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ANNUAL CHANGES OF THYROID STIMULATING HORMONE, THYROXINE, TRIIODOTHYRONINE AND CORTISOL HORMONES IN ANGORA GOATS

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ABSTRACT

In this research, annual changes of thyroid stimulating hormone (TSH), thyroxine (T_4), triiodothyronine (T_3) and cortisol hormones were studied on 13 heads of 1.5 years old Angora goat (6 heads of female and 7 heads of male). The blood samples (10 mL) were taken from vena jugularis of each goat in every month for a year in order to determine hormone levels. The blood samples were centrifugated at 4000xg for 5 min. for hormone analyzes. Sera were stored at -20 °C until analyzes time. Hormone analyzes in the serum were performed by enzyme immunoassay (EIA) method in the Reproductive Biology and Animal Physiology Laboratory at Ankara University, Faculty of Agriculture, Department of Animal Science. Monthly climatic values were obtained from the Turkish State Meteorological Service and temperature-humidity index (THI) was calculated with these values. The interaction between gender and month was not significant with respect to all hormones levels. In addition, there was no significant differences among the months for TSH levels, while there were significant (P<0.01) differences among the months for T_4, T_3 and cortisol levels in Angora goats. Based on the results of this research, it was concluded that the release of T_4, T_3 and cortisol hormones in Angora goats depend on the season and are affected by THI changes.

Keywords: hormonal changes; seasons; heat stress; thyroid.

INTRODUCTION

The purpose of farm animal breeding is to get benefit economically from their yields (meat, milk, fiber, etc.). The farm animals are exposed to many environmental stressors when performing these productions. Primary stress factors are insufficient and/or poor quality forage and water resources, other environmental factors such as high temperature and humidity can also show effects in some periods. Protection of homeostasis of the animals is mainly performed by the control of anabolic and catabolic physiological processes during stress and stress hormones (mainly cortisol) together with metabolic hormones such as T_4, T_3, GH (growth hormone) and IGF-I (insulin like growth factor-I) plays role in this control process (Blokhuis *et al.* 1998; Squires 2003).

A normal hormonal activity is considered crucial to sustain the productive performance (meat, milk and fiber production etc.) in farm animals. Thyroid hormones (TH) play an important role in physiological processes for animals by providing the ability to survive and mate in different environmental conditions. Changes in TH concentrations allow the animals to adapt their metabolic balance to different environmental conditions and variations in nutrient requirements and availability. This is especially important for traditionally reared small ruminants in terms of properties showing dependence on the season (Todini 2007; Elicin 2008).

Cortisol hormone, with significant functions in mammals for coping with stress, shows a very significant effect on mainly carbohydrates, protein and fat metabolism. Adverse environmental conditions cause an increase in the secretion of the cortisol hormone. Cortisol hormone while contributing to the preservation of homeostasis by particularly energy metabolism during acute stress, it can lead to significant losses on immune system, reproduction, milk, meat and fiber production during chronic stress in animals (Yilmaz 1999; Dobson and Smith 2000).

Nowadays, determining the hormones and their impact ways in mammal livestock, which control the reproduction, milk, meat and fiber yields with adaptation and stress physiology, researches continue to have benefit in genetic and environmental improvement programs. Although many studies have been carried out to determining blood concentrations of TH and cortisol for analyzing the effects on physiological processes such as meat, milk and fiber production in cattle and sheep, it can be regarded as insufficient efforts in this direction in the goat breeds especially in Angora goats.

Mohair, used by textile industry as animal fiber, is produced only by Angora goats. Although the Angora goat is a very important native genetic resource of Turkey, it is also breeding in South Africa, USA, Australia, Argentina and some European countries. Although number of researches has been conducted to determine mohair, meat and milk production and amount and direction of environmental effects on them in Angora goats raised especially in Turkey, South Africa and USA, researches to determine physiological controls of

primarily reproduction, mohair, milk and meat yields are very inadequate. From this point forth, in this study, thyroid stimulating hormone (TSH), thyroxine (T_4), triiodothyronine (T_3) and cortisol hormone changes and their reasons were investigated in Angora goats raised in Ankara, Turkey.

MATERIALS AND METHODS

This study was conducted on 13 heads of Angora goat of 1.5 years old (6 heads of female and 7 heads of male) and mean weighing 27.58 ± 1.35 kg at the beginning of the experiment, for a year (from December 2010 to November 2011) in the Animal Husbandry Station (39°57'42.5" north latitude, 32°51'56.2" east longitude) at Ankara University, Faculty of Agriculture, Department of Animal Science. During two months prior to start of the research, all animals were kept under control and subjected to internal and external parasite controls. All the animals were clinically healthy and free from internal and external parasites. They were housed in separate groups based on gender in shaded outdoor pen and for free except for mating period (September and October). Kiddings were occurred in March. Kids were kept together with their mother during lactation period and the goats were not milked during this period. The animals were given wheat straw, alfalfa hay, maize silage and concentrated feed (in some physiological periods). Fresh water was made available always for the goats. Management of experimental animals has not intervened in the general operation of the station. Also, the study was conducted within standard ethical norms.

The blood samples (10 mL) were taken regularly from the vena jugularis of each goat into vacuum containers without anticoagulant in every month for a year. The blood samples were centrifugated at 4000xg for 5 min. for hormone analyzes. Sera were stored at -20 °C until analyzes time. Hormone analyzes in the blood serum were performed by enzyme immunoassay (EIA) method in the Reproductive Biology and Animal Physiology Laboratory at Ankara University, Faculty of Agriculture, Department of Animal Science.

Monthly climatic values during the research was carried out were obtained from the Turkish State Meteorological Service (TSMS 2011) in order to estimate the severity of heat stress. Temperature-humidity index (THI) were calculated using the equation below reported by Marai *et al.* (2001) for sheep and goats (Marai *et al.* 2007) and shown in Table 1.

"THI=db C − {(0.31 − 0.31 RH/100) (db C − 14.4)}"

"*where db C is the dry bulb temperature (C) and RH is the relative humidity (RH%)/100. The values obtained indicate the following: <22.2 = absence of heat stress; 22.2 to <23.3 = moderate heat stress: 23.3 to <25.6 = severe heat stress and 25.6 and more = extreme severe heat stress*" (Marai *et al.* 2007).

Table 1. The average climatic values and THI during the experimental period

Months	Average temperature (°C)	Average humidity (%)	THI
December	11.4	75.3	11.63
January	0.2	67.3	1.64
February	-0.3	67.6	1.18
March	5.4	87.5	5.75
April	9.7	58.3	10.31
May	9.4	52.8	10.13
June	20.8	53.6	19.88
July	22.8	52.1	21.55
August	29.1	43.9	26.54
September	21.8	45.9	20.56
October	11.8	55.7	12.16
November	5.9	71.9	6.64

In the study, in order to determine any possible differences in the observed hormones levels with respect to genders and months, repeated measures ANOVA analysis was performed. Duncan multiple comparison test was used to determine the differences among levels of gender and month factors. The SPSS18 and MSTAT-C statistical softwares were used for the variance analyses and Duncan multiple comparison tests, respectively (Gürbüz *et al.* 2003).

RESULTS

In this research, the average monthly values of the serum TSH, T_4, T_3 and cortisol hormones in male and female Angora goat are given in Table 2 and Table 3. The interaction between gender and month was not significant with respect to all hormones levels. Moreover, there was no significant differences among the months for TSH levels, while significant differences were found (P<0.01) among the months for T_4, T_3 and cortisol levels in Angora goats.

As can be seen from Figure 1, while TSH hormone concentrations generally increased in summer months, they decreased in winter months in Angora goats. T_3 and T_4 hormones levels generally increased in low environmental temperature, whereas they decreased in high environmental temperature. Thus, T_3 and T_4 hormone levels decreases occurred in February, March, April, May, June, July and August along with the increase in the ambient temperature, while there was an increase depending on the decrease in the ambient temperature in September, October, November, December and January. General increase was observed in the cortisol concentrations of Angora goats in the winter months, but a decrease in the summer with some fluctuations. In this study, the cortisol levels showed decreases during the summer months, however significant increases were realized again in autumn.

Table 2. The average monthly concentrations of the serum TSH, T_4 and T_3 hormones in male and female Angora goat

Months	TSH (µIU/ml)			T_4 (nmol/l)			T_3 (ng/ml)		
	Female (n=6)	Male (n=7)	General (n=13)	Female (n=6)	Male (n=7)	General (n=13)	Female (n=6)	Male (n=7)	General (n=13)
	mean±SE	mean±SE	mean±SE	mean±SE	mean±SE	mean±SE	mean±SE	mean±SE	mean±SE
December	3.28±0.32	3.81±1.76	3.57±0.93	121.40±22.90	135.70±7.65	129.10^{ab}±11.0	1.16±0.10	1.16±0.07	1.16^{abcd}±0.06
January	3.24±0.20	3.30±1.37	3.27±0.71	123.90±20.10	138.80±12.50	132.00^{a}±11.2	1.36±0.12	1.40±0.18	1.38^{a}±0.11
February	3.38±0.13	4.02±2.13	3.72±1.11	102.37±4.90	116.80±15.70	110.14^{abc}±8.70	1.44±0.06	1.41±0.15	1.43^{a}±0.08
March	3.40±0.39	4.21±1.53	3.84±0.82	111.90±13.30	103.20±13.60	107.21^{abc} ±9.21	1.40±0.09	1.44±0.18	1.42^{a}±0.10
April	3.59±0.65	3.82±1.55	3.72±0.85	105.88±7.66	101.20±7.47	103.36^{bcd}±5.17	1.25±0.10	1.27±0.18	1.26^{ab}±0.10
May	3.37±0.30	4.43±1.66	3.94±0.89	107.21±6.68	97.30±10.40	101.90^{cd}±6.28	1.21±0.13	1.24±0.17	1.22^{abc}±0.11
June	3.35±0.51	5.82±2.68	4.68±1.45	89.68±8.39	68.42±4.66	78.23^{def}±5.36	0.93±0.04	0.97±0.15	0.95^{bcd}±0.08
July	3.51±0.26	6.22±2.74	4.97±1.48	75.48±6.20	74.58±7.62	75.00^{ef}±4.80	0.86±0.03	0.93±0.08	0.89^{cd}±0.04
August	3.52±0.36	5.73±2.12	4.71±1.15	79.83±6.32	60.12±2.56	69.22^{ef}±4.18	0.85±0.03	0.82±0.03	0.83^{d}±0.02
September	3.16±0.43	5.10±2.04	4.20±1.11	79.16±7.96	57.54±3.08	67.52^{f}±4.94	0.95±0.01	0.98±0.07	0.96^{bcd}±0.04
October	3.01±0.22	4.49±1.58	3.81±0.85	89.51±7.96	83.50±10.50	86.25^{cdef}±6.52	1.09±0.04	1.20±0.19	1.15^{abcd}±0.10
November	3.53±0.47	4.64±1.91	4.12±1.02	85.50±4.66	102.10±16.50	94.42^{cde}±9.11	1.29±0.10	1.34±0.24	1.32^{a}±0.13
General	**3.36±0.10**	**4.63±0.54**	**4.05±0.30**	**97.65±3.55**	**94.94±3.99**	**96.19±2.68**	**1.15±0.03**	**1.18±0.05**	**1.16±0.03**

^{a,b,c,d,e,f} Means along the same column with different superscripts differ significantly at P <0.01.

Table 3. The average monthly concentrations of the serum cortisol hormone in male and female Angora goat

Months	Cortisol (ng/ml)		
	Female (n=6)	Male (n=7)	General (n=13)
	mean±SE	mean±SE	mean±SE
December	35.20±4.64	42.90±5.38	39.35^{abc}±3.63
January	39.60±5.60	47.14±8.56	43.66^{abc}±5.19
February	42.10±12.60	51.15±8.26	46.96^{ab}±7.12
March	34.38±8.18	57.80±11.40	46.96^{ab}±7.69
April	27.23±8.91	30.88±5.98	29.19^{abc}±5.02
May	17.05±3.09	26.64±6.79	22.21^{bc}±4.02
June	23.65±4.25	18.86±4.95	21.07^{bc}±3.25
July	34.38±6.40	16.03±2.64	24.50^{abc}±4.09
August	22.28±2.24	11.55±2.74	16.50^{c}±2.32
September	20.07±4.92	13.91±2.19	16.75^{c}±2.59
October	27.77±4.90	73.30±30.00	52.30^{a}±17.00
November	34.10±11.40	54.40±22.20	45.10^{abc}±12.90

^{a,b,c} Means along the same column with different superscripts differ significantly at P <0.01.

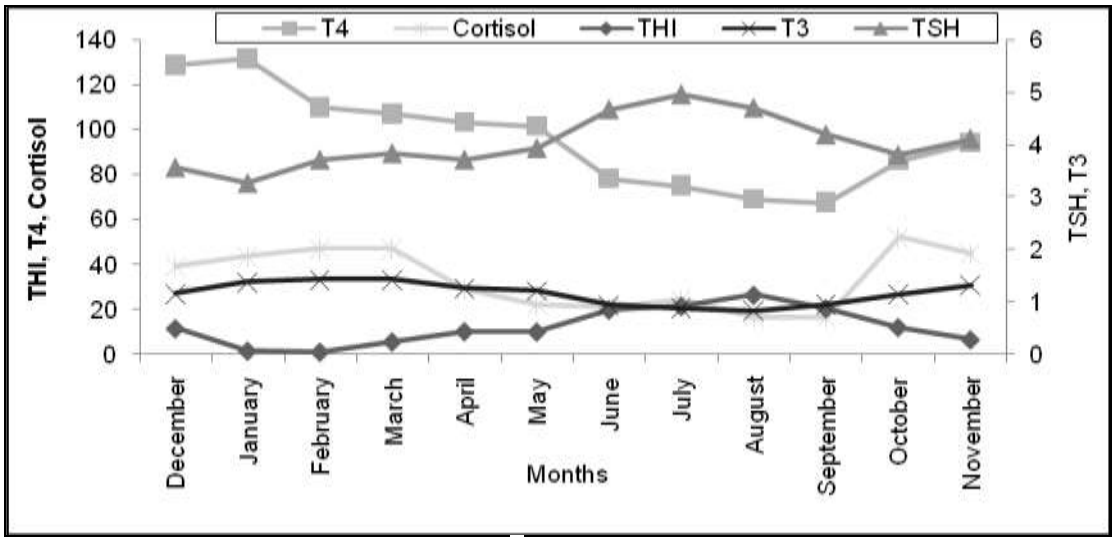

Figure 1. The annual change of the serum TSH, T_4, T_3 and cortisol hormones and THI in Angora goat.

As can be seen in Figure 1, the THI level is the lowest in February, a continuous increase was observed from this point and reached its highest level in August, while it showed a gradual decrease from August to January. Comparing to THI, the changes in T_4, T_3 and cortisol levels followed an opposite trends in the same period. T_4, T_3 and cortisol concentrations generally decreased in the months when the THI value increased, on the other hand they generally increased in the months when the THI value decreased. However, the THI value created extremely severe heat stress on the Angora goats included in the study only in August (Table 1) and depending on that T_3 and cortisol levels reached the lowest level when compared with the other months (Table 2 and Table 3). Compared to other months, despite the significant decrease in the concentration of T_4 in August, the lowest level in this hormone were observed in September. Moreover, the differences between the lowest average value of T_4 (September) and the value of T_4 (August, when the highest THI) were not significant (Table 2).

DISCUSSION

TSH is secreted from the anterior lobe of the pituitary gland in mammals and it stimulates the releases of T_4 and T_3 hormones from the thyroid gland. The concentrations of TSH in the blood is regulated by negative feedback by TH (Yilmaz 1999). In this study, the changes occurring in TSH levels can be said to be compatible with the endocrine control pathways of this hormone in mammals.

In this study, the findings related with the effect of changes in environmental temperature on TH concentrations in Angora goats are similar to the findings in Angora and other goat breeds. Thus, Colavita *et al.* (1983) in domestic goats, Emre (1987) in Angora goats, Todini *et al.* (1992) male and female goats, Todini *et al.* (2006) in Alpine and Saanen bucks, Taskin *et al.* (2007) in Saanen goats, Elicin (2008) in white goats, Polat and Dellal (2008) in male and female Ankara goat kids and Koluman *et al.* (2013) hair (ordinary) and Saanen goats determined that T_4 and T_3 hormones levels in circulation decrease depending on high temperature and that TH concentrations in circulation increase depending on low temperature. Similar findings also obtained from researches performing in sheep (Valtorta *et al.* 1982; Webster *et al.* 1991; James *et al.* 1991; Souza *et al.* 2002; Starling *et al.* 2005). In all of these researches on sheep and goats, it is explained that these changes, depending on increase or decrease of environmental temperature and TH concentrations, mainly based on the fact that these animals reorganize the secretion of the these hormones with the help of the nerve system due to control their metabolic rates (energy production) and control their body temperatures (Yilmaz 1999; Todini 2007; Elicin 2008; Koluman *et al.* 2013).

In this study, the findings on cortisol hormone concentrations in Angora goats were similar to findings reported by Howland *et al.* (1985) in Dwarf goats, Alila-Johansson *et al.* (2003) in Finnish Landrace, Meza-Herrera *et al.* (2007) in Granadina, Nubian, Saanen, Toggenburg, Alpine and Saanen x Criollo and Al-Busaidi *et al.* (2008) in Dhofari goat. The increase in serum cortisol levels during the winter months can be attributed to the increase of catabolic processes such as glycogenesis, proteolysis and lipolysis (Abilay *et al.* 1975; Meza-Herrrera *et al.* 2007) while the decrease in serum cortisol levels during the summer months can be attributed to the reduction of cortisol levels in order to reduce the their metabolisms. However, the significant increases in autumn and decreases in summer months in cortisol levels were observed. In this increase, the effect

of the decrease in ambient temperature together with this period of normal mating season in Angora goats, it can be stated that the increase especially in the testosterone hormone in male goats also contribute to their aggression behaviors (Alila-Johansson *et al.* 2003; Meza-Herrrera *et al.* 2007) since the cortisol hormone is one of the pre-synthesized molecules of testosterone that is mainly stimulating hormone in the emergence of mating request (Yilmaz 1999) and synthesis of cortisol is also increasing because of the increase in testosterone due to seasonal effects. Still, stress caused by aggressive behaviors that arising due to the increase in testosterone levels mainly during the mating season also increases the levels of cortisol hormone.

In this research, the opposite relationship between the release of T_4, T_3 and cortisol hormones with THI level can be explained that release of T_4, T_3 and cortisol levels is decreased in order to the decrease the metabolic rates when THI level is high (especially in heat stress) and that release of T_4, T_3 and cortisol levels is increased in order to the increase the metabolic rates when THI level is low. Thus, as in the other ruminant species, it was reported that release of T_4 and T_3 levels is low in blood during the heat stress in goat (Valtorta *et al.* 1982; Taskin *et al.* 2007; Elicin 2008; Koluman *et al.* 2013). Similarly, cortisol level in animals exposed to chronic heat is also found to be low (Dantzer and Mormede 1983; Verhagen 1987; Nelson and Drazen 2000; Al-Busaidi *et al.* 2008). In this study, the findings related to the relationship between changes in THI level and releases of T_4, T_3 and cortisol hormone concentrations in Angora goats during one year are similar to the findings reported by Taskin *et al.* (2007) in Saanen goats, Elicin (2008) in white goats, Polat and Dellal (2008) in male and female Ankara goat kids and Koluman *et al.* (2013) hair (ordinary) and Saanen goats.

Conclusion: Based on the results of this research, the releases of T_4, T_3 and cortisol hormones in Angora goats depend on the season and these hormones are significantly affected from the THI changes. These findings were obtained from Angora goats were similar to the findings of researches that were conducted in different goat breeds. Also, these findings was aimed to contribute to the genetic and environmental improvement programs for mohair and the other yields of Angora goats in Turkey, South Africa and other countries.

Conflict of Interest: All the authors declare that they have no conflict of interest.

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