



## Annual Change of the Hematological Parameters in Female White Goats

Güngör Özgün GÖRÜR<sup>1</sup>, Lizge TALAN<sup>2</sup>, Kenan ERDOĞAN<sup>3</sup>, Nurcihan Ayça FIRAT<sup>4</sup>, Hüseyin POLAT<sup>5,\*</sup>

<sup>1,3</sup>Department of Biology, Faculty of Arts and Science, Aksaray University, Aksaray, Türkiye.

<sup>2,4,5</sup>Department of Molecular Biology and Genetic, Faculty of Arts and Science, Aksaray University, Aksaray, Türkiye.

<sup>2</sup><https://orcid.org/0009-0001-3353-8240>, <sup>3</sup><https://orcid.org/0000-0003-0447-1582>, <sup>4</sup><https://orcid.org/0009-0003-1269-1996>,

<sup>5,\*</sup><https://orcid.org/0000-0003-2834-0659>

\*Correspondence: [polat.hsyn@hotmail.com](mailto:polat.hsyn@hotmail.com)

### Abstract

In this study, hematological parameters changes in female goats were observed. It has been shown that a decrease in the level of erythrocyte (RBC), Hematocrit (Htc) and Hemoglobin (Hb) in higher temperature conditions was statistically different from an increase in the level of these characters in lower temperature conditions ( $P<0.01$ ). Monthly changes in level of Leukocyte, lymphocyte, granulocyte and monocyte were statistically different ( $P<0.01$ ). Moreover, increase in level of WBC, granulocyte and monocyte in higher temperatures and a decrease in level of lymphocyte were detected. The effects of seasonal changes (temperature) on Thrombocyte (THR) values were significant and reached higher measurements during warmer months. Reductions in the level of RBC, Htc, Hb and THR values in months with a higher temperature can be considered as a result of the elevations of blood plasma volume. Rise in values of WBC, Gra and Mon in months with a higher temperature might be related with immunologic regulation and effects of physiological periods.

**Keywords:** White goat, hematological parameter, season.

### 1. Introduction

There are a lot of factors that have an important influences on average blood physiological parameters in animal. These are age, sex, season, genera, altitude, climatic conditions, feeding, physiological conditions of animal and daily life habits (Soch et al., 2010; Arfuso et al., 2016; Karaşahin et al., 2022). Interactions of these factors effects goat's productivity (meat, milk, fiber, etc.) (Di Grigoli et al., 2009). Appropriate situations are necessary to enable to express genetic potential of productivity especially in goats (Agradi et al, 2022). Environmental conditions are important in livestock productivity. There are some studies conducted to improve the productivity of goats and generally focused on to determine the impacts of adverse environmental circumstances.

Although goats have been known that they easily adapt to difficult conditions (Silanikove, 2000), reductions in productivity and feeding have been shown in temperature stress conditions (Quartermain and Broadbent, 1974; Lu, 1989). Different factors such as temperature, humidity and air pressure result in new physiological regulations in goats

*This article was produced from the thesis work of the first author.*

(Olsson et al., 1995; Karaşahin et al., 2022). These regulations caused shifts in biochemical, hormonal and hematological parameters (Al-Haidary, 2004) and also influences significantly animal metabolism including productivity processes (Silanikove, 2000). While obtaining some data especially blood content during productivity activities might help to understand the reason of the lower productivity (Parker and Blowey, 1976). Hematological parameters are in the blood content derived measurements and they helps to learn health and feeding conditions of animals (Gupta et al., 2007). It has been very well known that there are different variations in hematological parameters among goat races (Tambuwal et al., 2002; Daramola et al., 2005; Opara et al., 2010; Arfuso et al., 2016; Polat et al., 2020). White goats (Saanen X Kilis) are a goat race in Türkiye where their beef, milk and hair are used. There are limited results with hematological parameters related with seasonal physiological changes in white goats. It was aimed to find out seasonal hematological changes in white goats and their effects on physiological situations and productivity of this white goat race.

## **2. Materials and methods**

### ***Location, experimental animals and their management***

This study was carried out between December and November in a farm entitled Ankara University Faculty of Agriculture, Department of Animal Science, Animal Husbandry Station located in Ankara, Türkiye (39°57'42.5" N; 32°51'56.2" E) at an altitude of approximately 850 m above sea level. It was carried out on female White goats grown in Ankara University Faculty of Agriculture Department of Animal Science. Research materials consisted of female White goats (n: 5, age 1.5; n: 5, age 2.5) and blood samples taken from them.

During the two months prior to starting of the study, all goats were kept track and subjected to internal and external parasite controls. All the goats were clinically healthy. Kiddings occurred in March. Kids were kept together with their mother during lactation period, and the goats were not milked during this period. The goats were fed wheat straw, alfalfa hay, maize silage and concentrated feed (in some physiological periods such as pre-mating, late pregnancy and lactation) and female goats were not milking during the experimental period. Freshwater was made available always for the all the goats. The general operation of the farm was not intervened in the management of experimental goats. Experimental procedures of this study were in accordance with the principles of the Declaration of Helsinki.

### ***Blood collection and haematological analysis***

Blood samples were taken regularly from the vena jugularis of each goat into vacuum tubes containing Na<sub>2</sub>-EDTA (VACUETTE® K2E K2EDTA) as the anticoagulant in every month (at 11:00 am, in the middle of the month) during one whole year. Red blood cells (RBC), haematocrit (Hct), haemoglobin (Hb), white blood cell (WBC), lymphocytes (Lym), granulocyte (Gra), monocyte (Mon) and thrombocytes (THR) were analysed by haematology analyser (MS4e, Melet Schloesing Laboratories, France – Cat. No: WD1153) from the whole blood in the Reproductive Biology and Animal Physiology Laboratory at Ankara University, Faculty of Agriculture, Department of Animal Science.

### ***Climatic values and photoperiod***

Climatic values on the location of the farm where the experiment was carried out, were obtained from the Turkish State Meteorological Service (TSMS 2011) in order to estimate the severity of heat stress during the experimental period. Temperature-humidity index (THI) was calculated using the equation below reported by Marai et al., (2001) for sheep and goats (Marai et al., 2007).

$$\text{“THI} = \text{db } ^\circ\text{C} - \{(0.31 - 0.31 \text{ RH}/100) (\text{db } ^\circ\text{C} - 14.4)\}\text{”}$$

“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; Di Grigoli et al., 2009).

### Statistical analyses

Derived hematological parameters were tested by performing repeated two-way ANOVA analysis (Gürbüz et al., 2003). Following the varyans analyses, in which month and the group mean were differentiated from each other, were checked by applying a t-test and Duncan multivariate analyses. Varyans analyses were performed by using SPSS 15 and Duncan multivariate analyses were conducted with MSTAT-C packet programme.

### 3. Results

The values of average environmental temperature, average relative humidity and THI on the experimental days are shown in Table 1. As can be seen from Table 1, the goats were only affected by severe heat stress in August during the experimental period.

**Table 1.** Average temperature, relative humidity and THI during the experimental period (2009-2010).

Months	Average temperature (°C)	Average humidity (%)	THI
December	6,0	80,4	11,63
January	2,3	79,3	1,64
February	3,1	70,2	1,18
March	5,8	67,9	5,75
April	9,9	66,7	10,31
May	15,0	64,4	10,13
June	19,3	58,4	19,88
July	25,0	47,2	21,55
August	23,5	49,3	<b>26,54</b>
September	20,0	45,0	20,56
October	11,1	65,3	12,16
November	3,4	71,1	6,64

In table 2, changes in hematological parameters of the female white goats during a year were presented. As a result of the analyses parameters, it has been shown that annual changes in RBC, Hb and Htc were statistically significant (Table 2, P<0.01). The highest values were obtained in December and February and the lowest measurements were derived in June and August respectively. It has been also shown that differences in WBC, Lym, Gra, Mon and THR among months were statistically different (P<0.01). The highest values were measured in August, December, June and August and the lowest were determined in February, June, December, and August respectively. Hematological parameters between age groups were not significantly differed from each other.

**Table 2.** Female White goats (1.5 years old n: 5; 2.5 years old n: 5) for a year of hematological parameters (Mean  $\pm$  SE) findings.

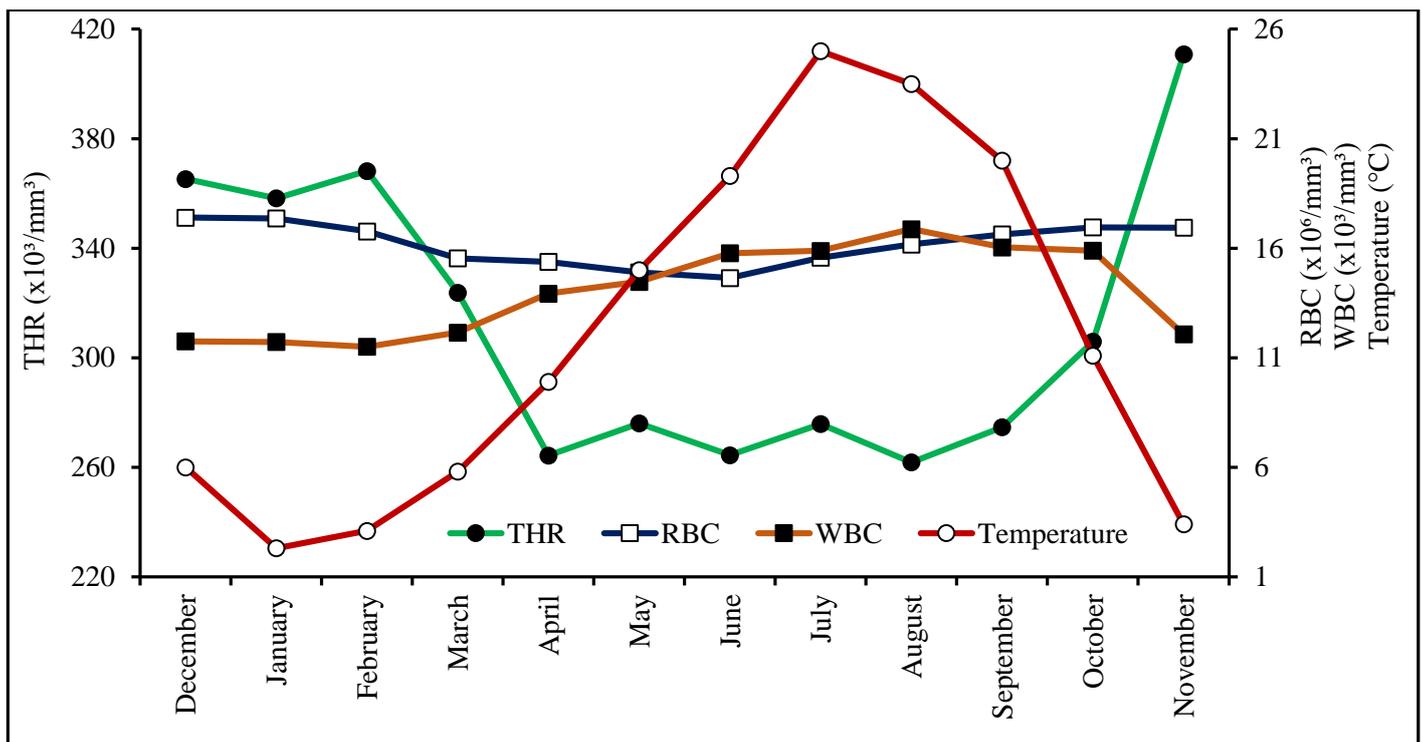
Parameter	Month											
	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.
<b>WBC</b> ( $\times 10^3/\text{mm}^3$ )	11.75 $\pm 0.48$ DEF*	11.72 $\pm 0.46$ DEF	11.50 $\pm 0.86$ EF	12.15 $\pm 0.74$ DE	13.93 $\pm 0.45$ CDE	14.47 $\pm 0.47$ BCD	15.77 $\pm 0.53$ ABC	15.88 $\pm 0.76$ AB	16.87 $\pm 0.83$ A	16.04 $\pm 0.49$ AB	15.89 $\pm 0.49$ AB	12.07 $\pm 0.58$ DE
<b>Lym</b> (%)	56.51 $\pm 2.53$ A	52.21 $\pm 3.18$ A	49.37 $\pm 1.95$ AB	35.09 $\pm 2.43$ C	25.90 $\pm 1.58$ D	25.58 $\pm 2.96$ D	25.02 $\pm 2.66$ D	27.86 $\pm 2.61$ D	32.07 $\pm 3.16$ CD	35.62 $\pm 2.01$ C	41.39 $\pm 2.50$ BC	52.01 $\pm 3.03$ A
<b>Gra</b> (%)	39.26 $\pm 2.50$ EFG	43.27 $\pm 3.09$ EFG	44.56 $\pm 2.07$ EFG	57.99 $\pm 2.53$ BCD	66.72 $\pm 1.78$ AB	67.01 $\pm 3.12$ AB	67.84 $\pm 2.71$ AB	65.43 $\pm 2.71$ AB	59.70 $\pm 3.23$ BC	56.48 $\pm 2.02$ BCD	51.19 $\pm 2.36$ DE	42.36 $\pm 3.28$ EFG
<b>Mon</b> (%)	4.23 $\pm 0.14$ E	4.52 $\pm 0.32$ E	6.07 $\pm 0.31$ D	6.92 $\pm 0.22$ BC	7.38 $\pm 0.26$ ABC	7.41 $\pm 0.27$ ABC	7.14 $\pm 0.24$ AB	7.71 $\pm 0.20$ AB	8.23 $\pm 0.29$ A	7.90 $\pm 0.27$ AB	7.42 $\pm 0.21$ ABC	5.63 $\pm 0.34$ DE
<b>RBC</b> ( $\times 10^6/\text{mm}^3$ )	17.40 $\pm 0.41$ A	17.36 $\pm 0.49$ A	16.77 $\pm 0.21$ AB	15.54 $\pm 0.30$ BCDE	15.38 $\pm 0.53$ CDE	14.90 $\pm 0.39$ DE	14.64 $\pm 0.39$ E	15.57 $\pm 0.37$ BCDE	16.17 $\pm 0.36$ ABCD	16.63 $\pm 0.44$ ABC	16.95 $\pm 0.46$ AB	16.94 $\pm 0.48$ AB
<b>Htc</b> (%)	35.50 $\pm 1.00$ A	35.34 $\pm 1.59$ A	29.94 $\pm 2.14$ BC	29.42 $\pm 1.05$ BC	30.01 $\pm 1.56$ B	26.64 $\pm 1.29$ C	25.14 $\pm 1.19$ C	26.54 $\pm 1.22$ C	27.37 $\pm 1.08$ BC	28.15 $\pm 1.50$ BC	30.43 $\pm 1.42$ B	32.78 $\pm 1.34$ B
<b>Hb</b> (g/dl)	10.31 $\pm 0.29$ AB	10.42 $\pm 0.50$ AB	11.05 $\pm 0.35$ A	9.58 $\pm 0.34$ BC	9.73 $\pm 0.38$ BC	8.84 $\pm 0.38$ CDE	8.50 $\pm 0.36$ DEF	8.39 $\pm 0.34$ DEF	7.71 $\pm 0.28$ F	9.28 $\pm 0.26$ CD	9.75 $\pm 0.34$ BC	9.91 $\pm 0.29$ AB
<b>THR</b> ( $\times 10^3/\text{mm}^3$ )	365.3 $\pm 24.2$ BC	358.2 $\pm 21.2$ BC	368.2 $\pm 19.9$ BC	323.8 $\pm 19.8$ BCD	264.3 $\pm 33.6$ CD	276.0 $\pm 45.7$ CD	264.4 $\pm 37.9$ CD	275.8 $\pm 41.3$ CD	261.8 $\pm 53.0$ CD	274.6 $\pm 56.3$ CD	305.9 $\pm 55.4$ BCD	410.8 $\pm 50.8$ A

\*: A, B, C, D, E Row means along the same line with different superscripts differ significantly at  $P < 0.01$ .

#### 4. Discussion

Generally, the hematological profile of animals plays a crucial role in understanding their overall health and wellbeing, such as their physiological status, diagnosis of diseases, monitoring treatment efficacy, and even assessing the impact of environmental factors on their health (Al-Eissa et al., 2012). Environmental changes (seasonal) result in various physiological reactions in animals. Among these changes body temperature and changes in respiration rate were evaluated as a indicator of the level of climatic stress (Prasetyo et al., 1984). Climatic conditions, altitude, season, feeding and physiological conditions have different effects particularly physiological parameters (Hormonal, biochemical and hematological) in goats (Soch et al., 2010; Arfuso et al., 2016; Polat et al., 2020). Especially CBC values in goats are sensitive to changes in climatic factors and can be accepted as an important indications of the reactions showed against environmental stresses (Al-Dawood 2017; Habibu et al., 2018; Polat et al., 2020). The elevation of glucocorticoids activated from the hypothalamus–pituitary–adrenal axis is one of the primary physiological mechanisms of vertebrates that cope with challenging environmental stressors, which reduces the immune response efficiency (Rashid and Irshadullah, 2020).

White goats were exposed to seasonal changes in order to follow how their hematological parameters were affected (Table 1). As it was easily recognized from Table 2 and Figure, RBC, Hct and Hb levels decreased during warmer months while increased in months with a lower temperature. It has been shown that water consumption in goats higher during the summer period (Prasetyo et al., 1984; Pospisil et al., 1987; Hadjipanayiotou 1995; Todini, 2007) and it caused an increase in blood plasm (hemodilution) in animals (Hadjipanayiotou, 1995; İriadam, 2007; Abdelatif et al., 2009; Barrett et al., 2010; Polat et al., 2020). Increase in Erythrocytes in white goats during summer months might be a result of the hemodilution and results of the Hct ve Hb indicated increase in blood plasm during summer periods (Figure 1).



**Figure 1.** Seasonal change of RBC, WBC and THR levels in female White goats.

Results obtained with White goats are coincident with the West African dwarf goats (Olayemi et al., 2009), Nubian goats (Abdelatif et al., 2009), Black Bengal goats (Bhatta et al., 2016), Aspromontana, Girgentana, Messinese, Maltese and Argentata dell'Etna goats (Arfuso et al., 2016), Angora goats (Polat et al., 2020) and other goat varieties. It has been shown that temperature had a significant effect on WBC, Lym, Gra and Mon in White goats ( $p < 0.01$ ) (Figure 1, Table 2). Particularly cortisol release increased in White goats during summer months as temperature caused stress (Pehlivan and Dellal 2017) and stress resulted an increase in WBC values in goats (Bafti and Mozaffari 2012; Polat et al., 2020). There are also some studies indicated the seasonal changes effects on hematological parameters of goats (Fadere et al., 2013; Polat et al., 2020). Findings of the presented study were similar with the highest level of total leukocyte measured during dry summer months while a slight decrease in winter months in female Nubia goats (Abdelatif et al., 2009) and WBC, Lym, Gra and Mon measurements derived from Ankara goats (Polat et al., 2020). WBC parameters obtained in presented study were also parallel with the previous studies (Tambuwal et al., 2002; Abdelatif et al., 2009; Olayemi et al., 2009; Addass et al., 2010; Fadare et al., 2013; Arfuso et al., 2016; Polat et al., 2020). Monocyte parameters measured during summer months in this study were higher during summer months than winter months and these findings were similar with female Nubia goats (Abdelatif et al., 2009), Dhofari goats (Al-Busaidi et al., 2008) and Ankara goats (Polat

et al., 2020). It has been also proposed that increase in monocyte level might be related with the increase in cortisol secretion (Abdelatif et al., 2009).

There are various factors influence on levels of platelets including systemic diseases that causes functional failure, trauma, bleeding, local or systemic infection and feeding. It has been shown that monthly changes in plateletes level (THR) during a year for white goats were statistically significant ( $p < 0.01$ ) (Figure 1, Table 2) and determined THR level not related wiht seasonal (temperature) changes. It has been pointed out that variability in platelets level in a year might be effected from physiological periods (Durotoye 1987; Waziri et al., 2010; Polat et al., 2020). It has been also considered that increase in blood plasm volume during summer months lead to changes in blood cell elements level (Hadjipanayiotou 1995; Iriadam 2007; Abdelatif et al., 2009; Polat et al., 2020). Reported decrease in platelest level during the summer months in Ankara goats were similar with the presented findings (Polat et al., 2020). Differences among age groups in this study were not statistically significant.

As a result of the study, it has been clearly shown that seasonal changes have important effects on variability in hematological parameters. Environmental stress (temperature) and different physiological periods had significant impacts on erythrocyte, platelets, leukocyte levels.

## References

- Abdelatif, A.M., Ibrahim, M.Y., Hassan, Y.Y. (2009). Seasonal variation in erythrocytic and leukocytic indices and serum proteins of female Nubian Goats. *Middle-East J Sci Res.* 4:168–174.
- Addass, P.A., Midau, A., Babale, D.M. (2010). Haemato-biochemical findings of indigenou goats in Mubi, Adamawa State, Nigeria. *J Agric Sci.* 6:14–16.
- Al-Eissa, M., Alkahtani, S., Al-Farraj, S., Alarifi, S.A., Al-Dahmash, B., Al-Yahya, H. (2012). Seasonal variation effects on the composition of blood in Nubian ibex (*Capra nubiana*) in Saudi Arabia. *Afr J Biotechnol.* 11:1283–6.,
- Agradi, S., Menchetti, L., Curone, G., Faustini, M., Vigo, D., Villa, L., ... & Gazzonis, A. L. (2022). Comparison of female verzaschese and camosciata delle alpi goats' hematological parameters in the context of adaptation to local environmental conditions in semi-extensive systems in Italy. *Animals*, 12(13), 1703.
- Al-Busaidi, R., Johnson, E.H., Mahgoub, O. (2008). Seasonal variations of phagocytic response, immunoglobulin G (IgG) and plasma cortisol levels in Dhofari goats. *Small Ruminant Research*, 79(2-3), 118-123.
- Al-Dawood, A. (2017). Towards heat stress management in small ruminants – a review. *Ann Anim Sci.* 17(1):59–88.
- Al-Haidary, A.A. (2004). Physiological responses of Naimey sheep to heat stress challenge under semi-arid environments. *Int J Agri Biol.* 6(2):307–309.
- Arfuso, F., Fazio, F., Rizzo, M., Marafioti, S., Zanghi, E., Piccione, G. (2016). Factors affecting the hematological parameters in different goat breeds from Italy. *Ann Anim Sci.* 16(3):743–757.
- Bafti, M.S. and Mozaffari, A.A. (2012). Normal hematological parameters in Iranian cashmere (Raini) goats. *Comp Clin Pathol.* 21:1653–1655.
- Barrett, K.E., Barman, S.M., Boitano, S., Brooks, H.L. (2010). *Ganong's review of medical physiology.* McGraw-Hill Medical, 23rd edition, New York, USA, 714.
- Bhatta, M., Das, D., Ghosh, P.R. (2016). The effect of the seasonal variation and sexual dimorphism on the erythrocytic indices of black Bengal goats (*Capra aegagrus hircus*) in Nadia, West Bengal. *Indian J Biol.* 3:2.
- Daramola, J.O., Adeloye, A.A., Fatoba, T.A., Soladoye, A.O. (2005). Haematological and biochemical parameters of West African Dwarf goats. *Livest Res Rural Dev.* 17(8):14.
- Di Grigoli, A., Todaro, M., Di Miceli, G., Luigia Alicata, M., Cascone, G., Bonanno, A. (2009). Milk production and physiological traits of ewes and goats housed indoor or grazing at different daily timing in summer. *Italian Journal of Animal Science*, 8(sup2), 616-618.
- Durotoye, L.A. (1987). E ffect of sex, pregnancy and lactation on osmotic fragility of the West African dwarf sheep. *Bull Anim Hlth Prod Afr.* 35:29–33.
- Fadare, A.O., Peters, S.O., Yakubu, A., Sonibare, A.O., Adeleke, M.A., Ozoje, M.O., Imumorin, I.G. (2013). Physiological and haematological indices suggest superior heat tolerance of white-coloured West African Dwarf sheep in the hot humid tropics. *Trop Anim Health Prod.* 45:157–165.

- Gupta, A.R., Putra, R.C., Saini, M., Swarup, D. (2007). Haematology and serum biochemistry of Chital (*Axis axis*) and barking deer (*Muntiacus muntjak*) reared in semi-captivity. *Vet Res Comm.* 31:801–808.
- Gürbüz, F., Baspınar, E., Camdeviren, H., Keskin, S. (2003). Tekrarlanan ölçümlü deneme düzenlerinin analizi [Analysis of the repeated measurement experiments]. Turkish: Van: Yüzüncü Yıl Üniversitesi Matbaası.
- Habibu, B., Dzenda, T., Ayo, J.O., Yaqub, L.S., Kawu, M.U. (2018). Haematological changes and plasma fluid dynamics in livestock during thermal stress, and response to mitigative measures. *Livest Sci.* 214:189–201.
- Hadjipanayiotou, M. (1995). Fractional outflow of soybean meal from the rumen, water intake and ruminal fermentation pattern in sheep and goats at different seasons and age groups. *Small Rumin Res.* 17:137–143.
- Iriadam, M. (2007). Variation in certain hematological and biochemical parameters during the peri-partum period in Kilis does. *Small Rumin Res.* 73:54–57.
- Karavaşin, T., Aksoy, N. H., Dursun, Ş., Bulut, G., Haydardedeoğlu, A. E., Çamkerten, G., Çamkerten, İ., İlgin, R. (2022). Effects of age and sex on some hematological and biochemical parameters in Hair goats. In *Veterinary Research Forum* (Vol. 13, No. 1, p. 15).
- Lu, C.D. (1989). Effect of heat stress on goat production. *Small Rumin Res.* 2:151–162.
- Marai, I.F.M., Ayyat, M.S., Abd El-Monem, U.M. (2001). Growth performance and reproductive traits at first parity of New Zealand White female rabbits as affected by heat stress and its alleviation under Egyptian conditions. *Trop Anim Health Prod.* 33:451–462.
- Marai, I.F.M., El-Darawany, A.A., Fadiel, A., Abdel-Hafez, M.A.M. (2007). Physiological traits as affected by heat stress in sheep—a review. *Small Rumin Res.* 71:1–12.
- Olayemi, F.O., Oboye, O.O., Azeez, O., Oyagbemi, A.A., Soetan, K.O. (2009). Influence of management systems and sex on haematology of West African dwarf goat. *Afr J Agric Res.* 4(11):1199–1202.
- Olsson, K., Joaster-Hermelin, M., Hossaini-Hilali, J., Hydrbrig, E., Dahlborn, K. (1995). Heat stress causes excessive drinking in fed and food-deprived pregnant goats. *Comp Biochem Physiol (A).* 110 (4):309–317.
- Opara, M.N., Udevi, N., Okoli, I.C. (2010). Haematological parameters and blood chemistry of apparently healthy West African Dwarf (Wad) goats in Owerri, South Eastern Nigeria. *N Y Sci J.* 3(8):68–72.
- Parker, B.N. and Blowey, R.W. (1976). Investigations into the relationships of selected blood components nutrition and fertility of the dairy cow under commercial farm conditions. *Vet Rec.* 98 (20):394–404.
- Pehlivan, E. and Dellal, G. (2017). Annual changes of thyroid stimulating hormone, thyroxine, triiodothyronine and cortisol hormones in Angora goats. *J Anim Plant Sci.* 27(3):819–824.
- Polat, H., Pehlivan, E., Dellal, G. (2020). Annual change of haematological parameters in Angora goats. *Biological Rhythm Research*, 51(5), 679-689.
- Pospisil, J., Kase, F., Vahala, J. (1987). Basic haematological values in the Cameroon goat (*Capra hircus*). *Comp Biochem Physiol.* 88A:451–545.
- Prasetyo, S., Miller, H.M., Scheurman, E.A., Holmes, J.H.G. (1984). The effect of heat and humidity on pregnant feral goats. *Anim Prod Aust.* 15:541–544.
- Quartermain, A.R. and Broadbent, M.P. (1974). Some patterns of response to climate by Zambian goats. *East Afr Agric For J.* 40:115–124.
- Rashid, S. and Irshadullah, M. (2020). Evaluation of antioxidant and oxidant status of goats (*Capra aegagrus hircus*) naturally infected with *Haemonchus contortus*. *Journal of helminthology*, 94, e36.
- Silanikove, N. (2000). The physiological basis of adaptation in goats to harsh environments. *Small Rumin Res.* 35:181–193.
- Soch, M., Srejberova, P., Broucek, J., Kisae, P., Stastna, J., Uhrincat, M., Cermak, B. (2010). Evaluation of hematological parameters and trace elements in the blood of sheep. *Anim Sci Biotechnologies.* 43(1):524–527.
- Tambuwal, F.M., Agale, B.M., Bangana, A. (2002). Haematological and biochemical values of apparently healthy Red Sokoto goats. *Proceeding of the 27th Annual conference Nigerian Society of Animal Production (NSAP), Akure, 17-21 March 2002, 50-53.*
- Todini, L. (2007). Thyroid hormones in small ruminants: effects of endogenous, environmental and nutritional factors. *Animal.* 1(7):997–1008.
- TSMS. (2011). Turkish state meteorological service [dataset]. Department of Statistics. Ankara.
- Waziri, M.A., Ribadu, A.Y., Sivachelvan, N. (2010). Changes in the serum proteins, hematological and some serum biochemical profiles in the gestation period in the Sahel goats. *Veterinarski Ahrhiv.* 80:215–224.