**ASSESSMENT OF HEMATOLOGICAL PARAMETERS IN SANGAMNERI GOATS DURING THE SUMMER AND WINTER SEASON**

**Abstract**

The present study aims to evaluate heat stress's effects on haematological parameters in Sangamneri goats. Haematological parameters in domestic animals may be impacted by seasonal and environmental variations**.** Goats are recognized to be able to adapt to adverse situations**.** The Sangamneri Goat breed is an Indigenous native breed of the Sangamner region of the Ahmednagar district of Maharashtra, India. The investigation was carried out on six apparently healthy, female (non-pregnant, non-lactating ) adult Sangamneri goats with ages of 1 to 1.5 years and above, having similar body weight and maintained under semi-intensive framing system at Instructional Livestock Farm Complex (ILFC), K.N.P.College of Veterinary Science, Shirwal. Dist. Satara. Blood samples were collected at 0, 15, and 30 days during both the summer and winter seasons. The results revealed a significant increase in total leukocyte count (TLC) and the neutrophil-to-lymphocyte (N:L) ratio, particularly under summer conditions, indicating a stress-related response. Conversely, haemoglobin (Hb), packed cell volume (PCV) and total erythrocyte count (TEC) values were significantly elevated during the winter season. These alterations may be attributed to seasonal adaptive mechanisms, wherein the haematological parameters are modulated in response to environmental stressors. The observed changes suggest that Sangamneri goats exhibit physiological adjustments to cope with thermal variations, likely as part of a broader thermoregulatory and immunological adaptation process.

**Keywords**: Haematological parameters, Sangamneri Goats, Season

**1. INTRODUCTION:**

Small ruminants, such as sheep and goats, have significant importance in the livelihoods of many people in tropical regions, especially those who rely on native breed types. They contribute to income generation, food security, sustainable agriculture, and the empowerment of marginalized groups (32,33). The Sangamneri Goat breed is an Indigenous native breed of the Sangamner region of the Ahmednagar district of Maharashtra. This breed is particularly recognized for its adaptability to diverse environmental conditions, especially the extreme and often unpredictable climatic patterns in the Indian subcontinent **(1)**. Although the breed is named after Sangamner Tehsil, it is also commonly found in neighbouring regions such as Sinnar Tehsil in the Nasik district and Junnar in the Pune district. Climate seasonality is the primary determinant of goat productivity. **(2)** In order to investigate the effects of different stressors, including season and environmental temperature, on goats, physiological and biochemical parameters serve as biological markers **(3).** The haematological and biochemical profiles test of blood can be used to monitor and evaluate the health, nutritional and physiological status of ruminants (31).

Animals under stress undergo a series of profound alterations in their biological processes, such as decreased intake of dry matter, decreased growth, feed efficiency, and disruptions in the metabolism of water, protein, energy, and mineral balances. **(4;5)** The temperature-humidity index can be utilized to predict an animal's seasonal stress. **(6)**

Blood maintains physiological homeostasis, therefore any changes in a livestock's body are reflected in its blood indices **(7)**. Haematological parameters in domestic animals may be impacted by seasonal and environmental variations. **(8).** Goats are recognized to be able to adapt to adverse situations **(9)**

The present study was undertaken to investigate seasonal rhythmicity in Haematological indices in Sangamneri goats the data is needed for the physiological characterization of this breed and helps in the interpretation of climatic influences on productivity.

**2 MATERIALS AND METHODS**

The experiment was conducted on six healthy female (non-pregnant, non-lactating) adult Sangamneri goats with ages of 1 to 1.5 years and above, having similar body weight and maintained under semi-intensive framing system at Instructional Livestock Farm Complex (ILFC), Krantisinh Nana Patil College of Veterinary Science, Shirwal. Dist. Satara. They were kept under similar management and nutritional regimens throughout the study in the summer and winter. Whole blood samples were collected aseptically by jugular vein puncture (03ml in K3 EDTA Vacutainer) at the peak of each season in a month on Days 0, 15 and 30, for Hematological parameters, during the summer and winter seasons. All the samples were then carried to the laboratory on ice and further processed. Blood collection was done from 09:00 to 10.00 am during the experiment. The haematological parameter was estimated using Abacus Junior Vet5 Automatic Hematology Analyzer (Diatron). The statistical analysis of data was carried out by applying a completely randomized design (CRD) using the WASP 2.0 software.

**3 RESULTS AND DISCUSSION**

Season and day-wise mean ± SE values of haematological parameters during the summer and winter seasons are depicted in table : 1

**3.1 Total Leukocyte Count (TLC)**

The results for total leukocyte count (TLC) ×10³/µl in the summer season on Day 0, Day 15 and Day 30 were 11.83 ± 1.04, 13.99 ± 2.09, and 11.01 ± 0.66, respectively, with an overall seasonal average of 12.28 ± 0.81. In the winter season, the values on Day 0, Day 15 and Day 30 were 12.36 ± 0.23, 10.97 ± 0.39 and 8.35 ± 0.53 respectively, with an overall seasonal average of 10.56 ± 0.23. Statistically, there was a significant difference (P≤ 0.01) in total leukocyte count values between the two seasons, with higher values in summer (12.28 ± 0.81) than in winter (10.56 ± 0.23).

There exists a difference in values of total leukocytic count of summer and winter in present findings with higher values in summer which were corroborated with those reported in Nubian Goats **(15)**, in Piemontese Cows **(12)**, in Indigenous Sheep **(10)**,in Ruminants **(13)**,in Kiko Meat Goats **(14)** and in Pramenka Sheep-Dubska Pramenka Strain **(15)**.

The significant increase in total leukocyte count during summer compared to winter in the present study was likely due to heat stress, and cortisol levels that might initially suppress immunity but subsequently trigger compensatory immune activation, leading to increased leukocyte counts. Heightened oxidative stress during summer conditions further contributes to leukocyte proliferation as a defence mechanism **(16, 17)**. Heat stress can stimulate the immune system, leading to an increase in leukocyte production as a physiological response to maintain homeostasis **(18)**.

**3.2 Neutrophil Lymphocyte Ratio (NLR)**

The neutrophil to lymphocyte ratio (NLR) on Day 0, Day 15, and Day 30 during the summer season was 1.39 ± 0.50, 1.29 ± 0.15, and 1.67 ± 0.06, respectively, with an overall seasonal average of 1.45 ± 0.30. In the winter season, the corresponding values were 0.91 ± 0.17, 0.63 ± 0.08, and 1.21 ± 0.17, with an overall seasonal average of 0.92 ± 0.15.

Statistical analysis of the results showed that significantly higher (P≤ 0.01) values of neutrophil to lymphocyte ratio were recorded in the summer (1.45 ± 0.30) than in the winter season (0.92 ± 0.15) in the present study.

Similar, results of neutrophil to lymphocyte ratio exhibiting seasonal difference with higher values in summer were also reported in Nubian Goats **(15),** in ruminants **(13)**, and in Kiko Meat Goats **(14)**. Seasonal alterations in the neutrophil to lymphocyte ratio as that of present findings were also reported in Red Sokoto & Sahel Goats **(17)**, in Shetland Ponies **(19)**, and in Saanen goats **(20)**.

**High environmental temperature lead to increased neutrophil activation in goats,** similar to findings from the present study in Sangamneri goats **(21)**.

The results of the neutrophil to lymphocyte ratio with significantly higher values in the summer as compared to winter in Sangamneri goats in the present study might be due to, **heat stress which increases the plasma cortisol levels** that enhance neutrophils in circulation while reducing lymphocyte numbers **(22, 23)**.

**3.3 Haemoglobin (Hb)**

The haemoglobin (Hb) concentrations in Sangamneri goats on Day 0, Day 15, and Day 30 during the summer season were 8.03 ± 0.72, 8.03 ± 0.72 and 7.43 ± 0.58, respectively, with an overall seasonal average of **7.83 ± 0.67** and that of during the winter season were 9.95 ± 0.23, 10.0 ± 0.18, and 9.86± 0.16, respectively, with an overall seasonal average of **9.94±0.19.** Statistical analysis of the results showed that there was a significant difference in neutrophil-to-lymphocyte ratio values between the summer (**7.83 ± 0.67**) and winter seasons (**9.94±0.19**). However, higher values in Hb concentration were observed in the winter compared to that in summer. This could be partly due to better nutritional intake during winter, such as increased availability of green fodder, which may enhance iron levels and support haemoglobin production. (24)

This study agrees with other studies in literature where they have shown the haemoglobin level has been increased during the winter and dropped during summer across various goat breeds (24). Supporting this, (25) noted that the highest haemoglobin concentrations were during winter. A significant difference (p ≤ 0.05) in cattle, with higher levels in winter (12.37 ± 0.16 g/dl) compared to summer (9.39 ± 0.15 g/dl) in Hb concentration was also reported (26).

**3.4 Packed Cell Volume (PCV)**

The PCV(%)in Sangamneri goats on Day 0, Day 15, and Day 30 during the summer season were 22.67 ± 1.62, 24.91 ± 0.37 and 21.42 ± 1.24, respectively, with an overall seasonal average of 22.99±1.08 while that of during the winter season were 26.5 ± 0.62, 26.5 ± 0.46 and 27.16 ± 0.06 respectively, with an overall seasonal average of 26.72+/-0.38.

Statistical analysis of the results showed that there was a significant difference in PCV (%) values between the summer (22.99±1.08) and winter seasons (26.72+/-0.38). However, a decrease in PCV (%) was observed in the summer compared to the winter.

In the present study, the observed findings regarding packed cell volume (PCV, %) were in agreement with previous reports, which demonstrated an increase in PCV levels during winter and a decrease during summer in goats (24,25). Similarly, the highest PCV values were observed during the winter season and the lowest during summer in buffaloes (27).

This seasonal variation in PCV could be attributed to increased oxygen demand during the cold season, reduced blood oxygen partial pressure (hypoxemia), and a higher metabolic rate, which enhances feed intake and stimulates erythropoiesis, resulting in elevated haematological values. Conversely, the decrease in PCV during hot and humid periods may be due to suppressed thyroid activity and heat stress caused by elevated ambient temperature and relative humidity, leading to reduced PCV levels during summer compared to winter (28).

**3.5 Total Erythrocyte Count (TEC)**

The TEC**(**X106/µL) in Sangamneri goats on Day 0, Day 15, and Day 30 during the summer season were 14.63 ± 1.65, 17.02 ± 0.38 and 12.76 ± 1.10, with an overall seasonal average of 14.81±1.04, while that of during the winter season were 16.66 ± 0.49, 17.79 ± 0.67, and 17.83 ± 0.29, respectively, with an overall seasonal average of 17.43a±0.48.

Statistical analysis of the results showed that there was a significant difference in neutrophil-to-lymphocyte ratio values between the summer (14.81±1.04) and winter seasons (17.43a±0.48). However, a decrease in TEC**(**X106/µL) in concentration was observed in the summer compared to the winter.

The TEC levels were observed to be higher during winter and lower during summer in the present study and were in agreement with the findings of (17, 29) which might be due to the fact that heat stress causes peripheral vasodilation and redistribution of cardiac output which are related with the expansion of blood volume and hemodilution (30).

**Table 1 Mean ± SE Season and Day wise values of different Haematological parameters for Sangamneri goats**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameters** | **SUMMER** | | | **WINTER** | | |
| **TLC (X10³/µL)** | **DAY 0** | **DAY 15** | **DAY 30** | **DAY 0** | **DAY 15** | **DAY 30** |
| **11.83 ± 1.04** | **13.99 ± 2.09** | 11.01 ± 0.66 | 12.36 ± 0.23 | 10.97 ± 0.39 | **8.35 ±**  **0.53** |
| **Average** | **12.28a ± 0.81** | | | **10.56b± 0.23** | | |
| **NL ratio** | 1.39 ± 0.50 | 1.29 ± 0.15 | 1.67 ± 0.06 | **0.91 ± 0.17** | 0.63 ± 0.08 | 1.21 ±  0.17 |
| **Average** | **1.45** a **± 0.30** | | | **0.92 b ± 0.15** | | |
| **Hb(gm/dl)** | 8.03 ± 0.72 | 8.03 ± 0.72 | 7.43 ± 0.58 | 9.95 ± 0.23 | 10.0 ± 0.18 | 9.86 ±  0.16 |
| **Average** | **8.36b±0.67** | | | **9.94a±0.19** | | |
| **PCV(%)** | 22.67 ± 1.62 | 24.91 ± 0.37 | 21.42 ± 1.24 | 26.5 ± 0.62 | 26.5 ± 0.46 | 27.16 ± 0.06 |
| **Average** | **22.99b±1.08** | | | **26.72a±0.38** | | |
| **TEC**  **(X106/µL)** | 14.63 ± 1.65 | 17.02 ± 0.38 | 12.76 ± 1.10 | 16.66 ± 0.49 | 17.79 ± 0.67 | 17.83 ± 0.29 |
| **Average** | **14.81b±1.04** | | | **17.43a±0.48** | | |

**\*\* In all the rows of average the similar superscript indicates no significant difference while dis similar superscripts indicates significant difference at 1% level.**

**4 CONCLUSION**

Haematobiochemical parameters such as total leukocyte count (TLC) and neutrophil to lymphocyte ratio (NLR), elevated significantly during the summer season compared to winter. However, the values of TEC, Hb and PCV% were significantly higher in winter than in summer in Sangamneri goat suggesting an impact of the season which might be due to different mechanisms underlining the physiological and metabolic adaptations.

**DISCLAIMER**

Author here by declared that No generative AI technologies such as Large Language Models (chatgpt ,Copilot etc.) and text to image generators have been used while writing or editing of the manuscripts.

**ETHICAL APPROVAL**

The Research was approved by the Institutional Animal Ethical Committee (IAEC) [Protocol No. IAEC/05/24/ KNPCVS/2024

**REFERENCES**

1) Verma, N. K., Aggarwal, R. a. K., Dangi, P. S., Dixit, S. P., & Joshi, B. K. (2010). Goat Genetic Resource of India - Sangamneri - An important goat breed of Maharashtra State*.National Bureau of Animal Genetic Resources.*

2) Bushara I, Besheer E, Mudalal MO, Mekki DM, Umsalama A, Ahmed M *et al*. Effect of different seasons on Taggar goat performance*. International Journal of Research Studies in Agricultural Sciences.* 2016; 2**(7):**22- 26.

3) Sophia I, Anandamoy K, Arun KD, Jai S, Sejian V. Seasonal changes in blood biochemical and endocrine responses of different indigenous goat breeds of tropical island agro-ecological environment. *Biological Rhythm Research*. 2017; **49**(3):412-421.

4) Purwar, V., Oberoi, P. S., & Dang, A. K. (2017). Effect of feed supplement and additives on stress mitigation in Karan Fries heifers. *Veterinary World,* ***10*(**12), 1407.

5) Purwar, V., Oberoi, P. S., Alhussien, M. N., Santoshi, P., Diwakar, S., & Kumar, N. (2018). Effect of protected fat, yeast, niacin, zinc and chromium supplementation on the productive performance of heat-stressed Karan Fries heifers. *Indian Journal of Dairy Science****, 71*(**3), 252–257.

6) Casella S, Scianò S, Zumbo A, Monteverde V, Fazio F, Piccione G. Effect of seasonal variations in Mediterranean area on haematological profile in dairy cow. *Comparative Clinical Pathology*. 2013; 1:**22**(4):691-5.

7) Silanikove, N., 2000. The physiological basis of adaptation in goats to harsh environments. *Small Ruminant Res*., **35**: 181-193.

8) F e l d m a n B.F., Z i n k l J.G., J a i n N.C. (2002). *Schalm’s Veterinary Hematology*. Lippincott Wil- liams and Wilkins, Philadelphia, Baltimore, New York, London, Buenos Aires, Hong Kong, Sydney, Tokyo.

9) Silanikove, N. (2000). Goat production under harsh environmental conditions: The physiological basis and the challenge. *The Opportunities and Challenges for Enhancing Goat Production in East Africa; Langston University: Langston, OK, USA*.

10) Rathwa, S. D., Vasava, A. A., Pathan, M. M., Madhira, S. P., Patel, Y. G., &Pande, A. M. (2017). Effect of season on physiological, biochemical, hormonal, and oxidative stress parameters of indigenous sheep. *Veterinary World*, **10**(6), 650–654.

11) 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 Journal of Scientific Research*, **4**(3), 168 174.

12) Mazzullo, G., Rifici, C., Caccamo, G., Rizzo, M., & Piccione, G. (2014). Effect of different environmental conditions on some haematological parameters in cow. *Annals of Animal Science*, **14(**4), 947–954.

13)Purwar, V., Dm, C., Singh, S., Kumar, J., Khare, A., & Thorat, G. (2019). Assessment of haematological parameters during different climatic seasons. *Journal of Pharmacognosy and,Phytochemistry*, **8(**1),1741,1744.

14) **Okere, C., King, R., &Gurung, N. (2022).**Seasonal variations in hematological and serum biochemical parameters in Kiko meat goats under semi-intensive management systems.Journal of Animal Research and Veterinary Science, **6**(1), 37.

15) **Ohran, H., Pojskić, N., Pašić-Juhas, E., Hrković-Porobija, A., Hrelja, E., Sivac, A., Batinić, V., &Hodžić, A. (2024).**Hematological and blood biochemical variations in Pramenka sheep under thermal stress conditions.VeterinarskiArhiv, **94**(6), 463-474.

16) Sejian, V., Indu, S., and S. M. K. Naqvi.(2013). Impact of short term exposure to different environmental temperature on the blood biochemical and endocrine responses of Malpura ewes under semi-arid tropical environment.Indian J. Anim. Sci, **83** (11): 1155-1160.

17) Habibu, B., Kawu, M. U., Aluwong, T., &Makun, H. J. (2016). Influence of seasonal changes on physiological variables, haematology, and serum thyroid hormones profile in male Red Sokoto and Sahel goats. Journal of Applied Animal Research, **45**(1), 508–516.

18) Debia, Y., Beena, V., Ramnath, V., Venkatachalapathy, T. R., &Zarina, A. (2021). Association of temperature humidity index during summer with haematological parameters in native and crossbred goats of Kerala.Journal of Veterinary and Animal Sciences, **52**(3), 222–227

19) **Shawaf, T., Al-Mufarrej, S. I., Al-Sobayel, H. I., & Al-Hamoudi, W. (2018).** Influence of seasonal changes, age, and gender on various clinical, haematological, and biochemical parameters in Shetland ponies. Journal of Veterinary Science, **19**(4), 567–574.

20) Dhuha, J. M., Muayad, M. T. A., Saeed, O. A., Al-Bayar, M., Saeid, Z. J. M., Al Bakri, S. A., Musa, H. C., Safaa, A., Abed, Q. N., Kaabi, S. A. G., Haniza, H. M. Z., &Shaari, A. (2021). Tropical seasonal changes impact on hematological parameters of goats. Journal of the Indonesian Tropical Animal Agriculture**, 46(**3), 219-226.

21) Mavrommatis, A., Theodorou, G., Politis, I., &Tsiplakou, E. (2021).Schizochytrium sp. dietary supplementation modifies Toll-like receptor 4 (TLR4) transcriptional regulation in monocytes and neutrophils of dairy goats. Cytokine, **148**, 155588.

22) KATAMOTO, H., FUKUDA, H., OSHIMA, I., ISHIKAWA, N., & KANAI, Y. (1998).Nitrobluetetrazolium reduction of neutrophils in heat stressed goats is not influenced by selenium and vitamin E injection. *Journal of veterinary medical science*, **60**(11), 1243-1249.

23) Ocheja, O. B., Ayo, J. O., Aluwong, T., &Minka, N. S. (2020).Ameliorative effects of L-glutamine on haematological parameters in heat-stressed Red Sokoto goats. *Journal of Thermal Biology*, **90**, 102571.

24 BANERJEE S., GHOSH S., CHAKRABORTY S., GHOSH N., & BHATTACHARYYA B. (2015). Seasonal variation in hematological parameters in goats reared under semi-intensive system of West Bengal. Indian Journal of Veterinary Science and Biotechnology, 11(3): 56–59.

25 RAHMAN M. M., MAHMUD S., SULTANA N., & HASAN M. M. (2019). Seasonal effects on hematological profiles in Black Bengal goats. *Bangladesh Journal of Veterinary Medicine*, 17(2): 129–134.

26 Giri A, Bharti VK, Kalia S, Ravindran V, Ranjan P, Kundan TR. Seasonal changes in haematological and

biochemical profile of dairy cows in high altitude cold desert. *Indian J Anim Sci*. 2017**; 87**(6):723-727.

27 MANJARI S., VERMA R., SINGH S. P., & SINGH S. K. (2018). Effect of seasonal variation on hematological parameters in Murrah buffaloes. *International Journal of Livestock Research*, **8**(3): 125–132.

28 Nathawat, M.S., Barkha Gupta, GS Gottam and Mohan Singh (2023). Profiling of haematological parameters due to seasonal variation in Sirohi goat.*The Pharma Innovation Journal* 2023; SP-**12**(7): 1890-1895

29 Upadhyay RC, Rao MVN. 1985. Haematological and biochemical constituents of blood in goats upto the one year age*. Ind J Dairy Sc*. 38:168–173.

30 Hales JR. Effects of exposure to hot environments on total and regional blood flow in the brain and spinal cord of the sheep. Pflügers Archive. 1973; 1:344(4):327-37.

31.REDDY, R. K., MONDAL, M., KURI, P., & KARUNAKARAN, M. (2025). Evaluation of Haematological Profile of Black Bengal Goats during Different Stages of the Estrous Cycle. *Journal of Scientific Research and Reports*, *31*(4), 605–610. <https://doi.org/10.9734/jsrr/2025/v31i42984>

32.Fanta, Y., Kechero, Y., & Yemane, N. (2024). Hematological parameters of sheep and goats fed diets containing various amounts of water hyacinth (Eichhornia crassipes). *Frontiers in Veterinary Science*, *11*, 1286563.

33.Mohammadabadi, M. (2021). Tissue-specific mRNA expression profile of ESR2 gene in goat. *Agric Biotechnol J*, *12*(4), 167-181.