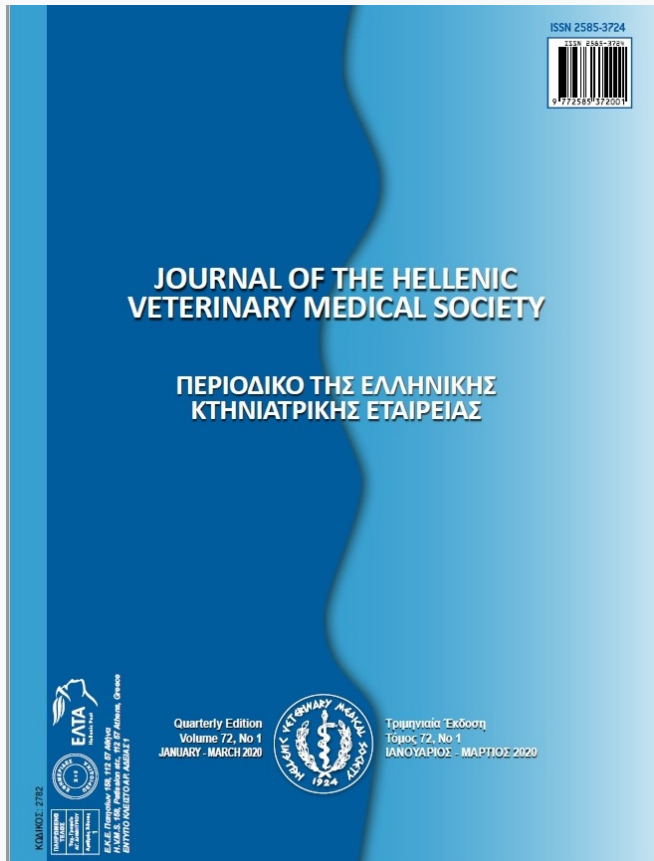


Journal of the Hellenic Veterinary Medical Society

Vol 72, No 1 (2021)



Hematological and Biochemical Parameters of Pregnant and Lactating Goats in Rangeland of Cholistan Desert, Bahawalpur, Pakistan

MH LASHARI, I AHMAD, S MASOOD, U FAROOQ, M ANAM, MS AKHTAR, AA FAROOQ, S LEGHARI, M NAEEM, M NAWAZ

doi: [10.12681/jhvms.26765](https://doi.org/10.12681/jhvms.26765)

Copyright © 2021, MH LASHARI, I AHMAD, S MASOOD, U FAROOQ, M ANAM, MS AKHTAR, AA FAROOQ, S LEGHARI, M NAEEM, M NAWAZ



This work is licensed under a [Creative Commons Attribution-NonCommercial 4.0](https://creativecommons.org/licenses/by-nc/4.0/).

To cite this article:

LASHARI, M., AHMAD, I., MASOOD, S., FAROOQ, U., ANAM, M., AKHTAR, M., FAROOQ, A., LEGHARI, S., NAEEM, M., & NAWAZ, M. (2021). Hematological and Biochemical Parameters of Pregnant and Lactating Goats in Rangeland of Cholistan Desert, Bahawalpur, Pakistan. *Journal of the Hellenic Veterinary Medical Society*, 72(1), 2781–2786. <https://doi.org/10.12681/jhvms.26765>

Hematological and Biochemical Parameters of Pregnant and Lactating Goats in Rangeland of Cholistan Desert, Bahawalpur, Pakistan

M. H. Lashari¹, I. Ahmad¹, S. Masood², U. Farooq³, M. Anam¹, M. S. Akhtar⁴, A. A. Farooq⁴,
S. Leghari⁵, M. Naeem², M. Nawaz⁶

¹Department of Zoology, Baghdad-ul-Jadeed Campus, The Islamia University of Bahawalpur, Punjab, Pakistan

²Institute of Pure & Applied Biology, B. Z. University, Multan, Pakistan

³Department of Physiology, University College of Veterinary & Animal Sciences, Baghdad ul Jadeed Campus, The Islamia University of Bahawalpur, Pakistan

⁴Faculty of Veterinary Sciences, B. Z. University, Multan, Pakistan

⁵Department of Botany, University of Balochistan, Quetta

⁶Department of Environmental Science, B. Z. University, Multan, Pakistan

ABSTRACT: Jattal goats (n=90) of approximately 2-6 years of age being reared in Cholistan desert of Pakistan were studied during January to December, 2015 to examine the alterations in hematochemical parameters of Jattal goats at different reproductive phases while feeding on natural vegetations of desert areas of Cholistan. These were divided into three equal groups (non-pregnant, pregnant and lactating). Blood samples were collected by jugular vein puncture from goats of these three groups. Hematological parameters, white blood cells (WBC), lymphocytes (LYM), monocytes (MON), granulocytes (GRA), red blood cells (RBC), hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC) and red cell distribution width RDW were recorded.

The results obtained revealed that all these parameters were generally lower in non-pregnant goats. The study revealed that significant higher values of hemoglobin (Hb), mean cell hemoglobin (MCH) and mean corpuscular volume (MCV) were observed in the lactating goats ($P < 0.05$). Pregnant goats showed a significantly ($P < 0.05$) higher values of leucocytes (WBC) than lactating and non-pregnant goats. Plasma sodium (Na) and potassium (K) concentration were markedly lower in lactating goats. Plasma alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were significantly lower in pregnant goats. The Plasma concentration of cholesterol and triglycerides were higher in pregnant goats.

In conclusion in present study changes in some hematochemical parameters have been determined in pregnant, non-pregnant and lactating goats of Jattal breed.

Keywords: Jattal goat, haematochemical, Cholistan desert.

Corresponding Author:
Mushtaq Hussai Lashari, Department of Zoology, The Islamia University of Bahawalpur, Punjab, Pakistan
E-mail address: mushtaqdashary@gmail.com

Date of initial submission: 01-05-2019
Date of revised submission: 19-05-2020
Date of acceptance: 30-06-2020

INTRODUCTION

Goats play a vital role in the livestock subsector of the Pakistani agricultural economy. Pakistan hosts 68.4 million goats and constitutes significant source of milk and meat for millions of Pakistani people. Livestock division contributes about 58.9% in total agricultural value increased and about 11.3% of country GDP (Anonymous, 2018). Keeping of small ruminants is necessary practice in rural parts of Pakistan as it plays a vital role in the socio-economic profile through provision of an income and employment. Goats consume a large number of grasses, bushes, shrubs, tree leaves and crop residues that would otherwise go waste and cause environmental pollution. The goats can be milked any time of the day and are therefore named as the 'moving refrigerators'. Goat meat is preferred over other meat in Pakistan because it is leaner (Jindal, 1984). The Jattal is one of the important breeds of goat maintained in Cholistan areas of Pakistan. Farmers prefer it over other breeds because it has high prolificacy with three kidding in two years (Lashari and Tasawar, 2010).

Diet, age, sex, pregnancy and estrus are known to affect the biochemical and hematological parameters (Balikci *et al.*, 2007). Blood is a reliable and main medium for measuring the health condition of animals. Research has confirmed the incident of modifications in certain constraints during lactation and gestation period after birth in several animal species (Ozyurtlu *et al.*, 2007), however, no indicated values are existing for blood constraints before and during pregnancy in the Jattal goat. Therefore, the present work focused on the chosen and biochemical parameters in pregnant, and lactating Jattal goats being reared in Cholistan desert of Pakistan.

MATERIALS AND METHODS

Location and climate of the study area

This research was performed on the Jattal breed of goat reared in Cholistan desert, Punjab, Pakistan. This is the seventh largest desert of the world. Cholistan desert comprises about 26,000 km² situated between latitude 27 to 29 N and longitude 69° to 75° E at height of about 112 m above sea level (Ali *et al.*, 2009).

The Cholistan environment is arid subtropical with meager rainfall, low relative humidity, high temperature and strong summer winds. It is the driest and hottest area of Pakistan, with summer spanning May through October. Randomly selected artificial/natural reservoirs and ponds, called Tobas. (Farooq *et al.*,

2015). It is the homeland of many precious animal genetic resources. Most of the Cholistan is covered with wide range of nutritious and drought tolerance species of plants.

Experimental Period and Animals

Ninety adult female goats ranging between 2-5 years of age were used in a study approved by the Ethical Review Committee for the Use of Animals, under the administrative control of the Office of Research, Innovation, and Commercialization of The Islamia University, Bahawalpur. Written consent was obtained from the Cholistan pastoralists involved in our study. The selected flocks were under natural grazing with seasonal/perennial grasses along with tree looping. Important species of natural cholistan vegetation consumed by goats were: *Cynodon dactylon*, *Ochthochola compressa*, *Solanum surattense*, *Tribulus longipetalus*, *Tribulus longipetalus*, *Tribulus terrestris*, *Pulicaria crispera*, *Avera javanica*, *Haloxylon salicornicum*, *Calligonum polygoxoidis*.

These goats were divided into three equal groups (n=30/group) viz .non-pregnant, pregnant (more than 90 days) and lactating. All animal were clinically normal and healthy and were free of endo/ectoparasites.

Blood collection

For hematology and biochemical parameters 10 mL blood samples were taken from every goat by jugular vein puncture into clean test tubes and stored as two aliquots: un-clotted for hematological examination and clotted for harvesting serum. While the animal was manually restrained, for the sake of standardization of collection technique all samples was collected by same person from animals restrained by same technique.

Transportation of samples was made in an ice box to the Physiology Laboratory, Department of Life Sciences, the Islamia University of Bahawalpur, Pakistan, refrigerated and analyzed within 12h for the assessment of hematological parameters by using an automated hematology analyzer (Mythic 18; Orphee, USA). Entire samples were examined on the same day.

Blood samples for biochemical analyses were centrifuged at 3500 rpm for 10-15 min., and the serum was harvested in serum collection containers. The biochemical parameters included triglycerides (TGs) cholesterol, aspartate aminotransferase (AST), ala-

nine aminotransferase (ALT), Sodium (Na^+) and Potassium (K^+) which were assessed using the biochemistry analyzer (CHEM 100, Japan).

Statistical Analysis

Statistical analysis was conducted through MINITAB. The mean values (\pm SEM) for the hematological parameters were calculated. Variation between the mean values for three groups was attained through ANOVA. $P < 0.05$ was considered as statistically significant.

RESULTS

Hematochemical Parameters

Table 1 shows the mean \pm SE values for red blood cells (RBC), hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC) and red cell distribution width RDW in non-pregnant, pregnant and lactating goats.

A gradual increase $3.41 \pm 0.17 \times 10^6/\mu\text{L}$, $3.73 \pm 0.13 \times 10^6/\mu\text{L}$ and $3.93 \pm 0.25 \times 10^6/\mu\text{L}$ in the number of erythrocyte was examined in the peripheral blood of non-pregnant, pregnant and lactating goats respectively. The haemoglobin (Hb) level was significantly lower ($P < 0.05$) in pregnant and lactating goats as compared to non-pregnant goats. The haematocrit (HCT) value was higher in pregnant and lactating goats as compared to non-pregnant goats. The mean corpuscular volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC) and red cell distribution width (RDW) were significantly ($P < 0.05$) lower in pregnant and lactating goats as compared to non-pregnant goats.

Table 2 shows the mean \pm SE values for white blood cells (WBC), lymphocytes (LYM), monocytes

(MON), granulocytes (GRA).

The mean leukocyte (WBC) value was $17.32 \pm 1.70 \times 10^3/\mu\text{L}$ in non-pregnant goats and prominent higher $24.44 \pm 2.08 \times 10^3/\mu\text{L}$ was detected in pregnant goats and significantly lower $20.78 \pm 1.65 \times 10^3/\mu\text{L}$ was recorded in lactating goats. The difference was statistically significant ($P < 0.05$). Lymphocyte (LYM) mean \pm SEM value was $9.04 \pm 1.14 \times 10^3/\mu\text{L}$ in non-pregnant goats. The highest value recorded $13.77 \pm 1.56 \times 10^3/\mu\text{L}$ in pregnant goats and the lactating goats also showed higher values of Lymphocyte as compared to non-pregnant goats. The mean \pm SEM value of monocytes (MON) was $0.84 \pm 0.05 \times 10^3/\mu\text{L}$ in non-pregnant goats which was significantly ($P < 0.05$) lower than lactating and pregnant goats.

Apparently higher $9.67 \pm 0.79 \times 10^3/\mu\text{L}$ value of granulocytes (GRA) was recorded in pregnant goats as compared to non-pregnant and lactating goats but statistically the difference was non-significant ($P > 0.05$).

The result of biochemical parameters of the non-pregnant, pregnant and lactating goats are shown in Table 3. There were statistically significant ($P < 0.05$) differences in the values of aspartate aminotransferase (AST), alanine aminotransferase (ALT), cholesterol and triglycerides between the non pregnant and pregnant goats. Aspartate aminotransferase (AST), cholesterol and triglycerides levels were higher in pregnant and lactating goats than non-pregnant, while a lower value of alanine aminotransferase (ALT) was observed in pregnant and lactating goat. There was significant decreasing trend in the sodium and potassium parameters, but the decrease was not statistically significant ($P > 0.05$).

Table 1. The mean \pm SEM values of red blood cell parameters of non pregnant, pregnant and lactating goats maintained in Cholistan desert of Bahawalpur

Parameters	Non-Pregnant (n=30)	Pregnant (n=30)	Lactating (n=30)
RBC ($10^6/\mu\text{L}$)	3.41 ± 0.17	3.73 ± 0.13	3.93 ± 0.25
Hb (g/dl)	7.93 ± 0.20	$7.32 \pm 0.16^{*a}$	$7.05 \pm 0.25^{*b}$
HCT (%)	10.08 ± 0.52	10.69 ± 0.38	11.34 ± 0.72
MCV (μm^3)	29.60 ± 0.16	$28.67 \pm 0.31^{*a}$	$28.83 \pm 0.19^{*b}$
MCH (Pg)	24.14 ± 0.99	20.47 ± 0.86	$18.70 \pm 0.85^{*b}$
MCHC (g/dl)	81.39 ± 3.21	$69.25 \pm 2.29^{*a}$	$64.83 \pm 2.92^{*b}$
RDW (%)	16.86 ± 0.84	$14.94 \pm 0.37^{*a}$	$13.68 \pm 0.48^{*b}$
RDW-SD (μm^3)	24.17 ± 0.31	23.09 ± 0.39	$21.37 \pm 0.67^{*b}$

Table 2. The mean \pm SEM values of white blood cell parameters of Non pregnant, pregnant and lactating goats maintained in Cholistan desert of Bahawalpur

Parameters	Non-Pregnant (n=30)	Pregnant (n=30)	Lactating (n=30)
WBC ($10^3/\mu\text{L}$)	17.32 \pm 1.70	24.44 \pm 2.08* ^a	20.78 \pm 1.65
LYM ($10^3/\mu\text{L}$)	9.04 \pm 1.14	13.77 \pm 1.56	10.96 \pm 1.08
MON ($10^3/\mu\text{L}$)	0.84 \pm 0.05	1.00 \pm 0.09	1.04 \pm 0.08
GRA ($10^3/\mu\text{L}$)	7.43 \pm 0.67	9.67 \pm 0.79	8.77 \pm 0.69
LYM (%)	50.04 \pm 2.32	54.00 \pm 2.54	52.33 \pm 2.13
MON (%)	5.30 \pm 0.27	4.48 \pm 0.38	5.13 \pm 0.27
GRA (%)	44.66 \pm 2.14	41.54 \pm 2.32	42.56 \pm 2.07

Table 3. The mean \pm SEM values of biochemical parameters of Non-pregnant, pregnant and lactating goats maintained in Cholistan desert of Bahawalpur

Parameters	Non-Pregnant (n=30)	Pregnant (n=30)	Lactating (n=30)
AST(IU/L)	36.57 \pm 7.50* ^a	36.43 \pm 4.83* ^a	39.29 \pm 5.13* ^b
ALT(IU/L)	26.43 \pm 4.33* ^a	20.71 \pm 3.15* ^b	23.14 \pm 2.83* ^b
Cholesterol (mg/dL)	56.86 \pm 6.92* ^a	76.14 \pm 6.69* ^b	70.71 \pm 5.44* ^b
Triglyceride (mg/dL)	54.86 \pm 6.01	74.43 \pm 3.91* ^a	63.43 \pm 3.15
Sodium(MEQ/L)	152.9 \pm 12.00* ^a	131.57 \pm 4.27* ^b	128.57 \pm 4.44* ^b
Potassium(MEQ/L)	3.96 \pm 0.21	3.54 \pm 0.23	3.90 \pm 0.31

DISCUSSION

This is the first study of Jattal goats of Colistan which was designed to determine salient hematochemical parameters among non-pregnant, pregnant and lactating goats maintained in Cholistan desert of Bahawalpur.

Hematochemical blood factors are most important for the livestock management as they provide essential indicators that may help to judge the animal's health status (Coles, 1986). It is accepted that numerous parameters like nutrition, age, stress, environment, muscle activity, gestation and disease have much effects on blood picture (Meyer and Harvey, 2004; Klinkon *et al.*, 2012).

In present study red blood cell (RBC) counts showed non-significant ($P>0.05$) difference among the non pregnant, pregnant and lactating goats. But pregnant and lactating goats had apparently higher RBCs count. This confirms the result of Pospisil (1987) who reported that there were no differences in red blood cell picture of 16 pregnant 30 non-pregnant and 20 lactating female goats older than 3 years.

Similar results have been documented in pregnant ewe, equine, pigs and canines. During the final stages of pregnancy the hemodilution effect boost in plasma levels of red blood cells (Jain, 1993). Azab and Abdel-Maksoud (1999) also found the same results

in pregnant goats. The hemodilution in ruminants decreases the flow of blood in the capillary vessels but it may improve the flow of blood through the capillary vessels of placenta to enhance the diffusion of Oxygen and other nutrients to the embryo (Yilmaz, 2000).

The present RBCs results were however different to that reported by Garkal *et al.* (2016) who described erythrocyte count decrease during pregnancy in buffaloes. This decrease may be due to the under stress condition due to the destruction of erythrocytes (Muna *et al.*, 2003).

The present study demonstrated that leucocyte counts were significantly ($P<0.05$) higher in pregnant and lactating goats as compared to non-pregnant goats. Present results are comparable to that described by Jain (1993), in that WBCs volume slowly boost up during the period of gestation upto the day of parturition. Lymphopenia and eosinopenia may be the cause of leucocytosis at the time of parturition. The neutrophils, lymphocytes and eosinophiles studies were comparable to those reported by (Azab and Abdel-Maksoud, 1999). The significant increase in the leukocytes count observed in pregnant goats is consistent with the earlier reports of Fortagne and Schafer (1989) who described an increase in the total leukocyte count in pregnant goats. Sandabe and Yahi, (2000) noted a significant increase in the leukocyte count of pregnant Sahel goats. This might be due to increase in

the bone marrow activity as well as, pregnancy stress. According to Dellmann and Brown (1987) the stress probably excite the discharge of main features called leucocytosis inducing factor (LIF) and colony stimulating factors (CSF) which are known to boost haemopoietic activities and blood cells mobilization into circulation.

The results of biochemical parameters in the present study showed that the cholesterol concentration was significantly ($P < 0.05$) higher in pregnant and lactating goats as compared to non pregnant goats. These results were comparable as reported by Waziri *et al.* (2010) in Sahel does. Similarly Biagi *et al.*, 1988 observed increased cholesterol level during pregnancy in sheep and Saanen goats respectively.

The differences in the level of biochemical parameters between the sources are enormous and results from nutrition breed, environment, season, age, stage of pregnancy, milk yield differences in the goats, time of sampling and analytical methods (Hassan *et al.*, 1986).

The triglyceride concentration was significantly higher in pregnant goats as compared to lactating and non-pregnant goats. Krokavec *et al.* 1992 reported the same result according to the present study. A variation in the results of triglycerides levels was reported by Nazifi *et al.* (2002) in Iranian goats.

A significant decrease in plasma sodium level was found in lactating goats in the present study. A non significant variation of K was observed among non-pregnant, pregnant and lactating goats. But apparently low potassium level was observed in pregnant group. The decrease in K level during pregnancy might be due to the mineral corticoid activity of progesterone (Azabe and AbedMaksoud, 1999) where the amount of discharge of potassium are increased which may be cause to reduce this electrolyte.

Alanin aminotransferase (ALT) was higher in the non-pregnant goats and lower in pregnant and lactating goats. The decrease in Alanin aminotransferase (ALT) activity in the pregnant goats was due to uterine and reproductive hormonal changes during pregnancy stage. The present results are comparable with Tainturier *et al.* (1984) who informed that alanin aminotransferase action reduced in the last months of pregnancy and that it remained stable in the start of lactation. Present study proved that lactating goats shoe increased levels of Alanin aminotransferase (ALT).

The highest activity of aspartate aminotransferase (AST) concentration was recorded in lactating goats and decreased in dry and pregnant groups. But apparently increased in the lactating goats was recorded. Tainturier *et al.* (1984) reported that AST activity in dairy cattle changes occasionally during pregnancy and lactation. This increase might be due to the release of this enzyme from liver metabolism during lactating period.

CONCLUSION

This study revealed that significant higher values of hemoglobin (Hb), mean cell hemoglobin (MCH) and mean corpuscular volume (MCV) were observed in the lactating goats ($P < 0.05$). Pregnant goats showed a significantly ($P < 0.05$) higher values of leucocytes (WBC) than lactating and non-pregnant goats. Plasma sodium (Na) and potassium (K) concentration were markedly lower in lactating goats. Plasma alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were significantly lower in pregnant goats. The plasma concentration of cholesterol and triglycerides were higher in pregnant goats.

CONFLICT OF INTEREST

None declared.

REFERENCES

- Ali I., M.S. Chaudhry and U. Farooq. 2009. Camel rearing in Cholistan desert of Pakistan. *Pakistan Veterinary Journal*. 29: 85-92.
- Anonymous. 2018. Economic Survey of Pakistan Livestock wing, Islamabad 2017-18.
- Azab M.E.H.A. and Abdel-Maksoud 1999. Changes in some hematological and biochemical parameters during prepartum and postpartum periods in female Baladi goats. *Small Ruminant Research*. 34: 77-85.
- Balikci E. A., A. Yaldiz and F. Gurdogan. 2007. Blood metabolic concentrations during pregnancy and postpartum in Akkaraman ewe. *Small Ruminant Research*. 67: 247-251.
- Biagi G., M. Bagliacca, A. Leto and A. Romagnoli. 1988. The use of metabolic profile test in a Saanen goat herd. *Ann. Fac. Med. Vet. Pisa*. 51: 395-410.
- Coles E. H. 1986. *Veterinary Clinical Pathology*. 3rd Edition. W. B Saunders Company, Philadelphia. 10-20.
- Dellmann H. D. and E. M. Brown. 1987. *Textbook of Veterinary Histology*. 3rd Edition. Lea and Febiger, Philadelphia. 71-95.
- Farooq U., S.A. Mahmood, A. Ijaz, N. Ahmad, M. Idris and M.T. Abbas. 2015. Evaluation of post thaw sperm parameters and fertility of Cholistan service bulls. *Turkish Journal of Veterinary and Animal Sciences*. 39: 472-479.
- Fortagne M. and M. Schafer. 1989. Haematological parameters of goats in the period from pregnancy to lactation. *Archiv für Experimentelle Veterinärmedizin*. 43: 223-230.
- Garkal R. A., P.M. Kekan, S. D. Kharde, V. K. Munde, B. W. Narladkar and M.S. Vaidya. 2016. Effect of different housing systems on haematological parameters of buffaloes. *Buffalo Bulletin* 35 (2): 191-197.
- Hassan G. A., F. D. El-Nouty, M. A. Samak and M. H. Saleem. 1986. Relations between milk productions and some blood constituents in Egyptian baladi goats. *Beiter. Trop. Landwirtsch Veterinärmed*. 24: 213-219.
- Jain N. C. 1993. *Essentials of Veterinary Hematology, Comparative Hematology of Common Domestic Animals*. Lea and Febiger, Philadelphia, PA. 44-46.
- Jindal S. K., 1984. *Goat Production*. Cosmo Publications, New Delhi, India.
- Klinkon M., G. Gorjanc, Z. Klinkon, J. Ježek and M. Simčič. 2012. Blood parameters of Cika calves and bulls. *Veterinary Clinical Pathology*. 41: 40.
- Krokavec M., K. Simo, A. Martinko and M. Krokavcova. 1992. Metabolic indicator in large scale breeding in goats during various seasons. *Journal of Veterinary Medicine*. 37: 879-889.
- Lashari M. H. and Z. Tasawar. 2010. Effect of hCG given on day 12 post-mating on ovarian function and embryo survival in Beetal goats in southern Punjab, Pakistan. *Turkish Journal of Veterinary and Animal Sciences*. 34(6): 513-517.
- Meyer D. J. and J. W. Harvey. 2004. *Veterinary Laboratory Medicine: Interpretation and Diagnosis* (3rd ed.), Saunders, St. Louis, p. 5.
- Muna Ahmed M. M., M. E. Awad and M. E. S. Barri. 2003. Some micro-mineral profile in the serum of female camels as affected by the physiological state. *Pakistan Journal of Biological Sciences*. 6: 1853-1855.
- Nazifi S., H. R. Gheisari and F. Shaker. 2002. Serum lipid and lipoprotein and their correlation with thyroid hormone in the clinically healthy goats. *Veterinarski Arhiv*. 72: 249-257.
- Ozyurtlu N., S. Y. Gürgöze, S. Bademkiran, A. Şimşek and R. Çelik. 2007. İvesikoyunlarında doğum öncesi viveson rasis dönemi dekibazı biyokimyasal parametreler ve mineral maddeleri düzeylerinin araştırılması. *F Ü Sag Bil Derg*. 21: 33-36 (in Turkish).
- Pospisil J., F. Kase and J. Váhala. 1987. Basic haematological values in the Cameroon goat (*Capra hircus*). *Comparative Biochemistry and Physiology. A Comparative Physiology*. 88(3): 451-454.
- Sandabe, U. K. and D. Yahi. 2000. Effect of pregnancy on some haematological parameters in Sahel goats. *Annals of Bornu*. 27: 326-330.
- Tainturier D. J., P. Braun, A. G. Rico and J. P. Thouvenot. 1984. Variation in blood composition in dairy cows during pregnancy and after calving. *Research in Veterinary Science*. 37: 129-131.
- Waziri M. A., A. Y. Ribadu and N. Sivachelvan. 2010. Changes in the serum proteins, hematological and some serum biochemical profiles in the gestation period in the Sahel goats. *Veterinarski Arhiv*. 80 (2): 215-224.
- Yılmaz B. 2000. *Blood and Blood Circulatory*. second edition. Feryal Matbaacilik, Ankara, Turkey, pp. 307-308.