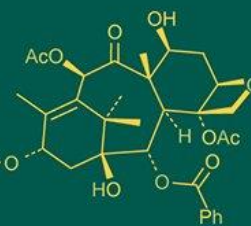
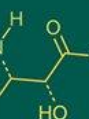
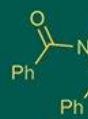
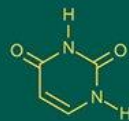
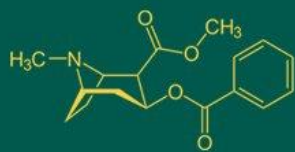


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Dr. Amit Kumar
 Assistant professor (Veterinary
 Biochemistry), Mahatma
 Gandhi Veterinary College
 Bharatpur Rajasthan, India

Dr. Barkha Gupta
 Assistant professor (Veterinary
 Biochemistry), Post Graduate
 Institute of Veterinary
 Education & Research, Jaipur,
 Rajasthan, India

Dr. Govind Sahay Gottam
 Professor & Head (Department
 of Physiology and
 Biochemistry), Post Graduate
 Institute of Veterinary
 Education & Research Jaipur,
 Rajasthan, India

Dr. Sagar Kumar Meena
 Veterinary Officer,
 Government of Rajasthan,
 Rajasthan, India

Dr. Ranjana Meena
 Veterinary Officer,
 Government of Rajasthan,
 Rajasthan, India

Corresponding Author:
Dr. Amit Kumar
 Assistant professor (Veterinary
 Biochemistry), Mahatma
 Gandhi Veterinary College
 Bharatpur Rajasthan, India

To determine the haematological profile during the transition period of Murrah buffaloes in eastern Rajasthan

Amit Kumar, Barkha Gupta, Govind Sahay Gottam, Sagar Kumar Meena and Ranjana Meena

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Abstract

The transition period, encompassing the final weeks of pregnancy through early lactation, represents a physiologically demanding phase for dairy buffaloes and is often associated with metabolic stress, immune modulation and increased susceptibility to disease. The present study was undertaken to evaluate the haematological alterations occurring during the transition period in Murrah buffaloes maintained under field conditions in eastern Rajasthan, with the objective of establishing physiological trends that may serve as indicators of health and adaptive capacity during this critical phase. A total of fifteen apparently healthy, advanced pregnant Murrah buffaloes were selected from local farms in the Bharatpur district. Blood samples were collected at four distinct stages of the transition period, namely the third week pre-partum, one week before parturition, 24 hours post-partum and the third week post-partum. Whole blood samples were analyzed for comprehensive haematological parameters using an automated haematology analyzer. The parameters studied included total leucocyte count (TLC), total erythrocyte count (TEC), platelet count, differential leucocyte count (lymphocytes, monocytes, neutrophils, eosinophils and basophils), haemoglobin concentration (Hb), packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC). The data were subjected to standard statistical analysis, including analysis of variance and comparison of means using Duncan's multiple range test. The results revealed that most haematological parameters remained within established physiological reference ranges throughout the transition period, however, significant stage-specific variations were evident. Total leucocyte count and neutrophil percentage showed an increasing trend around parturition, with peak values observed 24 hours post-partum, indicating a stress-related leukocytic response and enhanced innate immune activity. Conversely, lymphocyte percentage declined at calving, reflecting transient immunosuppression associated with cortisol surge and periparturient stress. Total erythrocyte count, haemoglobin concentration and PCV were significantly higher immediately after calving, suggesting increased oxygen demand, hemoconcentration and endocrine adjustments during the onset of lactation. Platelet counts and most erythrocyte indices exhibited non-significant variations, indicating relative haematological stability despite the physiological strain of parturition.

Keywords: Murrah buffaloes, transition period, haematological parameters, periparturient stress, differential leucocyte count, erythrocyte indices, parturition, early lactation

Introduction

The world's largest buffalo population is in India, at over 56%. About 109.85 million (20.47% of Indian livestock) are estimated. Buffalo numbers rose 1.06% since the 2012 livestock census. Female buffalo numbers rose 8.61% since 2012. As per 20th livestock census, Uttar Pradesh (33.0 million), Rajasthan (13.7 million), Gujarat (10.5 million) and Madhya Pradesh (10.3 million) have the most buffaloes. Rajasthan has 13.7 million buffaloes, second in the nation (20th Livestock Census, BAHs, 2019). Dairy cows transition from 3 weeks pre-calving to 3 weeks post-calving (Kočila *et al.*, 2013, Folnožić *et al.*, 2015, Đuričić *et al.*, 2020)^[12, 15, 30]. The word "transition" emphasises the major physiological, metabolic and dietary changes occurring during this time. Transition failure causes decreased milk production, immunological suppression and reproductive failure. Periparturient stress caused by hormonal and metabolic fluctuations, especially a negative energy balance, shortage of proteins, minerals and vitamins and lactation is the main cause of immune system impairment in high-yielding

cows (Goff, 2006) [17]. The cow may develop metabolic disorders like ketosis, acidosis and displaced abomasum (Drackley, 1999, Vernon, 2005), infectious disorders like metritis and mastitis (Sheldon *et al.*, 2002b, Mulligan, 2006), or calving-related disorders like dystocia, retained placenta and decreased fertility. Nearly 75% of dairy cow diseases occur in the first month after calving (LeBlanc *et al.*, 2006). Critical health issues during peripartum cause significant financial losses. Improved reproductive and productive efficiency in dairy animals requires a smooth pregnancy-to-lactation transition (Goncu *et al.*, 2017). Blood cell parameters change significantly as animals undergo massive metabolic adaptations from late pregnancy to early lactation. Hormonal changes are well-coordinated to support lactation (Bell, 1995, Dobranić *et al.*, 2008, Folnožić *et al.*, 2019). Transition dairy cows' metabolic adaptation depends on feeding management (Loor *et al.*, 2007, Graugnard, 2013, Roche, 2013) [6, 10, 15, 18, 19, 33, 34, 36, 41, 43, 48, 51].

Haematology is a valuable diagnostic tool in veterinary medicine, especially when combined with clinical examination (Ronald *et al.*, 2014). Prepartum hemogram and biochemical profiling can predict cow susceptibility to production diseases (Kevin and Ellen, 2012). The postpartum haematological parameters show dairy animals' adaptability to physiological change, from non-lactation to lactation. RBC, Hb and immunoglobulin levels decrease prepartum and rise immediately after calving, which is linked to foetal growth by Elitok *et al.* (2006) and Djokovic (2015) [13]. This critical period involves significant haematological, cellular and immunomodulatory changes in the mammary gland to accommodate involution, prepare for parturition, withstand parturition stress, transform colostrum into milk and reach peak milk production. These periods also impair lymphocyte and neutrophil function (Kehrli *et al.*, 1989). Ruminants get Lymphocytosis from chronic infections like pneumonia, peritonitis, pericarditis and liver abscesses. Chronic infections may cause primiparous cows' high WBC counts in early to mid-lactation. In the mammary gland, neutrophils flood colostrums and milk around calving and for the first week afterward (Guidry *et al.*, 1976), affecting erythrocyte parameters and total and differential leucocyte counts (DLC) (Klinkon, 1992) [20, 25, 26, 29, 44].

Materials and Methods

The present study was conducted on Murrah buffaloes (N=15) from local farms of eastern Rajasthan (Bharatpur district). The selected Murrah buffaloes in advanced pregnancy were apparently healthy and free from any parasitic infection or disease condition.

Collection, processing and preservation of blood samples

The blood samples during the transition period from Murrah buffaloes ($n = 15$) were collected in different phases according to the following protocol:

Group / Phase of Animals		No. of Animals
Pregnant pre-partum Animals	During 3rd week pre-partum	15 (Same)
	One week before parturition	
Lactating post-partum Animals	24 hours after parturition	
	During 3 rd week post-partum	

Blood samples (10 ml each) were collected aseptically from the jugular vein during the different phases of the transition period from Murrah buffaloes directly into the Plasma Separating Tubes (PST) (with EDTA) and Serum Separating Tubes (SST) (Non-EDTA) in order to analyze different haematological and biochemical parameters, respectively.

Haematological studies

Total Leucocyte Count (TLC), Total Erythrocyte Count (TEC), Platelet count, Differential Leucocyte Count (Lymphocyte percent, Monocyte percent, Neutrophil percent, Eosinophil percent and Basophil percent), Haemoglobin, Mean Corpuscular Haemoglobin (MCH), Mean Corpuscular Haemoglobin Concentration (MCHC), Packed cell volume (PCV/ Haematocrit) and Mean Corpuscular Volume (MCV) were determined from the collected whole blood samples (plasma separating tube) during the different phases of the transition period by using Vet Spincell 5 compact automated blood/ haematology analyzer in the Department of Physiology and Biochemistry at PGIVER, Jaipur.

Statistical analysis: Conventional standard statistical procedure was used to analyze the data for mean, standard error and ANOVA using SPSS 24th version and comparison of mean was tested using Duncan's multiple range test (Duncan's, 1995) [11].



Fig 1: Collection of Blood Samples



Fig 1: Vet Spincell 5 Compact Automated Haematology Analyzer

Results and Discussion

Total leucocytes count

The normal range for total leukocyte count in buffaloes is 5.80-15.5 ($10^3/\mu\text{l}$ or $10^9/\text{l}$), as reported by Wills (2010) and Dhillon *et al.* (2020). The mean TLC values were within the reference range. The mean $\pm$ SE values of total leukocyte count ($\times 10^9/\text{l}$) in Murrah buffaloes were 7.47 ± 0.19 , 8.63 ± 0.11 , 9.30 ± 0.46 and 7.76 ± 0.29 during the 3rd week pre-partum, one week before parturition, 24 hours post-partum and 3rd week post-part. Our findings align with Kornmatitsuk *et al.* (2001) in dairy heifers, Meglia *et al.* (2001) in periparturient dairy cows, Todorović and Davidović (2012) in HF cows, Pathan *et al.* (2015) in Sahiwal and Murrah buffaloes, Pande *et al.* (2016) in Murrah buffaloes, Patel *et al.* (2017) in Karan Fries cows and Aswal *et al.* (2021) in both. Abdelrazek *et al.* (2018) [1] found a substantial ($p < 0.05$) rise in TLC levels in Egyptian buffaloes during calving and postpartum compared to prepartum. Aswal *et al.* (2021) found that TLC dramatically rose ($p < 0.01$) from 2 weeks before calving until the day of calving, then reduced in the first week post-calving. In contrast, A.E. Mohamed *et al.* (2015) [3] found lesser TLC at parturition in cows and buffaloes. In response to metabolic requirements in the final stage of pregnancy and the start of lactation, haematological biomarkers changed significantly, ensuring nutritional energy and oxygen transport through the blood. WBC count is a crucial part of the total blood count since it indicates animal health. White blood cell dysfunction during calving decreases immunity (Klinkon and Zadnik, 1999) [4, 9, 28, 31, 38, 39, 40, 49, 52].

Total erythrocyte count

The buffaloes' mean total erythrocyte count (TEC) was within normal ranges, with values of 5.12-9.30 ($10^6/\mu\text{l}$ or $10^{12}/\text{l}$) as reported by Wills (2010) and Dhillon *et al.* (2020). The mean $\pm$ SE values of total erythrocyte count ($\times 10^{12}/\text{l}$) were 6.54 ± 0.23 , 7.51 ± 0.12 , 8.53 ± 0.10 and 7.15 ± 0.11 during the 3rd week pre-partum, one week before parturition, 24 hours post-partum and 3rd week post-part. The transition phase had a substantial ($p < 0.05$) effect on total erythrocyte count (TEC) in Murrah buffaloes, with the highest levels occurring 24 hours post-partum and the lowest during the 3rd week pre-partum. Our findings were consistent with A.E. Mohamed *et al.* (2015) [3] in buffalo heifers, Patel *et al.* (2017) in Karan Fries cows and Aswal *et al.* (2021) in Karan Fries and Sahiwal cows. Hagawane *et al.* (2009) and Abdelrazek *et al.* (2018) [1] found a similar pattern in buffaloes, Joshi *et al.* (2018) in Karan Fries cows and Oliveira *et al.* (2019) in Nellore cows, however the transition period had no influence ($P > 0.05$). Total erythrocyte count may rise due to erythropoiesis and sluggish erythrocyte degradation during transition. RBC levels decrease prepartum and rise soon after calving, which is linked to foetal growth due to its higher metabolic needs (Rani and Rao, 2021). RBC count increases with oxygen demand, causing kidney tissue to release erythropoietin. Hemoconcentration from reduced water intake and increased spleen contraction may also explain enhanced RBC counts at calving (Van Soest and Blosser, 1954). Our results contradicted Găvan *et al.* (2010) in Holstein cows, Elshahawy and Abullaziz (2017) in dairy cows, Sharma *et al.* (2017) in Murrah buffaloes, Oliveira *et al.* (2019) and Reddy and Sivajothi (2020) in buffaloes, who found fewer red blood cells at parturition [4, 6, 9, 14, 16, 21, 24, 37, 39, 41, 42, 47, 50].

Platelet Count: The observed mean platelet count in buffaloes was within normal reference values (160-604 ($10^3/\mu\text{l}$ or $10^9/\text{l}$)) as reported by Wills (2010) and Dhillon *et al.* (2020). The mean $\pm$ SE values of platelet count ($\times 10^9/\text{l}$) were 319.38 ± 2.45 , 318.43 ± 0.6 , 308.45 ± 0.47 and 317.76 ± 0.47 during the 3rd week pre-partum, one week before parturition, 24 hours post-partum and 3rd week post. This platelet count change may be due to calving blood loss. The non-significant difference during the transition phase with lower levels during calving was consistent with Abdelrazek *et al.* (2018) [1] in Egyptian buffaloes and Sateesh *et al.* (2018) in Deoni cows. Joshi *et al.* (2018) found no significant platelet count variations at 30, 15, 7, 3 days before and the day of calving. Buffaloes have many platelets in clusters and separately. Platelets are spherical or elongate and include purple granules of various sizes. Platelets typically measure 2.4 to 3.0 μm but can be larger (Wills, 2010) [9, 24, 45, 52].

Lymphocyte percent

The normal lymphocyte percent in buffaloes is 26-75%, according to Jain *et al.* (1982) and Wills (2010). Lymphocyte percentage was within reference range. Lymphocyte (%) mean $\pm$ SE values were 68.97 ± 0.93 , 64.12 ± 0.34 , 52.03 ± 0.40 and 62.01 ± 0.16 during pre-partum, one week before, 24 hours after and 3 weeks post-partum. Our findings align with Todorović and Davidović (2012) in HF cows, A.E. Mohamed *et al.* (2015) [3] in buffaloes, Elshahawy and Abullaziz (2017) in dairy cows, Patel *et al.* (2017) in Karan Fries cows, Abdelrazek *et al.* (2018) [1] in Egyptian buffaloes, Joshi *et al.* (2018) in crossbred cows, Oliveira *et al.* (2019) in Nellore cows, Reddy and Sivajothi (2020) in buffaloes. An abnormal differential leucocyte count indicated stress during parturition. Peripartum cows had lymphocytopenia due to cortisol surge at calving (Jacob *et al.*, 2001). Immune suppression during the transition period may have increased glucocorticoids, lowering leucocyte counts (Khadjeh *et al.*, 2002) [14, 23, 24, 27, 37, 39, 42, 49, 52].

Monocyte percent

According to Jain *et al.* (1982) and Wills (2010), buffalo monocyte percent should be 1-11.5 (%). The mean Monocyte percent was within the reference range. Monocyte percentages were 2.80 ± 0.03 , 1.59 ± 0.08 , 3.16 ± 0.09 and 2.35 ± 0.10 during the 3rd week pre-partum, one week before parturition, 24 hours post-partum and 3rd week post-partum, respectively. Meglia *et al.* (2001) found similar results in periparturient cows, Kulberg *et al.* (2002) in cows, Todorović and Davidović (2012) in dairy cows, Pande *et al.* (2016) in Murrah buffaloes, Patel *et al.* (2017) in Karan Fries cows, Abdelrazek *et al.* (2018) [1] in buffaloes, Oliveira *et al.* (2019) in Nellore cows and Aswal *et al.* (2021) in Karan Fries. In buffaloes, A.E. Mohamed *et al.* (2015) [3] found a non-significant higher monocyte percent in early lactation than late pregnancy. Buffalo blood monocytosis was caused by cortisol surge at calving. This increase may be to reduce calving-related general and uterine infections (Pande *et al.*, 2016). Monocytes may migrate from circulation to tissues and become macrophages to provide immunity during parturition stress (Klinkon and Zadnik, 1999). This contradicts Ate *et al.* (2009) and Joshi *et al.* (2018), who found lower values at early lactation and parturition in cows [4, 6, 24, 28, 35, 37, 38, 39, 49, 52].

Neutrophil percent

According to Jain *et al.* (1982) and Wills (2010), buffaloes have a mean neutrophil percentage of 13-54 (%). The mean $\pm$ SE values of neutrophils (%) were 24.47 ± 0.93 , 31.12 ± 0.33 , 41.12 ± 0.33 and 32.25 ± 0.30 during the 3rd week pre-partum, one week before parturition, 24 hours post-partum and 3rd week post-part. Our findings align with Meglia *et al.* (2001), Ate *et al.* (2009), Todorović and Davidović (2012) in dairy cows, Pathan *et al.* (2015) in Murrah buffaloes, Patel *et al.* (2017) in Karan Fries cows, Abdelrazek *et al.* (2018)^[1] in buffaloes and Aswal *et al.* (2021) in Karan Fries and Sahiwal. Our results contradicted Gavan *et al.* (2010) in HF cows, A.E. Mohamed (2015) in buffaloes, Elshahawy and Abullaziz (2017)^[3] in dairy cows, Oliveira (2019) in Nellore cows and Reddy and Sivajothi (2020) in buffaloes. Joshi *et al.* (2018) found crossbred cows had non-significant lower neutrophils at calving. In stressful conditions, cortisol release may increase the neutrophil count and N/L ratio on calving day as neutrophils migrate to the mammary glands to protect them from intra-mammary infection. Dairy animals are disease-resistant around peripartum due to increased blood neutrophilic function. The mammary gland's extensive neutrophil influx into colostrum around parturition affects white blood cell counts (Rani and Rao, 2021) [4, 6, 14, 16, 24, 35, 37, 39, 40, 41, 42, 49].

Eosinophil percent: The mean buffalo Eosinophil percent was 2-14 (%), as shown by Jain *et al.* (1982) and Wills (2010). The Mean $\pm$ SE values of Eosinophil (%) were 2.51 ± 0.05 , 2.16 ± 0.02 , 2.70 ± 0.08 and 2.38 ± 0.05 during the 3rd week pre-partum, one week before parturition, 24 hours post-partum and 3rd week post-partum. The granulocyte lineage produces eosinophils from bone marrow. Their functions include antigen presentation, lipid-derived, peptide and cytokine mediator release for acute and chronic inflammation, degranulation for helminth and parasite clearance and homeostatic immune responses. The current study found a slight increase in eosinophil percent, possibly due to calving-induced immune response. Results align with A.E. Mohamed *et al.* (2015)^[3] in buffaloes, Elshahawy and Abullaziz (2017) in dairy cows, Abdelrazek *et al.* (2018)^[1] in buffaloes, Reddy and Sivajothi (2020) in buffaloes and Aswal *et al.* (2021) in Karan Fries and Sahiwal cows. Todorović and Davidović (2012) and Joshi *et al.* (2018) reported higher percentages in dairy cows, while Oliveira *et al.* (2019) observed signs in Nellore cows [4, 14, 24, 42, 49, 52].

Basophil percent: The observed mean percentage of Basophils was within the established normal reference range for buffaloes, i.e., 0-3.5%, as documented by Wills (2010). The mean $\pm$ SE values of basophil (%) were recorded as 1.25 ± 0.05 , 1.01 ± 0.01 , 1.00 ± 0.04 and 1.01 ± 0.03 during the third week pre-partum, one week before parturition, 24 hours after parturition and the third week post-partum, respectively. A comparable pattern was observed by A.E. Mohamed *et al.* (2015)^[3] in buffaloes, Elshahawy and Abullaziz (2017) in dairy cows, Abdelrazek *et al.* (2018)^[1] in buffaloes, Reddy and Sivajothi (2020) in buffaloes and Aswal *et al.* (2021) in Karan Fries and Sahiwal cows. Our findings contradicted those of Todorović and Davidović (2012), Joshi *et al.* (2018) and Oliveira *et al.* (2019) in cattle [4, 14, 24, 37, 42, 49, 52].

Haemoglobin: The mean haemoglobin (Hb) in buffaloes was 8.90-15.9 (g/dl) as shown by Wills (2010) and Dhillon *et al.*

(2020). The mean $\pm$ SE haemoglobin (g/dl) values were 14.40 ± 0.15 , 14.43 ± 0.10 , 16.14 ± 0.03 and 14.10 ± 0.03 during the 3rd week pre-partum, one week before parturition, 24 hours post-partum and 3rd week post-partum. Our results matched Kornmatitsuk *et al.* (2001), Patel *et al.* (2017) and Aswal *et al.* (2021) in cows. However, Abdelrazek *et al.* (2018)^[1] in buffaloes, Joshi *et al.* (2018) in Karan Fries (KF) cows and Kumar *et al.* (2018) in Murrah buffaloes found the same pattern but no significant effect. Contrary to Kumar and Pachuri (2000) in crossbred cattle, Gavan *et al.* (2010) in HF cows, A.E. Mohamed (2015)^[3] in buffaloes, Elshahawy and Abullaziz (2017) in dairy cows, Sharma *et al.* (2017) in Murrah buffaloes, Oliveira (2019) in Nellore cows and Reddy and Sivajothi (2020) in buffaloes. On the day of calving or immediately after calving, the body tissues need more energy to complete all the physiological processes related to calving, but Hb levels decreased in the early lactation period due to the lower rate of erythropoiesis in these animals (Kumar and Pachuri, 2000) or anaemia or the mammary tissues' higher haemoglobin requirement for milk syntheses [4, 14, 16, 24, 31, 32, 37, 39, 42, 47].

Mean corpuscular haemoglobin (MCH)

According to Wills (2010) and Dhillon *et al.* (2020), buffaloes' mean corpuscular haemoglobin (MCH) is 13.5-20.5 pg. The observed values were close to this range. The mean $\pm$ SE values of corpuscular haemoglobin (pg) were 22.01 ± 0.73 , 19.21 ± 0.52 , 18.92 ± 0.40 and 19.72 ± 0.51 during the 3rd week pre-partum, one week before parturition, 24 hours post-partum and 3rd week post-part. The transition period's non-significant pattern was consistent with Gavan *et al.* (2010) in HF cows, Abdelrazek *et al.* (2018)^[1] in buffaloes and Aswal *et al.* (2021) in Karan Fries and Sahiwal cows. In dairy animals, A.E. Mohamed *et al.* (2015)^[3], Elshahawy and Abullaziz (2017) and Sateesh (2018) found a significant decrease at calving. While Sharma *et al.* (2017) in Murrah buffaloes and Joshi *et al.* (2018) in crossbred cows reported a significantly higher MCH at calving, our result was different. Peri-parturient animals may have lower MCH or immunogenicity due to iron deficiency (Detilleux *et al.*, 2004)^[7, 14, 24, 45, 47, 58].

Mean corpuscular haemoglobin concentration (MCHC)

Wills (2010) and Dhillon *et al.* (2020) report that buffaloes have a normal MCHC of 34.8-39.2 (g/dl). The mean MCHC values were slightly higher than the reference range due to breed, age, parity, individual physiological and environmental conditions (geographic, climatic, seasonal variation). The mean $\pm$ SE values of MCHC (g/dl) were 46.26 ± 0.93 , 44.77 ± 0.52 , 44.97 ± 0.30 and 44.16 ± 0.16 during the 3rd week pre-partum, one week before parturition, 24 hours post-partum and 3rd week post-partum. Patel *et al.* (2017) found similar results in Karan Fries cows, Abdelrazek *et al.* (2018)^[1] in buffaloes and Aswal *et al.* (2021) in Karan Fries and Sahiwal cows. In contrast to Elshahawy and Abullaziz (2017) in dairy cows and Joshi *et al.* (2018) in crossbred cows [4, 14, 24, 39, 52].

Packed cell volume (PCV)

According to Wills (2010) and Dhillon *et al.* (2020), buffaloes' packed cell volume/haematocrit should be 25.5-38.6%. The mean PCV values were within the reference range. The mean $\pm$ SE PCV values (%) were 31.13 ± 0.73 , 32.23 ± 0.39 , 35.89 ± 0.47 and 31.93 ± 0.58 during the 3rd

week pre-partum, one week before parturition, 24 hours post-partum and 3rd week post-partum. Seifi *et al.* (2003) reported similar results in cows, Abdulkareem (2013)^[2] in buffaloes, Patel *et al.* (2017) in cows, Abdelrazek (2018)^[1] in buffaloes, Oliveira (2019) in Nellore cows and Aswal (2021) in Karan Fries and Sahiwal cows. Contrary to Kumar and Pachuri (2000) in dairy cattle, Hagawane *et al.* (2009) in buffaloes, Gavan *et al.* (2010) in HF cows, A.E. Mohamed *et al.* (2015)^[3] in buffalo heifers, Elshahawy and Abullaziz (2017) in dairy cows, Sharma *et al.* (2017) in Murrah buffaloes, Joshi *et al.* (2018) in crossbred cows, Kumar (2018) in Murrah buffaloes and Reddy and Sivajothi (2020). High PCV immediately after calving may indicate that tissues need more oxygen to meet energy needs (Jain, 1996)^[4, 6, 9, 14, 16, 21, 24, 32, 37, 39, 42, 47, 52].

Mean corpuscular volume (MCV)

Wills (2010) and Dhillon *et al.* (2020) report a normal buffalo MCV of 37.3-47.6 (fl). The mean MCV values were within the reference range. MCV (fl) values were 47.60 ± 0.93 , 42.92 ± 0.72 , 42.07 ± 0.70 and 44.65 ± 0.23 during pre-partum, one week before parturition, 24 hours post-partum and 3rd week post-partum, respectively. Our trend matched Gavan *et al.* (2010) in HF cows, A.E. Mohamed *et al.* (2015)^[3] in buffaloes, Elshahawy and Abullaziz (2017) in dairy cows, Patel *et al.* (2017) in Karan Fries cows and Aswal *et al.* (2021) in Karan Fries and Sahiwal cow, in contrast to Sharma *et al.* (2017) in Murrah buffaloes and Joshi (2018) in crossbred cows. RBC indices like MCV, MCH and MCHC help diagnose anaemia, especially in pre-partum animals (Rani and Rao, 2021). MCV may decrease slightly due to calving-induced erythrocytes^[4, 9, 14, 24, 39, 41, 47, 52].

Conclusion

The present investigation clearly demonstrates that the transition period exerts a marked influence on the haematological profile of Murrah buffaloes, reflecting the intense physiological, metabolic and immunological adjustments associated with late pregnancy, parturition and early lactation. Although most haematological parameters remained within established reference ranges, statistically and biologically meaningful variations were observed across different phases of the transition period, highlighting its critical nature. An overall increase in total leucocyte count and neutrophil percentage around calving, accompanied by a decline in lymphocyte percentage, indicates a typical stress leukogram largely driven by cortisol-mediated responses and heightened innate immune activity. These changes underline

the transient immunosuppression and redistribution of leukocyte populations that predispose animals to periparturient diseases. The rise in neutrophils immediately after parturition further emphasizes their protective role against mammary and uterine infections during this vulnerable phase. Total erythrocyte count, haemoglobin concentration and packed cell volume peaked shortly after calving, suggesting increased oxygen demand, hemoconcentration and endocrine adaptations during uterine involution and the onset of lactation. The relative stability of platelet counts across the transition period indicates effective haemostatic regulation despite calving-associated blood loss. Variations in erythrocyte indices (MCV, MCH and MCHC), though largely non-significant, provide valuable insights into erythropoietic dynamics and potential subclinical anaemic tendencies during late gestation and early lactation. The present study clearly demonstrates that the transition period exerts a marked influence on the haematological profile of Murrah buffaloes, reflecting the intense physiological, metabolic and immunological adjustments associated with late pregnancy, parturition and early lactation. Most haematological parameters, including total leukocyte count, erythrocyte count, haemoglobin concentration, platelet count and erythrocytic indices, remained within established reference ranges, indicating effective adaptive mechanisms and overall physiological stability during this critical phase. However, distinct temporal variations were evident around calving, particularly increases in TLC, TEC, neutrophil percentage, haemoglobin, PCV and MCHC at or shortly after parturition, suggesting heightened oxygen demand, stress response and immune activation. The observed lymphocytopenia and neutrophilia at calving further confirm the role of cortisol-mediated stress and transient immunomodulation during the periparturient period. Monocyte and eosinophil percentages showed minor fluctuations, likely reflecting protective immune functions against infection and inflammatory challenges associated with calving. Variations in RBC indices (MCV, MCH and MCHC) highlight their diagnostic value in assessing erythropoietic status and potential anaemic conditions during late gestation and early lactation. Overall, the findings emphasize that haematological profiling is a valuable tool for monitoring health, stress and immune competence in buffaloes during the transition period, aiding in timely management interventions to ensure optimal productivity and welfare.

Phase	Number of Observation	Total Leukocyte Count ($\times 10^9/l$) Mean $\pm$ SE	Total Erythrocyte Count ($\times 10^{12}/l$) Mean $\pm$ SE	Platelet Count ($\times 10^9/l$) Mean $\pm$ SE	Lymphocyte (%) Mean $\pm$ SE	Monocyte (%) Mean $\pm$ SE	Neutrophil (%) Mean $\pm$ SE	Eosinophil (%) Mean $\pm$ SE	Basophil (%) Mean $\pm$ SE	Hemoglobin (g/dl) Mean $\pm$ SE	MCH (pg) Mean $\pm$ SE	MCHC (g/dl) Mean $\pm$ SE	PCV (%) Mean $\pm$ SE	MCV (fl) Mean $\pm$ SE
During 3rd week pre-partum	15	$7.47^a \pm 0.19$	$6.54^a \pm 0.23$	319.38 ± 2.45	$68.97^b \pm 0.93$	$2.80^{ab} \pm 0.03$	$24.47^a \pm 0.93$	2.51 ± 0.05	1.25 ± 0.05	$14.40^a \pm 0.15$	22.01 ± 0.73	46.26 ± 0.93	$31.13^a \pm 0.73$	47.60 ± 0.93
One week before parturition	15	$8.63^{ab} \pm 0.11$	$7.51^{ab} \pm 0.12$	318.43 ± 0.60	$64.12^{ab} \pm 0.34$	$1.59^a \pm 0.08$	$31.12^{ab} \pm 0.33$	2.16 ± 0.02	1.01 ± 0.01	$14.43^a \pm 0.10$	19.21 ± 0.52	44.77 ± 0.52	$32.23^a \pm 0.39$	42.92 ± 0.72
24 hours after parturition	15	$9.30^b \pm 0.46$	$8.53^b \pm 0.10$	308.45 ± 0.47	$52.03^a \pm 0.40$	$3.16^b \pm 0.09$	$41.12^b \pm 0.33$	2.70 ± 0.08	1.00 ± 0.04	$16.14^b \pm 0.03$	18.92 ± 0.40	44.97 ± 0.30	$35.89^b \pm 0.47$	42.07 ± 0.70
During 3rd week post-partum	15	$7.76^a \pm 0.29$	$7.15^{ab} \pm 0.11$	317.76 ± 0.47	$62.01^{ab} \pm 0.16$	$2.35^{ab} \pm 0.10$	$32.25^{ab} \pm 0.30$	2.38 ± 0.05	1.01 ± 0.03	$14.10^a \pm 0.03$	19.72 ± 0.51	44.16 ± 0.16	$31.93^a \pm 0.58$	44.65 ± 0.23

Note: Mean comparisons have been made within different phases.

Mean superscripted with different letters differ significantly ($p < 0.05$) from each other.

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