Kafkas Univ Vet Fak Derg
19 (3): 499-504, 2013
DOI: 10.9775/kvfd.2012.8163

Journal Home-Page: http://vetdergi.kafkas.edu.tr
Online Submission: http://vetdergikafkas.org

RESEARCH ARTICLE

Impacts of Climate Parameters on Physiological Characteristics of Karayaka Sheep

Sedat KARAMAN * Yuksel AKSOY ** Mustafa DUMAN ** Zafer ULUTAS **

* Department of Biosystems Engineering, Faculty of Agriculture, Gaziosmanpasa University, TR-60240 Tokat - TURKEY
** Animal Science Department, Faculty of Agriculture, Gaziosmanpasa University, TR-60240 Tokat - TURKEY

Makale Kodu (Article Code): KVFD-2012-8163

Summary

Objectives of this research were to investigate the variations in adaptation parameters of Karayaka rams and ewes to cold winter conditions, to determine mutual interactions among them and to put forward their physiological responses against climate parameters. Average body temperatures of rams and ewes were respectively determined as 39.51°C and 39.31°C in the morning, 39.64°C and 39.50°C in the evening; pulse rates were determined as 88.86 and 83.04 pulse/min in the morning, 91.68 and 86.96 pulse/min in the evening; respiration rates were determined as 39.71 and 43.06 times/min in the morning, 41.36 and 44.35 times/min in the evening. Effects of sex and measuring time on body temperature, pulse and respiration rates were found to be significant (P<0.01), interaction between sex and measuring time was found to be insignificant (P>0.05). A negative correlation was observed between relative humidity and physiological parameters. Correlations between air velocities and physiological parameters were found to be insignificant (P>0.05).

Keywords: *Environmental conditions, Physiological response, Body temperature, Respiration rate, Pulse rate, Ewe, Ram*

İklim Parametrelerinin Karayaka Koyunlarının Fizyolojik Özellikleri Üzerine Etkisi

Özet

Bu çalışma soğuk kış koşullarında iklim parametreleri ile Karayaka koç ve koyunlarının adaptasyon parametreleri değişimlerinin incelenmesi, birbirlerine olan etkilerinin belirlenmesi ve fizyolojik tepkilerinin ortaya konması amacıyla yapılmıştır. Erkek ve dişi bireylerde ortalama vücut sıcaklığı sırasıyla sabah 39.51°C, 39.31°C; akşam 39.64°C, 39.50°C; nabız sayısı sabah 88.86 adet/dak, 83.04 adet/dak; akşam 91.68 adet/dak, 86.96 adet/dak, solunum sayısı sabah 39.71 adet/dak, 43.06 adet/dak; akşam 41.36 adet/dak, 44.35 adet/dak olarak belirlenmiştir. Vücut sıcaklığı, nabız sayısı ve solunum sayısı ortalaması üzerine cinsiyet ve ölçüm zamanının etkisi önemli (P<0.01), cinsiyet ve ölçüm zamanı arasındaki interaksiyon istatistiki olarak önemsiz bulunmuştur (P>0.05). Bağıl nem ve fizyolojik parametreler arasında negatif bir korelasyon tespit edilmiş, rüzgar hızı ile fizyolojik parametreler arasında belirlenen korelasyonlar istatistiki olarak önemsiz bulunmuştur (P>0.05).

Anahtar sözcükler: *Çevre koşulları, Fizyolojik tepki, Vücut sıcaklığı, Solunum sayısı, Nabız sayısı, Koç, Koyun*

INTRODUCTION

Climate is one of the most significant factors effective in animal adaptation to surrounding environment. It has several parameters like ambient temperature, relative humidity and air movement all with considerable impacts either alone or in combination on both biological and yield activities of livestock. Therefore, breeding studies mostly deal with the adaptation capacities of livestock to various environmental conditions.

Impacts of climate on animal performance vary based on age, sex and breed of animals. Changes in environmental and climate conditions create some problems in adaptation of animals already adapted to previous conditions. Such changes even result in fatal losses in young animals. Therefore, environmental conditions have critical importance in livestock production activities. Climatic biological capacities of sheep are especially more flexible than the other livestock [1].

İletişim (Correspondence)
+90 356 2521616
sedat.karaman@gop.edu.tr

Basic objectives of environmental studies are to comprehend the effects of environmental changes on animal performance, to improve the adaptation capacities of animals to variable conditions through breeding activities and to provide support to knowledge in environmental physiology. All these objectives should be taken into consideration in relation with each other rather than considering them one by one. Primary aim of livestock production is to get sufficient yield with sufficient quality at low-cost. Beside the hereditary characteristics, environmental conditions have also significant impacts on the amount and quality of products in sheep breeding. Varied sheep breeds are raised in different regions of Turkey for milk, meat and mutton production. Karayaka sheep is one of the major indigenous sheep breeds of Black Sea Region in Turkey. This breed is commonly raised in Tokat, Samsun and Amasya Provinces of the region. It is highly adapted to harsh environment of the region. The total population of the breed in the region is about 1.300.000. Being a non-fat tailed sheep in a harsh environment makes the Karayaka sheep more interesting. This breed is mainly kept for its high meat quality. Characteristics of products vary considerably with climatic environmental conditions.

Adaptation capacities of animals to climatic environment may be understood by determining some physiological characteristics such as body temperature, pulse and respiration rates. There are no reports on effects of climate parameters on physiological characteristics of Karayaka ewes and rams. This study was conducted to investigate the impacts of yield-related climate parameters on physiological characteristics of Karayaka ewes and rams and to evaluate the relationships among these variables.

MATERIAL and METHODS

The study was carried out at the experimental farm of the Gaziosmanpasa University, Tokat, Turkey (40°31 'N, 36° 53' E and 650 m above the sea level). Data were collected from an experimental nucleus flock of Karayaka sheep at college farm of Gaziosmanpasa University in the year 2011. Experiments were carried out during the month January with the lowest temperatures of the year. A total of 30 Karayaka sheep were used in experiments. Of these, 10 were rams with an average weight of 50.9 kg and 20 were ewes with an average weight of 35.54 kg.

Experiments were carried out in an open-sided shelter type barn with open North side. Rams and ewes were housed at separate pens with 2 m^2 space per sheep. Sheep were exposed to cold stress during the experiments. Hourly air temperature and relative humidity in sheltered yard were continuously measured with data loggers (HOBO Type: U12-012- temperature measuring range between -20°C and 70°C with ±0.35°C accuracy; relative humidity range of 5-95% with ±2.5% accuracy) placed at a level equal to animal height. Air velocities were measured with a digital anemometer (Testo 425 hand-held hotwire anemometer - measuring range of 0-15 m/s with ±0.05 m/s accuracy).

Physiological adaptation mechanisms (body temperature, pulse and respiration rates) were determined to evaluate the impacts of climate. These adaptation mechanisms were measured every day at 8 a.m. and 6 p.m. Sheep were kept at resting position for a while before to take such measurements and were made ready for measurements. Pulse rate was determined by pressing over *arteria femoralis* with hand and counting the pulse for 60 sec. Respiration rate was measured by counting nose expressions for 60 sec. Body temperatures were measured with a digital thermometer by inserting it 4 cm into rectum. The thermometer was kept inside the rectum until a steady temperature was observed [2].

Sheep were fed with 200 g concentrated feed (93.1% dry matter, 15.2% crude protein, 29.41% ADF, 30.22% NDF, 2.23% crude oil, 8.6% crude ash, 2.605 cal/kg metabolic energy) daily during the experimental period. As a fodder, 1.1 kg medium quality dry clover forage (94% dry matter, 15% crude protein, 59.75% ADF, 58.22% NDF, 0.74% crude oil, 10.30% crude ash, 1878 cal/kg metabolic energy) was provided to each sheep daily.

Criteria specified by NIH (National Institute of Health Guide for the Care and Use of Laboratory Animals) were obeyed during the experiments carried on animals.

Experiments were conducted in 2x2 factorial randomized block design and SPSS 17.0 [3] was used for statistical analysis.

RESULTS

Daily average temperatures, relative humidity and air velocity values are presented in *Fig. 1*. Air temperatures, relative humidity, dew points, air velocity and enthalpy values measured in this study are given in *Table 1*.

During the research period, average temperature was determined as 2.3°C, the lowest as -7.8°C and the highest as 13.9°C. Temperature was below 4°C at 71% of the measuring period, below 0°C at 27.9% and below -5°C at 2.6%. Dew point temperature varied between -10.4 and 4.5°C and was below 0°C at 79.4% of the measuring period. The lowest average temperature during the hours in which adaptation parameters of animals are measured was determined as -6.2°C in morning measurements and -0.9°C in evening measurements.

Another significant environmental parameter, average relative humidity was determined as 73.7% and the value was above 80% at 40.1% of measuring period, below 60% at 17.7% of the time, below 80% at 59.8% and below 50% at 4.0% of the time.

Average air velocity was 1.25 m/s and morning values (1.3 m/s) were higher than evening values (0.8 m/s). The

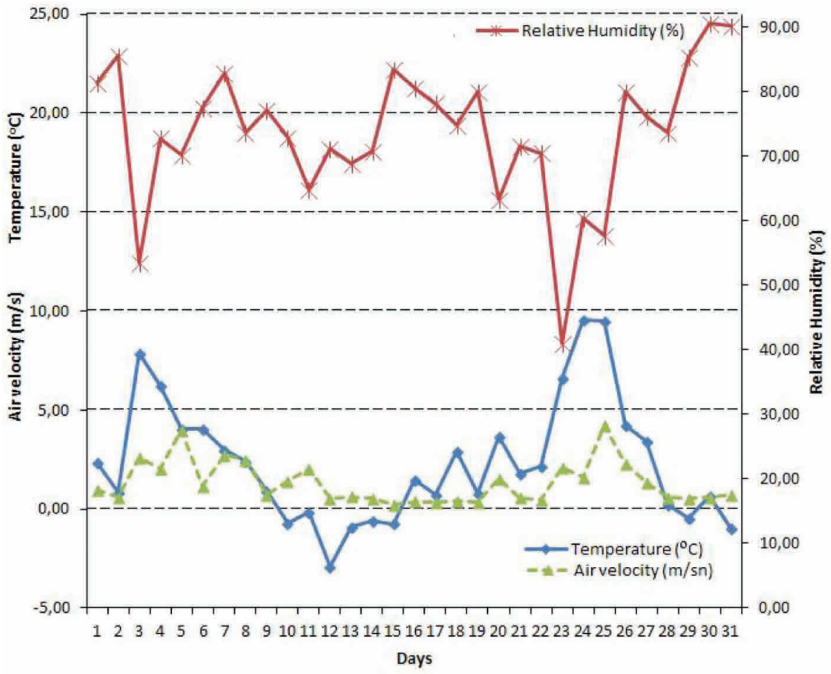

Fig 1. Daily average temperature, relative humidity and air velocity

Şekil 1. Günlük ortalama sıcaklık, bağıl nem ve hava akım hızı

air was still-windless at 26.1% of the measuring period. Air velocity was below 0.4 m/s at 49.8% of the time, above 5 m/s at 4.51% and above 3 m/s at 13.6% of the time.

Average body temperatures, pulse and respiration rates of rams and ewes in morning and evening hours are given in *Table 2*. The relationships between climate parameters and physiological characteristics are provided in *Table 3*.

Average body temperatures of rams and ewes were respectively measured as 39.5°C and 39.3°C in the mornings, 39.6°C and 39.5°C in the evenings. Body temperatures of ewes were found to be lower than rams ($P<0.01$). Measuring time and sheep sex had significant effects on body temperature ($P<0.01$). The interaction between measuring time and sheep sex was not found to be significant ($P>0.05$).

A correlation coefficient of -0.480 was observed between relative humidity and body temperature of ewes ($P<0.01$). Changes in air velocity did not have significant impacts on body temperatures ($P>0.05$).

Average pulse rates of rams and ewes of Karayaka sheep were respectively counted as 88.86 and 83.04 pulse/min in the morning, as 91.68 and 86.96 pulse/min in the evening. The lowest pulse rate was observed in ewes during morning measurements. Measuring time and sex had significant effects on pulse rates ($P<0.01$). Interaction between measuring time and sex was found to be insignificant ($P>0.05$).

While the effects of morning temperatures on pulse and respiration rates of rams and ewes were significant ($P<0.01$), effects on body temperature was not significant ($P>0.05$). Effects of evening temperatures on pulse rate and body temperatures were significant ($P<0.01$), effects on respiration rate were not significant ($P>0.05$).

A negative correlation was observed between relative humidity and physiological parameters. However, negative correlations between relative humidity and morning respiration rates of rams and ewes ($P<0.05$), between relative humidity and evening pulse rates of rams and ewes ($P<0.01$), between relative humidity and evening body temperature of ewes ($P<0.01$) were found to be significant.

Correlations between air velocity and physiological parameters of rams and ewes were found to be insignificant ($P>0.05$).

DISCUSSION

Air temperature, relative humidity and air velocity have direct and indirect impacts on animals. Such climate parameters significantly affect both heat exchange of animals with surrounding ambient atmosphere and physiological characteristics of animals. Therefore, climate parameters of the region should definitely be analyzed before the initiation of any sheep breeding facility. Optimum temperature range for sheep is specified as 10-13°C [4,5]. Convenient temperature ranges were implied as 4-24°C by [6,7], as 8-17°C by [8]. Lower limit of optimum temperature was indicated as 7°C by [4,5], as 5°C by [8]. It was also observed that sheep grown at temperatures between -27°C and 6°C had higher feed consumptions but lower weight gains than sheep raised at 15°C [7].

Another significant environmental factor to be considered for sheep health is relative humidity. Average relative humidity was determined as 73.7% in current study. Optimum relative humidity ranges were specified as 60-80% by Mutaf and Sonmez [8]. Ekmekyapar [7] indicated that 80% relative humidity at severely cold regions did not have significant

Table 1. *Climate parameters and enthalpy values*
Table 1. *İklim verileri ve entalpi değerleri*

Day	Temperature (°C)			Dew Point (°C)			Humidity (%)			Air Velocity (m/s)			Enthalpy (kcal/kg dry air)		
	a.m.	p.m.	Mean	a.m.	p.m.	Mean	a.m.	p.m.	Mean	a.m.	p.m.	Mean	a.m.	p.m.	Mean
1	1.6	3.0	2.4	0.1	-1.0	2.3	90	75	81	0.4	0.4	0.9	11.1	11.8	11.5
2	-3.4	1.9	0.8	-5.0	-3.4	0.4	89	68	86	0.0	0.9	0.6	3.1	9.3	9.4
3	7.6	10.3	7.8	-2.4	0.1	-1.1	49	49	54	4.0	2.7	2.6	15.5	19.9	16.7
4	7.2	5.3	6.2	0.4	3.5	1.6	62	88	73	2.2	0.0	2.0	17.0	17.5	17.0
5	4.3	3.4	4.0	-1.5	-1.2	-0.9	66	72	70	5.8	0.9	4.0	12.8	12.1	12.9
6	1.7	4.9	4.0	-0.4	1.2	0.4	86	77	78	0.0	1.8	1.2	10.9	15.2	13.8
7	3.2	2.7	3.0	1.5	-1.1	0.4	89	76	83	0.9	3.6	2.7	13.8	11.4	12.7
8	2.6	1.9	2.4	-2.1	-2.1	-1.9	71	75	74	5.4	0.4	2.5	10.7	10.0	10.6
9	1.2	-0.9	0.9	-1.2	-4.3	-2.7	84	78	77	0.0	0.0	0.7	9.8	6.0	8.7
10	-2.3	-0.5	-0.7	-6.3	-4.6	-5.0	74	74	73	4.0	0.4	1.4	3.6	6.2	5.8
11	-1.3	-0.9	-0.1	-6.5	-6.9	-6.1	68	64	65	4.9	0.4	2.1	4.5	4.7	5.9
12	-6.2	-1.7	-2.9	-8.9	-5.9	-7.5	81	73	71	0.4	0.4	0.5	-1.5	4.3	2.5
13	-5.3	1.2	-0.9	-7.3	-4.7	-6.3	86	65	69	0.0	0.4	0.6	0.1	7.9	5.2
14	-5.3	0.9	-0.6	-7.6	-4.0	-5.5	84	70	71	0.0	0.0	0.5	- 0.0	7.9	5.8
15	-1.9	0.6	-0.8	-4.4	-1.5	-3.2	83	86	84	0.0	0.0	0.2	4.9	9.1	6.7
16	0.7	1.1	1.4	-0.7	-2.8	-1.7	90	75	81	0.4	0.4	0.4	9.6	8.7	9.9
17	-1.1	2.9	0.7	-3.3	-2.0	-2.7	85	70	78	0.4	0.0	0.3	6.3	11.0	8.5
18	0.6	5.2	2.9	-1.1	-1.1	-1.4	88	64	75	0.4	0.4	0.4	9.3	14.0	11.6
19	-0.8	2.6	0.8	-3.0	-1.3	-2.3	85	76	80	0.0	0.0	0.4	6.7	11.2	8.8
20	1.1	3.9	3.6	-3.8	-2.3	-2.9	70	64	63	3.6	0.0	1.5	8.2	11.9	11.4
21	-1.4	2.6	1.8	-3.9	-2.3	-3.0	83	70	72	0.0	0.0	0.6	5.6	10.6	9.5
22	-2.3	3.9	2.2	-4.5	-1.2	-2.9	85	69	71	0.0	0.0	0.5	4.4	12.5	9.9
23	0.7	10	6.6	-2.7	-0.8	-1.5	78	47	41	0.4	2.2	2.1	8.4	19.0	12.9
24	9.5	10.6	9.5	1.9	2.2	2.1	59	56	60	0.0	3.1	1.6	20.4	21.8	20.7
25	10.1	10.2	9.5	0.4	1.8	1.3	51	56	58	4.0	1.8	4.3	19.9	21.1	20.2
26	3.2	5.2	4.2	1.7	0.4	1.0	90	71	80	0.0	0.4	2.3	13.9	14.9	14.5
27	2.7	3.6	3.4	0.7	-2.4	-0.5	87	65	76	0.0	0.9	1.3	12.7	11.5	12.6
28	-2.0	0.7	0.2	-4.3	-4.1	-4.0	84	70	74	0.0	0.0	0.6	4.8	7.6	7.3
29	-0.6	-0.2	-0.5	-3.6	-1.7	-2.7	80	90	85	1.3	0.9	0.5	6.6	8.1	7.3
30	0.3	0.7	0.6	-0.9	-0.6	-0.7	92	91	91	0.0	0.4	0.6	9.2	9.7	9.6
31	-1.7	-0.6	-1.0	-2.9	-2.0	-2.4	91	90	90	0.9	0.9	0.7	5.8	7.5	6.9
Average	0.7	3.0	2.3	2.6	-1.8	-1.9	79	71	74	1.3	0.8	1.3	11.1	11.8	11.5

negative impacts on physiological characteristics of sheep when the optimum temperatures were provided.

Temperature and relative humidity values of current study were out of the ranges specified by previous researches. These values indicate that sheep were exposed to high relative humidity and low temperature stress during most of the research period.

The air velocities measured in present study were generally above the recommended values. Although the rates between 0.15-0.40 m/s are found to be convenient for sheep, values above 2.5 m/s may have negative impacts on animals [7].

Body temperature findings of current study are in compliance with the findings of Williamson and Payne [11], AbiSaab and Sleiman [9], DaSilva and Minomo [10] and Ceyhan et al.[2]. A 1°C increase or decrease in body temperature is sufficient to drop the performance of sheep. Body temperature is a physiological response of animal to heat stress [12].

Srikandakurmar et al.[13] observed the body temperatures of cold-sheltered sheep as 39.5°C for Merino sheep and 39°C for Omani sheep. Increasing air temperatures raised the body temperatures of Merino sheep to 39.8°C and body temperatures of Omani sheep to 39.7°C.

Results indicated that sheep were under ambient temperature stress. Since the air temperatures were relatively lower in second and third weeks of the study,

Table 2. *Body temperatures, pulse and respiration rates*
Tablo 2. *Vücut sıcaklıkları, nabız ve solunum değerleri*

Parameter	Time	Ram	Ewe	Mean	P
Body Temperature	Morning	39.51±0.050	39.31±0.027	39.38±0.024	**
	Evening	39.64±0.047	39.50±0.031	39.54±0.026	
	Mean	39.57±0.034	39.40±0.021	39.46±0.018	
	P	**			
Pulse Rate	Morning	88.86±0.821	83.04±0.580	84.98±0.482	**
	Evening	91.68±0.898	86.96±0.640	88.54±0.526	
	Mean	90.27±0.611	85.00±0.435	86.76±0.359	
	P	**			
Respiration Rate	Morning	39.71±0.324	43.06±0.231	41.94±0.195	**
	Evening	41.36±0.330	44.35±0.227	43.35±0.193	
	Mean	40.53±0.234	43.70±0.163	42.64±0.138	
	P	**			

***P<0.01*

Table 3. *Correlation coefficients between physiological characteristics of Karayaka sheep*
Tablo 3. *Karayaka koyunlarının bazı fizyolojik parametreleri arasındaki korelasyon katsayıları*

Time	Parameter	Ram			Ewe		
		Body Temp.	Pulse	Respiration	Body Temp.	Pulse	Respiration
Morning	Air Temperature	0.350	0.591**	0.627**	0.271	0.520**	0.623**
	Relative Humidity	-0.261	-0.304	-0.357*	-0.455	-0.351	-0.371*
	Air Velocity	0.068	0.025	0.058	0.141	0.180	0.162
Evening	Air Temperature	0.560**	0.503**	0.397	0.596**	0.568**	0.276
	Relative Humidity	-0.336	-0.526**	-0.309	-0.480**	-0.581**	-0.280
	Air Velocity	0.189	0.047	0.191	0.327	0.028	0.194

** P<0.05; ** P<0.01*

body temperatures were also found to be lower in second and third weeks. Increase in total heat capacity of the air also increased the body temperatures of sheep.

Sheep are homo-thermic animals and they need stable body temperature to sustain their physiological functions. They can keep steady body temperature in certain ranges of ambient temperature. Sheep can arrange heat transfer between the ambient atmosphere and their bodies without hyperthermia or hypothermia and they do not need much energy to conserve body temperature within thermo-neutral (comfort) zone. Sheep do not sweat due to insufficient sweat glands and it is hard for them to adapt hot conditions. Therefore, they are better adapted to cold conditions than hot conditions [7,14].

Pulse rates observed in present study are in compliance with the values observed by Altan and Sendil [15], for sheep (60-90), by AbiSaab and Sleiman [9] for breeding and Ivesi sheep (99.0 and 93.1 pulse/min).

Eyal [16], reported the pulse rate as 80 pulse/min at 5 a.m., as 100 pulse/min at 7 p.m. and decreased rates later on. Naqvi et al.[17], investigated the physiological impacts of ambient temperatures on Bharat Merino sheep and observed the pulse rates of sheep as 73.7 pulse/min at 8 a.m. and as 93 pulse/min at 2 p.m.

Changes in metabolisms of small ruminant animals cause changes in pulse rates. Results indicated slowed metabolism and consequently lower pulse rates with decreasing ambient temperatures. Such rates indicate that Karayaka sheep could adapt to local conditions of Tokat Province. The point here is to have increasing pulse rates with increasing temperatures as expected and to have the highest values in evening hours.

Respiration rate was proven to be a significant factor in adaptation capacities of an animal to variable climate conditions [18-20]. The very first response of animals is to reduce their pulse rates when they are exposed to ambient temperatures below the comfort zone.

Respiration rates of rams and ewes of Karayaka sheep were respectively observed as 39.71 and 43.06 times/min in the morning, as 41.36 and 44.35 times/min in the evening. Measuring time and sex had positive impacts on respiration rates (P<0.01). The interaction between measuring time

and sex was found to be insignificant (P>0.05). The highest respiration rate was observed in ewes during evening measurements. The highest rates were seen in the days with the highest temperatures and the lowest rates were observed in the days with low temperature and high relative humidity. Results indicated that Karayaka sheep decreased their respiration rates as temperature decreases to sustain their body temperatures *(Table 3)*.

Silanikove [21], reported respiration rates of sheep in cold conditions as 40-60 times/min. Respiration rates of current study were similar to findings of AbiSaab and Sleiman [9], for breeding and Ivesi sheep (52.4 and 49.0 times/min) and lower than the findings of Ceyhan et al.[2] for Kıvırcık, SBA, (SBA X Kıvırcık) F1 and (SBA X F1) G1 sheep (50.379, 54.281, 55.186 and 56.673 times/min, respectively).

Heat loss of livestock decreases with decreasing temperature due to decreasing respiration rate. Reduced respiration is the first response of animal against decreasing temperatures. Temperature and humidity of air inhaled into lungs increase and the heat removed from the body decrease with decreasing volume of inhaled air [22].

Sheep are homo-thermic animals and need to perform some behavioral and physiological adaptations based on the trend and level of change in ambient temperature (either hot or cold) to maintain a steady body temperature against fluctuating environmental conditions. Decreasing ambient temperature decreases respiration and pulse rates of a homo-thermic animal through active heat release mechanisms.

There are several factors effective on production activities in sheep breeding. Temperature, relative humidity and air velocities are among the significant ones of these factors. In this study, relationships between such environmental factors and body temperature, pulse and respirations rates of sheep were investigated and environmental conditions were evaluated with regard to animal demands.

Results indicated decreasing body temperatures and consequent decrease in pulse and respiration rates with increasing ambient temperatures during the cold winter months. Such increases in temperature therefore cause some physiological changes in animals.

Negative effects of variable climate conditions may be decreased by improved adaptation capacity of animals through some physiological characteristics. Sheep try to minimize such negative impacts with instant physiological response against changes in environmental conditions. Karayaka sheep of the current study were able to have physiological response against changes in ambient temperature, relative humidity and air velocities by changing their body temperature, pulse and respiration rates. They were able to develop proper adaptation mechanisms for environmental conditions of Tokat Province.

REFERENCES

1. Laçin E, Aksoy AR: Comparison of growth characteristic of Morkaraman and Tuj lambs in Kars region. *Kafkas Univ Vet Fak Derg,* 9 (1): 33-37, 2003.

2. Ceyhan A, Kaptan C, Ada M, Erdoğan I, Talug AM: The physiological reactions in Bandirma environment conditions of Kivircik, German blackheaded mutton, (GBH x Kivircik) F1 ve (GBH x F1) B1 ewe. *Tarım Bilim Derg*, 12 (2): 113-120, 2006.

3. SPSS: SPSS for Windows, advanced statistics release 10. Chicago, IL, USA, 1999.

4. MWPS: Sheep Handbook Housing and Equipment. Iowa State University, Ames. Iowa. 80, 1974.

5. MWPS: Structures and Environment Handbook. Midwest Plan Service, Iowa State University, Iowa: 515.1-661.1, 1987.

6. Hahn LR: Discussion of environmental effect on ruminant production rational decisions based on current knowledge. *ASAE* 58-0174, *Livestock Environment Symposium*, pp. 232-236. St. Joseph Michigan, 1974.

7. Ekmekyapar T: Regulation of Environmental Conditions in Animal Buildings. Ataturk University Agricultural Faculty, No: 306, pp. 27-134 (In Turkish), 1993.

8. Mutaf S, Sonmez R: Climatic Environmental Control in Animal Barns. Ege University Faculty of Agriculture Publications, No: 435, pp. 10-131, (In Turkish), 1984.

9. AbiSaab S, Sleiman FT: Physiological responses to stress of filial crosses compared to local Awassi sheep. *Small Ruminant Res*, 16 (1): 55-59, 1995.

10. DaSilva RG, Minomo FR: Circadian and seasonal variation of the body temperature of sheep in a tropical environment. *Int J Biometereol*, 39, 69-73, 1995.

11. Williamson G, Payne WJA: An Introduction to Animal Husbandry in the Tropics. Tropical Agriculture Series, Third ed., p. 755, Longman, London, 1978.

12. El-Banna IM: Heat load and heat dissipation in sheep and goats under environmental heat stress. **In,** *Proc. 6th Int. Conf. On Animal and Poultry Production, held at University of Zagazig, Zagazig, Egypt,* 21-23 September, Vol. 2. Egyptian Society of Animal Production, pp. 459-469, 1982.

13. Srikandakurmar A, Johnson EG, Mahgoub O: Effect of heat stress on respiratory rate, rectal temperature and blood chemistry in Omani and Australian Merino sheep. *Small Ruminant Res*, 49, 193-198, 2003.

14. Esmay ML: Principles of Animal Environment. The Avi Publishing Company Inc., Westport, Connecticut: 16-273, USA, 1982.

15. Altan Y, Sendil C: Introduction to Internal Medicine Clinic. Publication of Istanbul University Veterinary Faculty, 3108, Istanbul, pp. 63-105 (In Turkish), 1983.

16. Eyal E: Shorn and unshorn Awassi sheep. II. Pulse rate. *J Agric Sci* (Great Britain), 60,169-173, 1963.

17. Naqvi SMK, Maurya VP, Gulyani R, Joshi A, Mittal JP: Effect of thermal stress on superovulatory response and embryo production in Bharat Merino ewes. *Small Ruminant Res,* 55, 57-63, 2004

18. Bianca W, Kunz P: Physiological reaction of three breeds to cold, heat and high altitude. *Livest Prod Sci*, 5, 57-69, 1978.

19. Quartermain AR, Broadbend MP: Some patterns of response to climate bye the Zambian goats. *East African Agricultural and Forestry J*, 40, 115-124, 1974.

20. Mc Dowell RE, Woodward A: Concepts in animal adaptation comparative suitability of goats, sheep and cattle two tropical environments. *Proceedings 3rd Int. Conf. On Goat Production and Disease,* January 10-15, Tucson, pp. 384-393, USA, 1982.

21. Silanikove N: Effects of heat stress on welfare of extensively managed domestic ruminants. *Livest Prod Sci*, 67, 1-18, 2000.

22. Devendra C: Bioclimatology and the adaptation of livestock. **In,** Johonson HD (Ed): World Animal Science. pp. 157-168, Elsevier, Amsterdam, 1987.