forward to late August, with a 10.9% increase of Cashmere growth and 12.5% more Cashmere production, but the Cashmere growth patterns remained the same.

Under grazing conditions, as the nutritional value of forage declines and sunlight diminishes sunlight, Cashmere began growing from June through July, and it continued growing in August, September, October, November, and December. Cashmere production was gradually decreased from August (12.2 mm) to December (3.9 mm), exhibiting slow-fast-slow growth mode. The primary growth season was from late August to early December, with the peak growing time in August (12.2 mm). This was synchronized with the grass growing season which was from August to October. The climate was warm, so it provided good conditions for the local goats to recover from winter and gain weight. It was also the time when the days started to shorten. The current results showed that the Cashmere growth patterns were basically consistent with those found in previous studies. However, the fast-growth and peak-growth seasons were both moved ahead by 1−2 months. The possible mechanism is still under further investigation.

Thyroid hormones are an important type of metabolic regulatory hormone in animals. It is speculated that thyroid hormones and Cashmere growth are closely related. Studies have demonstrated that the plasma levels of thyroid hormones increased as the hours of sunlight increased, and vice versa. This is consistent with the relationship between the rate of Cashmere growth and periodic variation of the light. In this way the Cashmere growth rate is generally believed to accelerate as thyroid hormone levels increases.

As early as the 1970s, it was reported that thyroid hormones failed to promote wool growth (Ryder, 1973). However, in the 1990s, researchers found that lack of thyroid hormone reduced the cell division rate in goat hair follicles, which caused a reduction in the rate of wool growth and wool production (White *et al.*, 1994). Park *et al.* (2016) reported that thyroid hormones had no impact on the wool quality. However, Rhind *et al.* (1995) found that wool growth rate was positively correlated with plasma concentration of thyroid hormones (T_3, T_4). Maddocks and Setchell (1988) found that removal of thyroid in the sheep slowed down the wool growth rate by 60%. However, supplementation of exogenous thyroid hormones restored sheep plasma thyroid hormones levels to 30% of normal, which was sufficient to bring wool growth back to normal. When plasma thyroid hormone levels were up to three times normal levels, and the wool growth rate was only slightly higher than the normal growth rate. This suggests that although thyroid hormones have a pronounced impact on wool growth, when plasma thyroid hormone levels reach a certain level, even if the concentration of thyroid hormones increased further, there would be only a slight increase in the rate of wool growth. However, the Cashmere fiber requires more triiodothyronine during germination and growth, which suggests that, in skin tissue, thyroid hormones (especially T_3) have important physiological significance in Cashmere germination and growth, which confirms that thyroid hormones are one of the more important hormones involved in Cashmere germination and growth (Yue and Jia, 2007).

The results of this experiment showed that, when the concentration of T_3 increased, the Cashmere growth became active. Along with the increase of T_3 concentration to its highest value, Cashmere growth entered its prime period. Analysis of five Cashmere growth data and average T_3 concentration data showed that, in August, September, October, November, and December, the average T_3 level was positively correlated with the Cashmere growth rate (r=0.955, *P*=0.011). The data collected here are consistent with Rhind's findings (1995), which further confirmed the relationship between thyroid hormones and Cashmere growth and the role of thyroid hormones in Cashmere growth.

Conclusion

The experimental data showed that the concentration of blood thyroid hormones in Hexi Cashmere goats exhibited seasonal variation. The concentration of thyroid hormone was highest in summer, moderate in spring and fall, and lowest in winter. The thyroid concentration was higher in summer than in winter. During Cashmere growth peak season, i.e., August, September, October, November, and December, T_3 concentration was positively correlated with Cashmere growth (r=0.955, P=0.011), which suggested that thyroid is one of the more important hormones in Cashmere germination and growth.

Acknowledgements

The first author acknowledgements the financial from the support program of the Ministry of agriculture of China.

References

Corssac, G.B., A.L. de Castro, A.V. Tavares, C. Campos, R.O. Fernandes, V.D. Ortiz, R. Siqueira, T.R. Fernandes, A. Bello-Klein and A.S. Araujo, 2016. Hyroid hormones effects on oxidative stress and cardiac remodeling in the right ventricle of infarcted rats. *Life Sci*., 146: 109–116

Duan, C., J. Xu, C. Sun, Z. Jia and W. Zhang, 2015. Effects of melatonin implantation on Cashmere yield, fibre characteristics, duration of Cashmere growth as well as growth and reproductive performance of Inner Mongolian Cashmere goats. *J. Anim. Sci. Biotechnol*., 6: 22

Maddocks, S. and B.P. Setchell, 1988. The rejection of thyroid allografts in the ovine testis. *Immunol. Cell Biol.,* 66: 1–8

McDonald, B.J., H.J. Chung and R.L. Huganir, 2001. Identification of protein kinase C phosphorylation sites within the AMPA receptor GluR2 subunit. *Neuropharmacology*, 41: 672–679

Niu, Y.B., Z.H. Jia, D.X. Lu, B.I. Guo, X.H. Kong and R.I. Wang, 2005. Study on dynamic change of Cashmere growth of grazing Cashmere goats. *Acta Zoonutr. Sin.,* 17: 33–37

Park, B.H., S.J. Baik, H.A. Lee, Y.S. Hong, H.S. Kim and H. Park, 2016. The association of thyroid hormones and blood pressure in euthyroid preadolescents. *J. Pediatr. Endocrinol. Metab*., 29: 459−464

Rhind, N.R., L.M. Miller, J.B. Kopczynski and B.J. Meyer, 1995. Xol-1 acts as an early switch in the C. elegans male/hermaphrodite decision. *Cell*, 80: 71–82

Ryder, M.L., 1973. The structure of, and growth cycles in, the coat of wild Mouflon sheep (*Ovis musimon*) and their crosses. *Res. Vet. Sci*., 15: 186–196

Villar, D., F. Nicol, J.R. Arthur, P. Dicks, A. Cannavan, D.G. Kennedy and S.M. Rhind, 2000. Type II and type III monodeiodinase activities in the skin of untreated and propylthiouracil-treated Cashmere goats. *Res. Vet. Sci*., 68: 119–123

Villar, M.T.A., P. Hill, H. Inskip, P. Thompson and C. Cooper, 1998. Will elderly rest home residents wear hip protectors? *Age Ageing*, 27: 195–198

White, C.L., G.B. Martin, P.I. Hynd and R.E. Chapman, 1994. The effect of zinc deficiency on wool growth and skin and wool follicle histology of male Merino lambs. *Brit. J. Nutr.,* 71: 425–435

Wei, Y.X., 2008. Progress report on the mechanism of Cashmere growth in Cashmere goats. *Chin. Herbivore*, 28: 64–65

Yue, C.W. and Z.H. Jia, 2007. Study the relation between thyroid and Cashmere growth. *J. Chin. Agric. Univ*., 12: 151–551

(Received 08 January 2018; Accepted 12 January 2018)