

# Location-dependent variation in haematological traits of feedlot bulls during the hot season in Kano State, Nigeria

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**ABSTRACT:** The study aimed to determine the effect of location on the haematological traits of feedlot bulls fattened in the hot period of Kano. Ninety (90) bulls (Ambala), comprising (30) each from the three (3) purposively sampled locations (Bichi, Danbatta and Karaye feedlot fattening Areas), were used for the experiment, which started from March–May 2025 (late dry season), and only clinically healthy bulls of similar ages (3-4 years) were used for the study. Blood samples were collected from the jugular vein of 90 bulls using a syringe and needle. The effect of location on properties indicated that location significantly influenced ( $p < 0.05$ ) all the haematological properties studied. Karaye feedlot bulls were superior in all haematological properties; Haemoglobin (10.72 g/dl), White Blood Cell ( $12.32 \times 10^3/\text{mm}^3$ ), Red Blood Cell ( $7.87 \times 10^6/\text{mm}^3$ ) and packed cell volume (36.36%), while the least of those parameters were observed in Danbatta and Bichi. Correlation coefficient indicated that the parameters evaluated were significantly ( $p < 0.05-0.01$ ;  $r = 0.36$  to  $0.64$ ) correlated with each other, except ( $p > 0.05$ ;  $r = 0.19$ ) for the relationship between Haemoglobin and Red Blood Cell. The haematological parameters related to location, Danbatta, were comparable to the values considered to be physiological for feedlot bulls fattened during the hot period and can be influenced by heat stress. There is a need to use shade to mitigate heat stress during the hot period. Further studies with more locations and animals are also recommended for a holistic evaluation of the effect of heat stress on the feedlot.

**Keywords:** Feedlot bulls, haematological traits, hot season, Kano State.

## INTRODUCTION

Hot weather affects animal bioenergetics and has negative effects on their performance and well-being. Reductions in feed intake, growth, and efficiency are commonly reported in heat-stressed cattle (Hahn *et al.* 2003). The effect of heat load on these production losses is quite varied, ranging from little to no effect in a brief exposure to death in vulnerable animals during an extreme event (Hahn and Mader, 1997). Economic losses associated with heat stress originate from three primary factors, including decreased performance, increased mortality, and decreased reproduction (St-Pierre *et al.*, 2003). When losses are summarised for the United States over an entire summer season, the average estimated losses over all livestock species are US\$ 2.4 billion, and US\$ 369 million

is associated with feedlot cattle (Brown-Brandl, 2018). For instance, in Nigeria, reduced milk yield was recorded in Nigerian indigenous breeds of cattle during the hot season in Nigeria (Abbaya, 2023). In recent years, there has been an increase in the incidence of heat waves, leading to increased exposure of animals to high environmental temperatures along with prolonged drought, exposing animals to heat stress conditions. Heat stress can induce oxidative stress and metabolic disorders by elevated levels of free radicals and/or reactive oxygen species in the circulatory system if the haematological defence system is depleted (Chauhan *et al.*, 2014b). Elevated temperature and extremely hot conditions have been reported to cause heat stress, which in turn compromises the metabolic status

and haematological defence systems of animals, leading to reduced performance and productivity (Chauhan *et al.*, 2016). Under heat exposure, an animal's body temperature can rise beyond the thermoneutral zone to the heat load zone, and when total heat load exceeds the animal's capacity to dissipate heat, animals are subject to heat stress. Such conditions can interfere with animal antioxidant defence systems, with tolerance to stresses ultimately causing illness and/or productivity loss (Chauhan *et al.*, 2014a; Ganaie *et al.*, 2013). Productivity loss in feedlot bulls is mainly due to reduced feed intake, the consumption of feeds low in nutrients and the loss of energy due to regulation of body temperature (thermoregulation).

The dynamics of the heat stress can vary with the location zone, but the resilience and adaptability to thermal stress of a feedlot bull may vary with individuals based on the physiological status, metabolic demand for production and the antioxidant potential of the body (Dikmen *et al.*, 2012). Based on the geographic location and temperature regions where the studies are undertaken in farm animals, the thermoneutral zone ranges have been categorised differently by various researchers; for example, in dairy cattle, 5 to 15°C as proposed by Hahn *et al.* (2003) and 5 to 25°C by Hahn *et al.* (2003). Therefore, the magnitude and type of changes in animal metabolism (as indicated by DNA damage, protein denaturation or lipid peroxidation) are expected to deviate for different temperature zone and different demographic regions (Ramnik *et al.*, 1999). Haematological parameters have been used as indicators of animal response to environmental conditions changes. The parameters can be influenced by heat stress, but cannot be used as parameters to evaluate the degree of heat stress in cattle (Dikmen *et al.*, 2012; 2018). The blood system is also particularly sensitive to changes in temperature and is an important indicator of physiological responses of livestock to stressors. Quantitative and morphological changes in blood cells are associated with heat stress, reflected in variations in haematocrit values, number of circulating white blood cells, content of erythrocytes and haemoglobin in the red blood cell (Roll *et al.*, 2010). It is believed that this series of events will release corticosterone and reduce lymphocytes, thereby contributing to reduced productivity. The different approaches used to manage heat stress in feedlot bulls include cooling, selection, shading, and nutrition. A genetic selection program is one of the ways to improve production traits (meat, milk or eggs); however, it may enhance the animal's susceptibility to high ambient temperature ( $T_a$ ) because of the strong relationship between production level and metabolic heat production (Segnalini *et al.*, 2011). When exposed to heat stress, cattle exhibit specific physiological reactions. The normal metabolic balance is threatened by any change in environmental conditions, as is the case during heat stress, and typically results in positive feedback once the temperature is above the upper critical temperature (UCT) (Hayes *et al.*, 2009; Atrian and

Aghdam, 2012). Some physiological characteristics have reportedly been linked to an animal's capacity to deal with heat stress (Garner *et al.*, 2016). For instance, when animals are exposed to a warm environment, their respiration rate, sweating rate, and rectal temperature all rise (Dikmen *et al.*, 2012; Perano *et al.*, 2015; Garner *et al.*, 2016). For logistical and financial reasons, it may be difficult to select thermotolerant animals using large-scale phenotypic recording systems that include these heat tolerance indicator features. (Hammami *et al.*, 2015; Carabano *et al.*, 2016). Cattle feedlot is one of the panaceas for meeting the growing demand in the human population due to increased protein requirements. The feedlot system and the cow-calf system are the two most famous intensive systems of livestock management in the tropics (Madziga *et al.*, 2013). The feedlot system, as opposed to the cow-calf system of cattle management, ensures optimum weight gain shortly before slaughter. The basic principle of the feedlot is to increase the amount of fat gained by each animal as quickly as possible; if animals are kept in confined quarters rather than being allowed to range freely over grassland, they will gain weight more quickly and efficiently, with the added benefit of economies of scale. Gabdo *et al.* (2020) advanced the feedlot system of management as one of many, adding to the value of beef requirements, beef cattle fattening serves as a source of employment, increased revenue to the participants, and provides additional foreign exchange to the nation in instances of export. In Nigeria, the main breeds of bulls used for fattening were Sokoto Gudali (72.60%) and Rahaji (20.00%) (Ja'afar-Furo *et al.*, 2021).

Therefore, the objective of this study is to determine the effect of location on the haematological traits of feedlot bulls fattened in the hot period of Kano, Nigeria.

## MATERIALS AND METHODS

### Study area

Kano State is characterised by a tropical semi-arid climate with marked seasonal variations in temperature, humidity, and rainfall. The ambient temperature in the state typically ranges from 18°C during the cool dry season to about 40–42°C during the peak hot period (March–May). During this hot season, daytime temperatures frequently exceed 35°C, predisposing livestock to heat stress. The relative humidity in Kano varies widely across seasons, ranging from approximately 15–25% during the dry season to 60–80% during the rainy season, with lower humidity levels prevailing during the hot period. The state receives an average annual rainfall of about 800–1000 mm, with most precipitation occurring between June and September. Rainfall distribution is often uneven, which is typical of the Sudan savannah ecological zone. These climatic conditions, particularly the high ambient temperatures and low relative humidity during the hot season, have significant

implications for livestock physiology, including haematological responses in feedlot bulls (Nigerian Meteorological Agency, 2022).

### Sources of experimental animals and management

Ninety (90) bulls comprising (30) each from the three purposively sampled locations (Bichi, Danbatta and Karaye feedlot fattening Areas) were used for the experiment. The experiment spanned three months (March – May, 2025).

### Collection of a blood sample

Blood samples were collected using the jugular vein puncture method. About 5 ml of the blood sample was collected using a 10 ml syringe and put into a bijou bottle containing Ethylene Diamine Tetra Acetate (EDTA), then placed in a cooler and carried to the laboratory for analysis. The blood samples for biochemical analyses, on the other hand, were collected into an EDTA-free bijou bottle and allowed to clot for serum separation. Serum was separated from the plasma immediately by centrifugation of the blood at 4000 rpm for 15 minutes and thereafter analysed for biochemical indices. The haematological analysis was carried out according to the procedure described by Ochei and Kolhatkar (2010).

### Hematological parameters

Blood samples were collected via jugular vein from 90 bulls (30 from each location) into bijou bottles containing EDTA and carried to the laboratory for blood and plasma analyses (Hematology, biochemical and antioxidant parameters) using the method described by AOAC (2010).

### Determination of packed cell volume

Packed cell volume was determined using the Win Trobes tube method as described by AOAC (2010). The Win Trobes tubes were filled with blood to the 100 mark and centrifuged for 15 minutes at 3500 rpm until packed, and after that, the blood was separated into three layers. The percentage of the height or column of blood occupied by packed red cells was read and recorded as the hematocrit.

### Hemoglobin estimation

Haemoglobin tube was filled up to the 20 ml mark with 0.1N/10 HCl and blood sucked using a pipette will be added till the specific mark on the pipette is reached. The tubes were allowed to stay for 45 minutes, and the mixture of the acid blood in the tubes was stirred constantly. Distilled

water was added until a match is obtained, read, and the haemoglobin concentration recorded in haemoglobin g/100 ml of blood (g/dl) as described by AOAC (2010).

### White blood cell count

The white blood cell (WBC) count was determined using the improved Neubauer chamber procedure. A pipette is filled with blood to the 0.5 ml mark, and WBC diluting fluid was added to 0.02 ml of blood with a haemoglobin pipette. The fluid and blood mixture were gently mixed to avoid bubbling. The cover slip was placed on the counting chamber in the right place. The fluid-blood mixture was shaken properly, and the mixture was transferred using a fine-bore paper for 2 minutes for counting. The WBC count was calculated using the formula:

$$\text{WBC} = \frac{\text{cells counted} \times \text{blood dilution} \times \text{chamber dept}}{\text{Area of chamber counted}} \quad \text{using the method described by AOAC (2010).}$$

### Red blood cell count determination

Red blood cell (RBC) count was determined by drawing blood to the 0.5 ml mark in the RBC pipette. A diluting fluid was drawn to the 10 ml mark and shaken for 3 minutes, and the chamber was charged. Red blood cells were counted using x 40 objectives in the smallest squares and computed using the formula of Ramnik (1999) as follows:

$$\text{RBC} = \frac{\text{No. of cells counted} \times \text{dilution factor} \times \text{dept dept}}{\text{Area counted}}$$

### Data analysis

Data collected from the experiment was analysed using the statistical software SAS, 9.0 (Statistical Analysis System, 2002) and means with significant differences were separated using Least Squares Difference (LSD). The statistical model for the experiment is given below.

$$Y_{ijk} = \mu + L_i + \epsilon_{ijk}$$

Where:  $\mu$  = universal mean,  $L_i$  =  $i^{\text{th}}$  fixed effect of location;  $\epsilon_{ijk}$  = experimental error.

For the genetic study, the statistical model is given below;

1. The population mean of the error term is zero  $E(\epsilon_i) = 0$ .
2. That the error term is not used to determine the observed values of the independent variables  $\text{Cov}(X_i, \epsilon_i) = 0$ .
3. Error term observations are drawn separately from one another and are not connected with one another  $\text{Cov}(\epsilon_i, \epsilon_j) = 0$ .
4. The data for the error term are drawn from the identical

probability distribution with constant variance  $\text{Var}(\varepsilon_i) = \sigma^2$ .

5. No independent variable has a perfect linear relationship with any other independent variable (perfect collinearity or multicollinearity).
6. The error term is normally distributed  $\varepsilon_i \sim (0, \sigma^2)$ .

## RESULTS AND DISCUSSION

### Effect of location on haematological properties of feedlot bulls fattened during the hot season in Kano

The effect of location on the haematological properties of feedlot bulls fattened during the hot season of Kano is shown in Table 1. The effect of location on haematological properties indicated that location significantly influenced ( $p < 0.05$ ) all the haematological properties studied. Karaye feedlot bulls were superior in all haematological properties; Haemoglobin (10.72 g/dl), White Blood Cell ( $12.32 \times 10^3/\text{mm}^3$ ), Red Blood Cell ( $7.87 \times 10^6/\text{mm}^3$ ) and packed cell volume (36.36%), while the least of those parameters were Danbatta and Bichi.

### Correlation between haematological properties in feedlot bulls fattened during the hot season of Kano

Table 2 shows the correlation among the haematological properties according to the location of the feedlot bulls studied. Correlation coefficient indicated that the parameters evaluated were significantly ( $p < 0.05$ - $0.01$ ;  $r = 0.64$  to  $0.36$ ) correlated with each other except for ( $p > 0.05$ ;  $r = 0.19$ ) for the relationship between Haemoglobin and Red Blood Cell.

## DISCUSSION

Livestock are exposed to a variety of stressors that affect growth performance, milk production, immune function, welfare, and health. Heat stress is one of the most important factors affecting growth performance and economic losses in livestock (St-Pierre *et al.*, 2003). Regarding this, average ambient temperatures have continuously increased during the summer season due to global warming, further aggravating damage to livestock (Hulme and Mahony, 2010). Heat Stress causes behavioural and metabolic changes in cattle that result in lower productivity and profitability (Hulme and Mahony, 2010).

Haemoglobin is the main component of erythrocytes and functions as the carrier of oxygen and carbon dioxide. The highest haemoglobin levels were found in Karaye, which was similar to the haemoglobin levels reported by St-Pierre *et al.* (2011) but still within the range of reports by Roland *et al.* (2014) and Ja'afar *et al.* (2021), which had haemoglobin levels of 12.53 g/dl and 10.62 g/dl, respectively,

and in general similar to the result reported by Roland *et al.* (2014). Normal haemoglobin levels reported by Abbaya (2013) for cows are 10–15 (g/dl), and by Hulme and Mahony (2010) are 8–15 (g/dl), which the present study falls within. However, haemoglobin levels found in Karaye may be due to distinguishing normal state from state of stress, which can be nutritional, environmental or physical (Roll *et al.*, 2004).

According to Hahn *et al.* (2003), heat stress can result in erythrocyte lysis due to increased free radicals in the erythrocyte membrane, which is rich in fat. This can lower haemoglobin levels or lead to a lack of nutrients for the synthesis of haemoglobin because the animal consumes less feed. Ja'afar *et al.* (2021) explain that haemoglobin correlates with the number of erythrocytes; when the number of erythrocytes decreases, haemoglobin levels also decrease. Haemoglobin synthesis occurs at the beginning of erythrocyte formation. When erythrocyte formation is disrupted, haemoglobin synthesis is also disrupted. Dikmen *et al.* (2012) reported that local Andamanese cattle during the dry season had significantly lower erythrocyte count and haemoglobin than cattle reared during the wet season.

White blood cells, also known as leukocytes, are blood cells that play a role in protecting the body from disease-causing infections. Feedlot bulls' fattened cattle had different leukocytic counts between the locations. The leukocytic count in this study is not much different from the results of Garner *et al.* (2016), who reported the leukocytic count of Bali cattle at  $12.26 \times 10^3/\text{mm}^3$ , although the contrast was higher than that of Ja'afar *et al.* (2021), who reported  $7.13 \times 10^3/\text{mm}^3$ . The normal values for lymphocytes, monocytes, eosinophils and basophils reported by Dikmen *et al.* (2012) for cow, 40 – 70, 1 – 6, 0 – 4, and 0 – 2(%), respectively. Garner *et al.* (2016) reported leukocyte counts of Tharparkar and Karan Fries cattle that showed no difference in cattle exposed to heat stress and oxygen levels compared to controls. In contrast, Abbaya (20) reported that local Andamanese cattle have lower leukocytic counts during the dry season than during the rainy season.

Red blood cells, also known as erythrocytes, are blood cells that function as an oxygen transportation hub from the lungs to body tissues and provide the oxygen needed by body cells (Carabano *et al.*, 2016). The erythrocytic counts in feedlot bulls of different locations fall within the normal range. Normal value ranges for RBC may vary slightly among different livestock. According to Gabdo *et al.* (2020), the normal range of values for RBC for cows is 5.0 – 10.0 ( $\times 10^6/\text{mm}^3$ ). Higher than normal numbers of RBC may be due to congenital heart disease, dehydration (such as from severe diarrhoea), low blood oxygen levels (hypoxia), polycythemia vera, among others. When an animal moves to a higher altitude, the RBC count increases for several weeks (Gabdo *et al.*, 2020). Lower than normal numbers of RBCs may be due to anaemia, bone marrow failure (for example, from radiation, toxins or tumor), erythropoietin deficiency (secondary to kidney

**Table 1.** Effect of location on hematological properties of feedlot bulls fattened during the hot season in Kano.

| Parameters   | Bichi              | Karaye             | Danbatta           | SEM  |
|--|--------------------|--------------------|--------------------|------|
| Hemoglobin g/dl                                      | 10.36 <sup>b</sup> | 10.72 <sup>a</sup> | 10.27 <sup>b</sup> | 0.11 |
| White Blood Cell (x 10 <sup>3</sup> /mm)             | 8.98 <sup>b</sup>  | 12.32 <sup>a</sup> | 9.09 <sup>b</sup>  | 0.50 |
| Red Blood Cell (x 10 <sup>6</sup> /mm <sup>3</sup> ) | 6.91 <sup>b</sup>  | 7.87 <sup>a</sup>  | 7.15 <sup>b</sup>  | 0.27 |
| Packed Cell Volume %                                 | 32.76 <sup>b</sup> | 36.36 <sup>a</sup> | 33.19 <sup>b</sup> | 1.48 |

<sup>abc</sup> mean with different superscripts within the rows are significantly different at 5%.

**Table 2.** Correlation between haematological properties in feedlot bull fattened during the hot season in Kano.

|     | Hb     | WBC   | RBC   | PCV |
|-----|--------|-------|-------|-----|
| Hb  | 1      |       |       |     |
| WBC | 0.64** | 1     |       |     |
| RBC | 0.19   | 0.52* | 1     |     |
| PCV | 0.43*  | 0.41* | 0.36* | 1   |

\*=significant at 5%; \*\*=significant at 1%; \*\*\*= significant at 0.1%.

disease), hemolysis (RBC destruction due to blood vessel injury or other causes) hemorrhage (bleeding), malnutrition, nutritional deficiencies or iron, copper, folate, vitamin B12, vitamin B6, over dehydration, pregnancy among others. Some drugs also decrease the RBC count (AOAC 2010). Specific causes of erythrocyte abnormalities which might manifest in chronic blood loss include bloody diarrhoea, bleeding, and blood-sucking parasites, among others (Johnston and Morris, 1996; Chineke *et al.*, 2006).

The erythrocytic counts in feedlot bulls were not much different from the research of Chineke *et al.* (2006), which was  $5.49 \pm 0.88 \times 10^6 / \text{mm}^3$  (male);  $4.89 \pm 0.53 \times 10^6 / \text{mm}^3$  (female), St-Pierre *et al.* (2011), which was  $5.2 \times 10^6 / \text{mm}^3$  and Ja'afar *et al.* (2021), which was  $5.18 \pm 0.41 \times 10^6 / \text{mm}^3$ . The decrease in the erythrocyte count in polled Bali cattle indicates that sun exposure and exercise during the day can interfere with erythrocytes, as explained by Abbaya (2023) that heat stress can affect the erythropoietin hormone in the spinal cord, so that the production and development of erythrocytes are inhibited. Johnston and Morris (1996) reported that daytime sun exposure and exercise had a negative impact on the number of erythrocytes in Caracu beef cattle. Another report by Chineke *et al.* (2006) reported lower erythrocytic counts in local Andamanese cattle during the dry season than during the wet season. Piemontese cattle reared in a hotter environment showed lower erythrocyte counts (Atrian and Aghdan, 2012).

Hematocrit, also known as packed cell volume (PCV), is a term used to describe the proportion of erythrocytes in 100 mL of blood (Atrian and Aghdan 2012). The hematocrit value of feedlot bulls is not significantly different from that reported by Ja'afar *et al.* (2021), but the hematocrit values of horned and polled Bali cattle were still higher than the reports of St-Pierre *et al.* (2003) but still in the normal

category. According to AOAC (2010) posited the range of 30 – 45% (24 – 34 x 10<sup>-2</sup>/l) as reference range for PCV for cows. An increase or decrease in hematocrit value is related to erythrocyte counts, which affects the viscosity of the blood, with high or low values having an impact on increasing or slowing blood flow and heart (Dikmen *et al.*, 2012). The implication of high haematological parameters in Karaye cattle or low values in Danbatta and Bichi may be due to management or environmental factors.

## Conclusion

In conclusion, feedlot bulls raised in Karaye exhibited superior haematological performance, recording the highest values for haemoglobin (10.72 g/dl), white blood cell count ( $12.32 \times 10^3 / \text{mm}^3$ ), red blood cell count ( $7.87 \times 10^6 / \text{mm}^3$ ), and packed cell volume (36.36%), whereas bulls from Danbatta showed comparatively poorer performance in these parameters. Furthermore, correlation analysis revealed significant positive relationships ( $p < 0.05$ – $0.01$ ;  $r = 0.36$ – $0.64$ ) among most of the haematological traits evaluated, indicating their interdependence, except for the relationship between haemoglobin and red blood cell count, which was not significant ( $p > 0.05$ ;  $r = 0.19$ ).

## CONFLICT OF INTEREST

The author declared that they have no conflict of Interest.

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