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Hematological Changes in Livestock under Varying Temperatures

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ABSTRACT: One important issue that can negatively impact the wellbeing, productivity, and health of livestock is stress. It causes a variety of physiological reactions, including as changes in hematological parameters, which can be used as markers of the health of the animal. The hematological alterations are seen in livestock under a range of stressors, including as handling stress, disease-related stress and environmental stress. Common hematological alterations include changes in hemoglobin concentration, red and white blood cell number and platelet count, which reflects animal's adaptive response to stress. For instance, stress can lead to an increase in cortisol levels, which in turn may cause alterations in the immune system and hematopoiesis, resulting in immune suppression, anemia, or altered clotting function. These changes are critical for understanding the overall health and welfare of livestock, as well as their capacity to cope with challenging conditions. The review on hematological parameters provides valuable insights for managing livestock care, optimizing production, and minimizing the negative effects of stress.

Keywords: Stress, Haematology, RBC, Productivity, Haemoglobin.

INTRODUCTION

Seasonal patterns of physiological processes are displayed by mammals, particularly ruminants, to adapt to changes in the climate and maintain balance (Duarte *et al*., 2010). Every change that occurs in a mammalian organism is expressed in the blood values because blood maintains physiological homeostasis (Casella *et al*., 2013). Livestock are susceptible to a variety of stressors, including temperature, chemical, nutritional, psychological, and physical stress. Environmental stressors like temperature fluctuations can have a major impact on hematological parameters in livestock, which are essential for evaluating their general health and performance (Habeeb and Mohamed 2018). Animal husbandry relies heavily on stress for behavior, reproduction, and productivity. One of the primary elements that negatively impact animal wellbeing and, consequently, the financial loss to animal husbandry sector is heat stress. Heat stress is brought on by an imbalance in the mechanisms of heat gain and loss. Stress in animals results in a series of profound alterations in 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 (Purwar *et al.,* 2018). Stress in animals provokes a series of severe changes in biological activities that include decline in feed intake, even reduces the efficiency and utilization, leads to several abnormalities in metabolism of various basic nutrients causing an imbalance in water-electrolyte in the body (Ganaie *et al*., 2013).

Heat stress is frequently linked to decreased hemoglobin and hematocrit levels in sheep and cattle, maybe as a result of fluid imbalance and dehydration (Zhao *et al.*, 2017). Stress frequently causes an increase in white blood cells, which indicates that the immune system is activated (Kettlewell *et al.*, 2015). Red blood cell mass frequently rises in response to cold stress, maybe as a result of a drop in plasma volume (Alvarez *et al.*, 2019). Maintaining normal hematological profiles and lessening the effects of thermal stress can be achieved by making sure animals are properly hydrated (Nardone *et al.*, 2010).

The Indian subcontinent is home to numerous indigenous breeds with a vast genetic diversity and their responses to various stressors will be highly diverse. These variations due to stress degrade the overall development, productivity, and reproduction performance of animals. Seasonal and climatic changes can also affect the hematological values of domestic animals (Feldman *et al*., 2002). Praveen (2013) reported that Punganur cattle showed significant changes in their haematological values based on variations in the season. According to Singh *et al.* (2016), an animal's haematological profile is a significant predictor of physiological alterations and can be used as an animal-based indicator to assess heat stress. Interpreting each haematological indicator alone provides valuable information about how animals react to heat stress, but integrating many haematological data is crucial for optimal comprehension (Casella *et al.*, 2013).

One important element that might have a detrimental impact on cow performance is the thermal environment, particularly in animals with high genetic value. Increased production illnesses that reflect alterations in blood profiles are linked to higher cattle productivity (Hewett, 1974). Variations in climatic factors such wind, rainfall, relative humidity, and ambient temperature were identified as possible risks to livestock production and growth. Endogenous annual rhythmicity is an adaptive mechanism that certain species have developed to respond ahead of time to regular seasonal changes in their environment (Piccione *et al*., 2009). The animal's body generates heat through metabolic processes, and it can also absorb heat from its surroundings. Radiation, conduction, convection, water evaporation from the skin and respiratory tract, and the excretion of urine and feces are all ways that heat is lost from the body. When heat gain and loss are equal, there is a thermal steady state. Homeotherms strive to maintain balance in heat gain and loss because their varied thermoregulatory processes are a set of physiological modifications that serve to achieve a thermal stable state at a range of the body's average temperature. The body's blood primarily maintains physiological balance, however a variety of physiological circumstances can change this balance (Ahmed *et al*., 2003).

Changes in the animal's hematological components are crucial markers of its physiological or pathological condition. As part of a minimal database, the Complete Blood Count (CBC) is a significant and effective diagnostic tool. It can be used as a basis for creating an inventory of differential diagnoses or to track how well a treatment is working to determine how serious an illness is. It is commonly known that physic-biochemical parameters are influenced by factors including breed, age, physiological stage, reproductive and lactation stage, and environmental conditions/season. Limitations on beef cow productivity have been identified using hematological measures (Grunwaldt *et al*., 2005). Among other biochemical components, metabolic profile testing included hemoglobin and packed cell volume (Payne *et al*., 1970). Jazbec *et al.* (1993); Klinkon *et al.* (1994) emphasized how crucial erythrocyte indicators are for interpreting metabolic profile testing in cattle. Changes in specific haematological profile components brought on by an animal's physiological state (Shrikhande *et al.*, 2008) and because of season (Shaffer *et al*., 1981) have been observed in tropical and temperate areas. Cattle have been shown to experience stress-induced disturbances to immune function, including modifications to humoral and cell-mediated immunity that have a major effect on immunocompetence and may make an animal more prone to infection (Carroll and Forsberg 2007). When cows are exposed to heat conditions, their thermoregulatory system is stimulated, which lowers their appetite, metabolism and productivity (Abdelatif and Alameen 2012). An animal needs to be in a thermal balance with its surroundings, which includes humidity, air temperature, air movement, and radiation, in order to preserve its homeothermy (Kadzere *et al.*, 2002). Any amalgamation of environmental factors that raises the environment's effective temperature above the animal's "thermoneutral" zone results in heat stress (Armstrong, 1994). According to earlier research by Armstrong (1994); Kadzere *et al.* (2002); Dikmen and Hansen (2009), the temperature-humidity index (THI) may be used to gauge the degree of stress experienced by cows and the thermal climate. Variations in climatic factors such wind, rainfall, relative humidity, and ambient temperature were identified as possible risks to livestock production and growth. Endogenous annual rhythmicity is an adaptive mechanism that certain species have developed to respond ahead of time to regular seasonal changes in their environment (Piccione *et al.*, 2009). Animals with poor cold adaptation have lower RBC parameters, whereas those with excellent cold adaptation have higher RBC parameters (Habibu *et al.*, 2018).

HEMATOLOGICAL PARAMETERS

Red Blood Corpuscles. The findings of Abdalla *et al.* (2009) revealed that haemodilution and blood volume expansion are linked to peripheral vasodilatation and cardiac output redistribution at high ambient temperatures. During heat stress, haemodilution was seen in goats that were fed and goats that were not fed. In goats and sheep, exposure to heat causes an upsurge in cardiac output and hence increases cutaneous blood flow, which is linked to blood being redistributed to peripheral tissues (Silanikove, 2000). Additionally, he noted that goats' MCV and MCH levels rose during the winter.

According to Shibu *et al.* (2008), the moist summer had the greatest erythrocyte count levels when compared to the dry summer and winter. According to Babeker *et al.* (2013), the high-yielding cattle's mean total erythrocyte count (TEC) fluctuated with season, peaking in the summer and falling in the monsoon. However, Mirzadeh *et al.* (2010) in Iranian cattle and Soley and Singh (2003) in dairy cattle reported lower TEC in the summer. Prava and Dixit (2008) found that calves and milch cattle aged five had greater TEC in the summer. The breed's adaptive mechanism to boost blood oxygen carrying capacity in hot conditions may be the cause of the summertime rise in TEC (Naik *et al.*, 2013).

During the warmest times, studies on cattle by Gutierrez-De Lar *et al.* (1971); Casella *et al*. (2013) showed a large drop in RBC count along with corresponding substantial fluctuations in haemoglobin (Hb) and hematocrit (Hct).To facilitate evaporative cooling especially in very high temperatures more water was carried in the circulatory system due to the haemodilution effect resulting in decreased RBC, Hb, and the percentage of red blood cells in blood (Koubkova *et al.*, 2002). The substantial drop in MCV and MCH at high environmental temperatures, along with the decrease in Hb and Hct, indicates that this adaptation is linked to a decrease in cellular oxygen demands in order to lower metabolic heat load (El-Nouty *et al.*, 1990). Animals with poor cold adaptation have lower RBC parameters, whereas those with excellent cold adaptation have higher RBC parameters (Habibu *et al.*, 2018).

Haemoglobin. According to Shibu *et al.* (2008), Hb is considerably lower in hotter temperatures than in colder ones. The Hb values found by Lateef *et al*. (2014) were within the physiological range and did not significantly alter as the temperature changed. In Kankrej cattle, Naik *et al.* (2013) found comparatively higher Hb level during the summer and monsoon seasons than the winter months. There are two possible explanations for the greater Hb concentration during the summer and monsoon: either the elevated total iron concentrations in these two seasons, or the haemoconcentration that occurs under stressful conditions of high humidity and heat, respectively. The high temperatures and humidity throughout the summer and monsoon seasons may be the cause of the apparent rise in HCT. According to reports, a hot and muggy environment causes perspiration, which results in water loss, hemoconcentration, and an increase in Total Erythrocyte Count and, consequently, haematocrit value (Piccione *et al*., 2010).

Due to the release of red blood cells from the spleen or a boost in oxygen consumption brought on by tissue demand that causes the release of erythrocyte-stimulating factor (ESF), the local cattle's Hb concentration, MCH, and MCHC were much greater in the summer than in the winter. Because of heat stress, cattle may have higher metabolic demands and consume more oxygen during the summer. Higher Hb levels could arise from this increased demand, which could also cause the spleen to release more red blood cells or erythrocyte-stimulating factor (ESF). Also the spleen can act as a reservoir for red blood cells, and in times of stress, it can contract and release these cells into the bloodstream. This spleenic contraction could contribute to the higher Hb levels observed in summer (Muna *et al*., 2009). In line with Srikhande *et al.* (2008), the average hemoglobin level was greater in the summer. Nonetheless, there was no discernible variation between the winter and rainy seasons' hemoglobin levels. The increased overall binding capacity of iron during the summer months may be the cause of the higher hemoglobin levels.

White Blood Corpuscles. According to Abdelatif (2009), white blood cell counts and neutrophil:lymphocyte ratios are two physiological indicators of stress. In their study on Sahiwal cattle, Bhan *et al.* (2012) found that WBC increased throughout the winter and decreased during heat stress as compared to the spring, indicating that WBC varies with changes in the surrounding temperature. The total leukocyte count in goats did not exhibit any apparent seasonal variations, as reported by Hassan *et al.* (1987). Additionally, he stated that the proportions of neutrophils, lymphocytes, eosinophils, and basophils in goats were not significantly impacted by climate change. According to Lateef *et al*. (2014), the Kankrej herd of cattle did not exhibit any discernible seasonal variations in TLC. Nonetheless, winter had the greatest TLC values, while during summer and monsoon there was a modest decline. The physiological reactions to the hot and muggy weather may be the cause of this decrease. Contrastingly, Al-Saeed *et al*. (2009) found that local cattle had a considerably reduced amount of TLC in the winter than in the summer and came to the conclusion that the rise in TLC during summer can be caused by greater levels of parasite infection seen during hot, humid summer conditions.

According to Minka and Ayo (2007), the ratios of neutrophils, lymphocytes, eosinophils, and basophils were not significantly impacted by seasonal climatic variation. Nonetheless, the neutrophil to lymphocyte ratio (N:L) seems to be higher in the summer. Actually, the most often used indicator of stress and an animal's ability to adapt to its surroundings is the neutrophil: lymphocyte ratio, which typically rises in stressful situations.

In the study by Al-Busaidi *et al.* (2008), summertime had a higher monocyte count than winter and monsoon. Increased cortisol output may be linked to the summertime rise in monocyte counts. When blood corticosteroid levels rise, monocytes react, but the kind of reaction and the mechanism of monocytosis vary depending on the species (Jain, 1993).

The studies by Abdelatif and Alameen (2012); Mazullo *et al*. (2014), WBC values rose as temperatures increased. This could be because atmospheric heat stress causes the secretion of corticosteroids or epinephrine, which raises the leukocyte count. According to Narayan *et al.* (2007), neutrophil counts declined during the hottest time, but lymphocyte counts were higher. In White Fulani cattle, the total WBC count was much lower in the winter and somewhat higher in the summer (Saror and Coles 1973). According to Mazullo *et al.* (2014), a rise in monocytes during the summer months in cattle may be linked to an increase in cortisol release. Although the type of reaction and the mechanism of monocytosis vary by species, monocytes react to increases in blood corticosteroid levels.

CONCLUSIONS

To sum up, hematological alterations in stressed livestock are important markers of the physiological reaction of the animal to difficult circumstances. It has been demonstrated that stress affects important hematological parameters as hemoglobin (Hb) concentration, white blood cell (WBC) count, and red blood cell (RBC) count. The WBC count may increase as a result of an increased immunological response to stresses, while the RBC count and Hb levels may decrease under stress, suggesting possible anemia or decreased oxygen-carrying ability. The intricate relationships between the immunological and endocrine systems under stress are reflected in these alterations, which may jeopardize the general well-being and productivity of cattle. Better management techniques can be informed by monitoring these hematological markers, which offer important insights for the quick identification of stress-related health concerns. Managing animal well-being and increasing output requires lowering stress in cattle through appropriate handling, environmental management, and health monitoring.

Livestock shows several changes in hot weather, including elevated body temperature, respiratory and heart rates, and more. In terms of hematology, this could result in an increase in hemoglobin, haematocrit, and red blood cell (RBC) concentrations as the body tries to make up for decreased oxygen-carrying capacity brought on by dehydration or circulation alterations. Furthermore, elevated levels of stress hormones like cortisol might affect immunological function and increase vulnerability to disease. During colder climates, there will be lower ambient oxygen levels and a slower metabolic rate, the body may produce more red blood cells in colder climates to improve oxygen delivery and a result of changes in blood viscosity and general circulation, there would be other hematological alterations, such as elevated white blood cell (WBC) levels, due to body's immune response to fight certain infections.

Over time, livestock can adapt to temperature extremes by developing acclimatization mechanisms, which can stabilize or lower specific hematological parameters after extended exposure. However, chronic or severe temperature stress might harm the animals' physiological systems irreparably, which will impact their general health and production. Optimizing husbandry operations require an understanding of the hematological changes that occur in livestock under different temperatures. It implies that in order to reduce heat stress and improve animal wellbeing, it is crucial to provide suitable shelter, water, and food. Additionally, blood parameter monitoring can act as an early warning system for heat or cold stress, enabling prompt treatments to lessen adverse effects.

To sum up, hematological parameters are important markers of animal health, and changes in them can reveal important information about the effects of environmental stresses like severe temperatures. Different hematological alterations, such as changes in hemoglobin levels, electrolyte balance, and red and white blood cell counts, are brought on by both heat and cold stress. These alterations demonstrate how animals' bodies adjust to temperature fluctuations and emphasize how crucial blood parameter monitoring is for evaluating animal welfare. To lessen the negative impacts of temperature stress, effective management techniques including insulation, cooling systems, and shade provision are crucial. Gaining an understanding of these hematological reactions is essential for enhancing the health and production of livestock, especially in light of climate change.

FUTURE SCOPE

Comprehending these hematological alterations is essential for efficient animal care and management. Livestock productivity, disease resistance, and general health may all be impacted by these changes. To further understand species-specific mechanisms and create mitigation methods for temperature-induced stress in various environmental settings, more research is required in this area.

Conflict of Interest. None.

REFERENCES

Abdelatif A. M. and Alameen A. O. (2012). Influence of season and pregnancy on thermal and haemotological responses of crossbred dairy cows in a tropical environment. *Global Veterinaria*, *9*, 334-340.

Abdelatif, A. M., Ibrahim, M. Y. and 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.

Ahmed I. A., Gohar N., Ahmad and Ahmad M. (2003). Haematological profile in cyclic, non cyclic and endometritic crossbred Cattle, *Int. J. Agri. Biol*., *5*(3), 332-334.

Ahmed, I. A., Ahmad, G. N. and Ahmad, M. (2003). Haematological profile in cyclic, non cyclic and endometritic crossbred Cattle. *International Journal of Agriculture & Biology*, *5*(3), 332-334.

Al-Busaidi, R., Johnson, E. H. and Mahgoub, O. (2008). Seasonal variations of phagocytic response, immunoglobulin G (IgG) and plasma cortisol levels in Dhofari goats. *Small Ruminant Research*, *79*, 118-123.

Al-Saeed, M. H., Hardik, K. A. and Ghadhabam, R. F. (2009). Selective evaluation of certain blood and biochemical parameters of local cattle during winter and summer seasons. *Basrah Journal of veterinary Research, 8*(1), 138-143.

Alvarez, A. S. and Di-Marco, L. (2019). Effects of cold exposure on hematological parameters in sheep. *Theriogenology*, 129: 8-14.

Armstrong, D. V. (1994). Heat stress interaction with shade and cooling. *Journal of Dairy Science*, *77*, 2044-2050.

Babeker, E. A., Elmansoury, Y. H. A. and Suleem, A. E. (2013). The influence of seasons on blood constituents of Dromedary camel (*Camelus dromedaries*). *Online Journal of Animal Feed Research*, *3*(1), 1-8.

Bhan, C., Singh, S., Hooda, O. K., Upadhyay R. C., Beenam, B. and Mangesh, V. (2012). Influence of temperature variability on physiological, hematological and biochemical profile of growing and adult sahiwal cattle. *Journal of Environmental Research and Development*, *7*(2), 986-994.

Carroll, J. A. and Forsberg, N. E. (2007). Influence of stress and nutrition on cattle immunity. *Veterinary clinics of North America. Food animal practice*, *23*, 105-149.

Casella, S., Sciano, S., Zumbo, A., Monteverde, V., Fazio, F. and Piccione, G. (2013). Effect of seasonal variations in Mediterranean area on haematological profile in dairy cow. *Comparative Clinical Pathology*, *22*(4), 691-695.

Dikmen, S. and Hansen, P. J. (2009). Is the temperature-humidity index the best indicator of heat stress in lactating dairy cows in a subtropical environment?*Journal of Dairy Science*, *92*, 109-116.

Duarte, G., Nava-Hernandez, M. P., Malpaux, B. and Delgadillo, J. A. (2010). Ovulatory activity of female goats adapted to the subtropics is responsive to photoperiod. *Animal Reproduction Science*, *120*, 65-70.

El-Nouty, F. D., Al-Haidary, A. A. and Salah, M. S. (1990). Seasonal variation in hematological values of high and average yielding Holstein cattle in semi-arid environment. Journal of King Saud University – *Science*, *2*(2), 173-182.

Feldman, B. F., Zinkl, J. G. and Jain, N. C. (2002). Schalm's Veterinary Hematology. Lippincott Williams and Wilkins, Philadelphia, Baltimore, New York, London, Buenos Aires, Hong Kong, Sydney, Tokyo. (2002).

Filar, J. (1999). Ailments of carbohydrate-lipid metabolism in ruminants. Wyd. AR w Lublinie. (1999)

Finco, D. R. (1989). Clinical Biochemistry of Domestic Animals. 4thed. Academic press, Toronto (1989).

Ganaie, A. H., Ghasura, R. S., Mir, N. A., Bumla, N. A., Sankar, G. and Wani, S. A. (2013). Biochemical and Physiological Changes during Thermal Stress in Bovines: A Review. *Iranian Journal of Applied Animal Science*, *3*(3), 423-430.

Ganaie, A. H., Shanker, G., Bumla, N. A., Ghasura, R. S., Mir, N. A., Wani, S. A. and Dudhatra, G. B. (2013). Biochemical and physiological changes during thermal stress in bovines. *Journal of Veterinary Science and Technology*, *4*(1), 126- 132.

Ganong, W., (2003). Circulation. In: Review of Medical Physiology. Lange Medical Publications/Los altos, California. (2003).

Geneser, F. (1986). Textbook of Histology, 1st Ed. Munksgaard, Copenhagen, Denmark, (1986).

Grunwaldt, E. G., Guevara, J. C., Estevez, O. R., Vicente, A., Rousselle, H., Alcu-ten, N., Aguerregaray, D. and Stasi C. R. (2005). Biochemical and haematological measurements in beef cattle in Mendoza plain rangelands (Argentina). *Tropical Animal Health and Production, 37,* 527–540.

Gutierrez-De-Lar, J. H., Warnick, A. C., Cowley, J. J. and Hentgs, J. F. (1971). Environmental physiology in the substropics. I. Effect of stress in some haematological values of beef cattle. *Journal of Animal Science, 32,* 968-973.

Habeeb, A. A. and Mohamed, M. A. (2018). Blood biochemical and hematological changes in goats during heat stress. *Small Ruminant Research*, *154*, 1-8.

Habibu, B., Dzenda, T., Ayo, J. O., Yaqub, L. S. and Kawu, M. U. (2018). Haematological changes and plasma fluid dynamics in livestock during thermal stress, and response to mitigative measures. *Livestock Science*, *214*, 189-201.

Hales, J. R. S. (1973). Effects of exposure to hot environments on total and regional blood flow in the brain and spinal cord of sheep. *Pflügers Archiv European Journal of Physiology, 344*(2), 327-338.

Hassan, G. A., Salem, M. H., El-Nouty, F. D., Okab, A. B. and Latif. M. G. (1987). Haematoloical changes during summer and winter pregnancies in Barki and Rahmani sheep (*Ovis aries*). *World Review of Animal Production, 23,* 89-95.

Hewett, C. (1974). On the causes and effects of variations in the blood profile of Swedish dairy cattle. *Acta veterinaria Scandinavica. Supplementum, 50*, 1-152.

Jain N. C. (1986). Schalm's Veterinary Haematology. 4th Edition, Lea and Febiger, Philadelphia, pp. 236.

Jain N. C. (1993). Essentials of Veterinary Haematology. 1stEdition, Lea and Febiger, Philadelphia. pp. 1-18.

Jazbec, I., Zadnik, T., Modic, T., Lobnik, R., Praprotnik, A., Klinkon, M. and Nemec, M. (1993). Haematological, biochemical and corprological profile in dairy cows of Radlje. *Znanost in Praksa v Govedoreji (Slovenia*) *17,* 185-196.

Kadzere, C. T., Murphy, M. R., Silanikove, N. and Maltz, E. (2002). Heat stress in lactating dairy cows: a review. *Livestock Production Science, 77,* 59-91.

Kettlewell, P. J. and Green, M. S. (2015). Influence of heat stress on immune function in livestock. *Veterinary Immunology and Immunopathology*, *166*(1-2), 46-56.

Klinkon, M., Jazbec, I., Zadnik, T. and Trenti, F. (1994). Red blood cell (RBC) count in cattle in Slovenia. *Proceedings of the 18th World's Buiatrics Congress: 26th Congress of the Italian Association of Buiatrics, Bologna, Italy*, *2*, 1269-1271.

Koubkova, M., Knizkova, I., Kunc, P., Hartlova, H., Flusser, J. and Dolezal, O. (2002). Influence of high environmental temperatures and evaporative cooling on some physiological, haematological and biochemical parameters in high-yielding dairy cows. *Czech Journal of Animal Science*, *47*, 309-318.

Lateef, A.,Das, H. H., Panchasara, H., Nilufar, H. and Sanap, M. J. (2014). Seasonal effects on milk yield, erythrocytic and leukocytic indices of Kankrej cattle (*Bos indicus*). *Veterinary World, 7*, 471-477.

Mazzullo, G., Rifici, C., Cammarata, F., Gino, C., Maria, R. and Piccione, G. (2014). Effect of different environmental conditions on some haematological parameters in cow. *Annals of Animal Science, 14*(4), 947–954.

Meyer, K. Y. and Harvey, J. W. (1998). Veterinary laboratory medicine. W. B. Saunders Company.USA.(1998).

Minka, N. S. and Ayo, J. O. (2007). Physiological responses of transported goats treated with ascorbic acid during the hot dry season. *Animal Science Journal*, *78*(2), 164-172.

Mirzadeh, K. H., Tabatabaci, S., Bojarpur, M. and Mamoei, M. (2010). Comparative study of haemological parameters according strain, age, sex, physiological status and season in Iranian cattle. *Journal of Animal and Veterinary Advances*, *9*(16), 2123-2127.

Muna, H., AL-Saeed.,Haidar, K. A. and Ghadhbam. R. F. (2009). Selective evaluation of certain blood and biochemical parameters of local cattle during winter and summer seasons. *Basra Journal of Veterinary Research, 8*(1), 138-143.

Naik, B. R., Sivaumar, A. V. N., Ravi, A., Bramhaiah, K. V. and Praveen, V. (2013). Effect of seasons on physiological and hematological values in Punganur cattle. *International Journal of Pharmacy and Biological Sciences, 4*(4), 40-49.

Narayan, U., Singh, D. V. and Sharma, R. J. (2007). Physiological responses in Holstein-Friesian crossbred lactating cows under heat stress ameliorating treatments. *Indian Journal of Animal Research*, *41*, 130-133.

Nardone, A. and Renna, M. (2010). Climate change and livestock health. *Animal Production Science*, *50*(3), 123-133.

Payne, J. M., Dew, S. M., Mansto, R. and Faulks, M.(1970). The use of a metabolic profile test in dairy herds. *Veterinary Record, 87,* 150-158.

Piccione, G., Giannetto, C., Casella, S. and Caola, G. (2009). Annual rhythms of some physiological parameters in *Ovis aries* and *Capra hircus*. *Biological Rhythm Research*, *40,* 455-464.

Piccione, G., Casella, S., Lutri, L. and Vazzana, I. (2010). Reference values for some haematological, haematochemical, and electrophoretic parameters in the Girgentana goat. *Turkish Journal of Veterinary & Animal Sciences, 34*(2), 197-204.

Prava, M. and Dixit, N. K. (2008). Effect of season on Blood erythrocyte picture of Frieswal cattle. *Indian Journal of Dairy Science, 61*(2), 162-164.

Praveen, V. (2013). Effect of seasons on physiological and hematological values in punganur cattle. *International Journal of Pharma and Bio Sciences, 4*, 40-49.

Purwar, V., Oberoi, P. S., Alhussien, M. N., Santoshi, P., Diwakar and 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.

Saror, D. and Coles, E. H. (1973). The blood picture of White Fulani (Zebu) and White Fulani/Fresian (crossbreed) dairy cow. *Bulletin of Epizootic Diseases Africa, 21,* 485-487.

Shaffer, L., Roussel, J. D. and Koonce, K. L. (1981). Effects of age, temperature, season, and breed on blood characteristics of dairy cattle. *Journal of Dairy Science, 64,* 62-70.

Shibu, C. T., Singh, S. V. and Upadhyay, R. C. (2008). Impact of temperature rise on pulmonary dynamics, heat dissipation and antioxidant status in KF heifers, *Indian Journal of Animal Nutrition, 25*(1), 67.

Shrikhande, G. B., Rode, A. M., Pradhan, M. S. and Ashlesha, K. S. (2008). Seasonal effect on the composition of blood in cattle. *Veterinary World, 1*(11), 341-342.

Silanikove, N. (2000). Effects of heat stress on the welfare of extensively managed domestic ruminants. *Livestock Production Science, 67,* 1-18.

Singh, K. M., Singh, S., Ganguly, I., Ganguly, A., Nachiappan, R. K., Chopra, A. and Narula, H. K. (2016). Evaluation of Indian sheep breeds of arid zone under heat stress condition. *Small Ruminant Research, 1*(141), 113-117.

Soley, M. J. and Singh, S. V. (2003). Physiological, haematological and growth responses of crossbred male calves under two housing conditions. *Indian Journal of Animal Science, 73*(2), 202-203.

Wegner, T. N., Schuh, J.D., Nelson, F. E. and Stott, G. H. (1976). Effect of stress on blood leucocyte and milk somatic cell counts in dairy cows. *Journal of Dairy Science, 59,* 949-956.

Zhao, X., Zhang, L. and Sun, X. (2017). Hematological responses of cattle to heat stress: A review. *Journal of Animal Science, 95*(2), 575-582.

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