# Serum biochemistry and heamatology of gravid and non-gravid West African dwarf goats raised in the transitional forest zone

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**Abstract**

The hematology and serum biochemical parameters of seventeen (17) healthy West African Dwarf goats (WAD) consisting of ten (10) gravid and 13 non-gravid does were assessed. The animals weighed between 15 to 25kg with ages ranging from 18 to 30 months and were managed under a semi-intensive system. The whole uncoagulated blood and serum were sampled from each of the does. Only the Red blood cell (RBC) and white blood cell (WBC) counts among the hematological parameters showed a significant ($p<0.05$) difference both of which are higher in the pregnant does ($13.93 \times 10^{12}$/L; $25.27 \times 10^{9}$/L) than in the non-pregnant ($9.06 \times 10^{12}$/L; $16.51 \times 10^{9}$/L. The urea increased (4.64mg/dL± 0.19 to 4.77mg/dL ± 0.08) significantly ($p<0.05$) while the calcium decreased (2.56 mmol/dL ±0.07 to 2.49 mmol/dL0.03) significantly ($p<0.05$) in the pregnant does. No observable significant differences ($p>0.05$) were obtained among the other determined biochemical parameters, namely sodium (Na), potassium (K), Phosphorus (P), bicarbonate ($HNO_3$); Total protein (Tp), Glucose (Glu), Albumin (Alb), Aspartate Transaminase (AST), Alanine Transaminase (ALT) and Alkaline Phosphate (ALP). These results conclude that hematological and mineral imbalances are unlikely to occur in normal healthy pregnant WAD goats when properly managed while the difference in a few parameters recorded in the gravid and non-gravid suggests the increased activities and nutritional requirement and not the ecological influences.

Keywords: Hematology; Serum biochemistry; West African Dwarf goats; Gravid and non-gravid

## 1. Introduction

Various diseases and the nutritional status of animals have been widely diagnosed and determined by hematological tests. A serological and hematological assessment provides informative objectives on the health status to detect health disorders or for monitoring stress factors prior clinical stage (Etim et al., 2014). According to Donia et al., (2018), the information obtained from the blood parameters would substantiate the physical examination as well as medical judgment. Fazio, (2019), reported serum biochemistry and hematological analyses as the important and reliable means for monitoring the health status of an animal and may also indicate the degree of damage to the host tissue and severity of infection.

The significance of determining biochemical and hematological indices of domestic animals has been well documented (Zhu et al., 2010). There is a great variation in the biochemical and hematological parameters as observed between breeds of goats and this may make it difficult to formulate a universal metabolic profile test for goats (Muayad et al., 2018; Sarangi, 2018). Many investigations have been carried out on some hematological and blood biochemical parameters during pregnancy and the early postpartum period. The hematological attributes during pregnancy assumed new importance when it was realized that pregnancy is a form of physiological stress and hormones appear to be involved in the process of pregnancy and parturition (Schuler et al., 2018; Shah et al., 2019; Valsamakis et al., 2019). Different studies reported the effects of pregnancy and the parturition of WAD goats. Among the few studies that are currently available are those of Makinde et al., (1983) and Igado et al., (2004), as well as the effect of age, and sex on the hemogram (Daramola et al., 2005).

Despite this, a careful literature search did not indicate any documentation of the hemogram profile of West African Dwarf (WAD) goats that were raised in the transitional forest zone. Therefore, this study attempted to come up with normal hematological and biochemical reference values of gravid and non-gravid WAD goats raised in the transitional forest zone of Nigeria under a semi-intensive system as influenced by pregnancy.

## 2. Materials and Methods

### 2.1. Experimental animals and management

Twenty-three sexually mature WAD Does and two WAD bucks aged between 1½ to 2 ½ years (based on dentition, Dyce et.al., 2000) with weights ranging between 15 to 25kg within the small ruminant unit of the Teaching and Research Farm of Landmark University, Omu-Aran, Nigeria was selected for this study. The animals were allowed to stabilize for two weeks during which they were prophylactically treated with antibiotics (Terramycin® L.A.) given intramuscularly at a dose rate of 20 mg/kg body weight and Ivermectin (Bimectin®) at 200 µg/kg body weight given sub-cutaneous against internal and external parasites.

The animals were allowed to graze pasture consisting of Brachiara decumbens, Panicum maximum (Guinea grass), and (Pennisetum purpureum) elephant grass, and they were equally allowed free access to dry cassava peels (Mannihot esculata) supplemented with concentrate made from beans husk, groundnut cake, maize bran, bone meal, and wheat offal and water were offered freely. All the animals were maintained in a large, roofed, enclosed, clean, and well-ventilated pen in the Teaching and Research Farm, Department of Animal Science, College of Agriculture, Landmark University, Omu-Aran, Nigeria.

### 2.2. Experimental site

Landmark University is located along longitude $5^0$ 6' 0"! E and latitude $8^0$ 8' 0"! N. The site is about 88 km south of Ilorin, Kwara State, Nigeria with an annual average rainfall of 1400 mm, most of which falls between April and October, and the dry season from November to March.

### 2.3. Experimental procedure

Twenty-three (23) of the West African Dwarf goat does were synchronized with Estrumate® (Cloprostenol, a synthetic analogue of PGF2α given at 250µg/mL) and naturally served with two healthy and sexually active West African Dwarf buck. Non-return to service was considered as an indication of conception and they were tested to confirm the pregnancy status. The ten (10) goats that became pregnant were grouped as pregnant, while seven animals that remained as cycling non-pregnant were equally grouped.

### 2.4. Ethical approval

The ethics for this research was approved by the Landmark University Ethics Research Ethics Review Committee.

### 2.5. Blood collection

The blood sample (10ml) was drawn from the jugular vein of each of the seventeen WAD does, using a 10 ml plastic disposable syringe. 10ml of blood obtained from each animal were divided into two parts (5ml each) and were kept in plain universal bottles and clean dry heparinized (EDTA) bottles for biochemical and hematological analysis respectively and were evaluated on the same day of collection (Schalm, 1975) at Department of Chemical Pathology, Faculty of Veterinary Medicine, University of Ilorin, Kwara State, Nigeria**.**

During the collection of blood samples, the animals were kept, quiet to avoid excitement that may cause a significant change in the composition of the blood (Kelly, 1984) and different needles and syringes were used for individual animals. Prior to collection, the site from where the blood was drawn was cleaned with methylated spirit. Blood samples were collected from randomly selected seven (7) dry does and ten (10) pregnant does at the last trimester of the gestation period respectively.

### 2.6 Hematology and Serum evaluation

Heparinized blood samples were analyzed for erythrocyte count (RBC), leukocyte count (WBC), and their cell differentials (Monocytes, Eosinophiles, Basophils, Neutrophils, and Lymphocytes), Hemoglobin (HB) concentration and Packed Cell Volume (PCV) after appropriate dilution using Automatic Haematocytometer. Mean Corpuscular Volume (MCV), Mean Corpuscular Heamoglobin (MCH), and Mean Corpuscular Heamoglobin Concentration (MCHC) were calculated from Red blood cell (RBC), HB and PCV values respectively, according to Dacie and Lewis (2001).

$$MCV = PCV/RBC \times 10$$
$$MCH/RBC = Hb \times 10$$
$$MCHC = Hb/PCV \times 100$$

The sera were separated by centrifuging at 3500Rev/minute for 10minutes and stored at -200C until required for analysis (Mitruka and Rawnsley, 1977) procedure. Spectrophotometer, Merck Mega, Version 0.6, 1995 (E. Merck, Darmstadt, Germany) was used for determination of metabolic indicators of Glucose, Total Protein, Albumin, and Urea; electrolytes: sodium, Calcium, Potassium, Phosphate and Carbonates, and serum enzyme Aspartate Transaminase (AST), Alanine Transaminase (ALT) and Alkaline Phosphate (ALP) activities were also measured calorimetrically (Schrockert and Basseler, 1971).

### 2.7 Statistical analysis

Statistical significance of differences between pregnant and non-pregnant groups was analyzed by using the Student t-test procedure embedded in SPSS version 16 Tests were carried out at a 95% level of confidence ($P<0.05$) and the data were expressed as mean standard error (M ± SEM).

## 3. Results

The mean values of hematological parameter studied were comparable ($p>0.05$) in pregnant and non-pregnant WAD goats but the values of RBC and WBC were significant ($p<0.05$) high in the pregnant WAD goats compared to non-pregnant WAD goats (Table 1). From Table 2, the live enzyme assay revealed that ALP, ALT, and AST were not significantly ($p>0.05$) different among the pregnant and non-pregnant WAD goats. Likewise, serum total protein (TP), albumin (Alb) and glucose (Glu) levels were comparable ($p>0.05$) in the pregnant and non-pregnant WAD goats but the urea level in the pregnant WAD goats is significantly ($p<0.05$) high compared to those of non-pregnant WAD goats.

The Glu level in the pregnant WAD goats was observed to be lower than that of the non-pregnant goats, however, the difference was not significant ($p>0.05$). The electrolyte result indicated that the serum Na, K, P, and $HCO_3$ values were comparable ($p>0.05$) in both pregnant and non-pregnant WAD goats studied, however, the calcium (Ca) level was noted to be significant ($p<0.05$) low in the pregnant WAD goats compared to the non-pregnant WAD goats.

Table 1. Haematological parameters (Mean ± S.E) of non-pregnant and pregnant WAD Goats

| PARAMETERS | ANIMALS STATUS | N | MEAN | S.E.M | RANGE | NORMAL VALUES |
|---|---|---|---|---|---|---|
| RBC ($\times 10^{12}$/L) | Non-pregnant | 10 | $9.06^{a}$ | ± 0.37 | 8.20 – 9.70 | 8.00 – 18.00 |
| | pregnant | 7 | $13.92^{b}$ | ± 0.97 | 12.40 – 14.50 | |
| PCV (%) | Non-pregnant | 10 | 21.80 | ± 1.56 | 11.00 - 26.00 | 22.00 – 38.00 |
| | pregnant | 7 | 27.00 | ± 1.74 | 21.00 - 34.00 | |
| HB (g/dL) | Non-pregnant | 10 | 8.54 | ± 0.54 | 4.40 - 10.70 | 8.00 – 12.00 |
| | pregnant | 7 | 9.68 | ± 0.64 | 7.40 - 12.30 | |
| MCV (FI) | Non-pregnant | 10 | 27.12 | ± 2.49 | 16.13 - 34.37 | 5.20 – 8.00 |
| | pregnant | 7 | 19.69 | ± 1.37 | 15.67 - 25.00 | |
| MCH (Pg) | Non-pregnant | 10 | 9.80 | ± 0.88 | 7.50 - 16.17 | |
| | pregnant | 7 | 7.34 | ± 0.39 | 5.52 - 8.56 | |
| MCHC (g/dL) | Non-pregnant | 10 | 37.25 | ± 1.99 | 32.50 - 55.33 | 30.00 – 36.00 |
| | pregnant | 7 | 37.82 | ± 1.69 | 32.26 - 45.56 | |
| WBC ($\times 10^{9}$/L) | Non-pregnant | 10 | 37.25 | ± 1.99 | 15.50 - 18.00 | 4.00 – 13.00 |
| | pregnant | 7 | 37.82 | ± 1.69 | 22.10 - 27.60 | |
| NEU (%) | Non-pregnant | 10 | 31.50 | ± 5.45 | 14.00 - 72.00 | 30.00 – 48.00 |
| | pregnant | 7 | 42.43 | ± 8.65 | 12.00 - 75.00 | |
| EOS (%) | Non-pregnant | 10 | 0.70 | ± 0.36 | 0.00 - 3.00 | 3.00 – 8.00 |
| | pregnant | 7 | 0.86 | ± 0.55 | 0.00 - 4.00 | |
| BASO (%) | Non-pregnant | 10 | 0.00 | ± 0.00 | 0.00 - 0.00 | 0.00 – 2.00 |
| | pregnant | 7 | 0.28 | ± 0.28 | 0.00 - 2.00 | |
| LYMPH (%) | Non-pregnant | 10 | 71.60 | ± 6.44 | 28.00 - 100.00 | 50.00 – 70.00 |
| | pregnant | 7 | 56.42 | ± 8.96 | 24.00 - 88.00 | |

Values with different superscripts a, b: are statistically different ($P<0.05$); Normal values; according to Fraser et al., (1991) and veterinary drugs Handbook. D.C Plumb. Iowa State University Press 1999; RBC= Red Blood Cells, WBC= White Blood Cells, Hb= Haemoglobin, PCV= Packed Cell Volume, MCV=Mean Corpuscular Volume, MCH= Mean Corpuscular Haemoglobin, and MCHC= Mean Corpuscular Haemoglobin Concentration.

Table 2. The Serum Biochemistry (Mean ± S.E) of Non-Pregnant and Pregnant WAD Goats.

| PARAMETERS | ANIMALS STATUS | N | MEANS | S.E.M | NORMAL VALUES |
|---|---|---|---|---|---|
| Serum Enzymes | | | | | |
| ALT (IU/L) | Non-pregnant | 10 | 17.40 | ± 0.64 | 15.30 – 52.30 |
| | pregnant | 7 | 16.85 | ± 0.40 | |
| AST (IU/L) | Non-pregnant | 10 | 24.00 | ± 0.63 | 66.00 – 230.00 |
| | pregnant | 7 | 25.00 | ± 1.02 | |
| ALP (IU/L) | Non-pregnant | 10 | 43.00 | ± 1.93 | |
| | pregnant | 7 | 44.14 | ± 1.10 | |
| Metabolic Indicators | | | | | |
| PROTEIN (mg/dL) | Non-pregnant | 10 | 60.40 | ± 1.19 | 64.00 – 78.00 |
| | pregnant | 7 | 57.57 | ± 1.48 | |
| ALBUMIN (mg/dL) | Non-pregnant | 10 | 32.00 | ± 0.39 | 23.50 - 35.70 |
| | pregnant | 7 | 31.71 | ± 0.47 | |
| UREA (mmol/dL) | Non-pregnant | 10 | $4.64^{a}$ | ± 0.19 | 1.26 – 25.80 |
| | pregnant | 7 | $4.77^{b}$ | ± 0.08 | |
| GLUCOSE (mg/dL) | Non-pregnant | 10 | 44.01 | ± 0.86 | 48.2 – 76.40 |
| | pregnant | 7 | 33.99 | ± 0.51 | |
| Serum Electrolytes | | | | | |
| $Na^{+}$ (mmol/L) | Non-pregnant | 10 | 135.20 | ± 0.51 | 133.50 – 154.00 |
| | pregnant | 7 | 134.71 | ± 0.61 | |
| $K^{+}$ (mmol/L) | Non-pregnant | 10 | 3.83 | ± 0.09 | 4.60 – 9.80 |
| | pregnant | 7 | 3.92 | ± 0.07 | |
| $Ca^{2+}$ (mmol/L) | Non-pregnant | 10 | $2.56^{b}$ | ± 0.07 | 1.15 – 10.60 |
| | pregnant | 7 | $2.49^{a}$ | ± 0.03 | |
| Phosphate (mmol/L) | Non-pregnant | 10 | 1.38 | ± 0.04 | 3.20 – 9.80 |
| | pregnant | 7 | 1.38 | ± 0.04 | |
| $HCO_3^{-}$ (mmol/L) | Non-pregnant | 10 | 21.90 | ± 0.41 | |
| | pregnant | 7 | 22.43 | ± 0.92 | |

Values with different superscripts a, b: are statistically different ($P<0.05$); Normal values; according to Fraser et al., (1991) and veterinary drugs Handbook. D.C Plumb. Iowa State University Press 1999; AST= Aspartate Transaminase, ALT= Alanine Transaminase, ALP= Alkaline Phosphate.

Table 3a. Comparative Biochemical Values of Nigerian Goat Breeds

| PARAMETERS | ANIMALS STATUS | PRESENT STUDY | SAHEL GOAT (Waziri et al 2010) | WAD GOATS (Daramola et al 2005) | RED SOKOTO GOAT (Tambuwal et al 2002) |
|---|---|---|---|---|---|
| ALT (IU/L) | Non-pregnant | 17.40 ± 0.64 | 28.4 ± 1.59 | 8.90 ± 0.90 | NA |
| | pregnant | 16.85 ± 0.40 | 28.70 ± 1.44 | | |
| AST (IU/L) | Non-pregnant | 24.00 ± 0.63 | 52.88 ± 2.73 | 20.90 ± 1.20 | NA |
| | pregnant | 25.00 ± 1.02 | 52.23 ± 1.11 | | |
| ALP (IU/L) | Non-pregnant | 43.00 ± 1.93 | 46.72 ± 0.76 | 10.70 ± 1.20 | 3.1 ± 2.8 |
| | pregnant | 44.14 ± 1.10 | 47.04 ± 0.20 | | |
| PROTEIN (mg/dL) | Non-pregnant | 60.40 ± 1.19 | NA | 7.10 ± 0.10 | 4.4 ± 1.5 |
| | pregnant | 57.57 ± 1.48 | NA | | |
| ALBUMIN (mg/dL) | Non-pregnant | 32.00 ± 0.39 | NA | 3.40 ± 0.70 | 2.5 ± 1.8 |
| | pregnant | 31.71 ± 0.47 | NA | | |
| UREA (mmol/L) | Non-pregnant | 4.64 ± 0.19 | 16.16 ± 0.86 | 2.70 ± 0.30 | 4.7 ± 2.1 |
| | pregnant | 4.77 ± 0.08 | 16.11 ± 0.80 | | |
| GLUCOSE (mg/dL) | Non-pregnant | 44.01 ± 0.86 | 68.33 ± 1.21 | NA | NA |
| | pregnant | 33.99 ± 0.51 | 45.74 ± 1.58 | | |

| | | | | | |
|---|---|---|---|---|---|
| $Na^+$ (mmol/L) | Non-pregnant<br>pregnant | 135.20 ± 0.51<br>134.71 ± 0.61 | 143.6 ± 1.66<br>140.97 ± 1.02 | 135.10 ± 1.70 | 138.00 ± 0.60 |
| $K^+$ (mmol/L) | Non-pregnant<br>pregnant | 3.83 ± 0.09<br>3.92 ± 0.07 | 4.56 ± 0.12<br>5.40 ± 0.76 | 4.80 ± 0.10 | 5.30 ± 1.80 |
| $Ca^{2+}$ (mmol/L) | Non-pregnant<br>pregnant | 2.56 ± 0.07<br>2.49 ± 0.03 | 8.94 ± 0.27<br>11.86 ± 0.55 | 1.60 ± 0.10 | NA |
| Phosphate (mmol/L) | Non-pregnant<br>pregnant | 1.38 ± 0.04<br>1.38 ± 0.04 | 6.3 ± 0.21<br>6.43 ± 0.87 | 2.4 ± 0.20 | NA |
| $HCO_3^-$ (mmol/L) | Non-pregnant<br>pregnant | 21.90 ± 0.41<br>22.43 ± 0.92 | NA | NA | NA |

NA= Not Available, AST= Aspartate Transaminase, ALT= Alanine Transaminase, ALP= Alkaline Phosphate.

Table 3b. Comparative Haematological Values of Nigerian Goat Breeds

| PARAMETERS | ANIMAL STATUS | PRESENT STUDY (WAD goat) | SAHEL GOAT (Waziri et al 2010) | WAD GOATS (Daramola et al 2005) | RED SOKOTO GOAT (Tambuwal et al 2002) |
|---|---|---|---|---|---|
| RBC ($\times 10^{12}$/L) | Non-pregnant<br>pregnant | 9.06 ± 0.37<br>13.92 ± 0.97 | 9.10 ± 0.40<br>12.54 ± 0.64 | 11.5 ± 0.40 | 10.90 ± 2.10 |
| PCV (%) | Non-pregnant<br>pregnant | 21.80 ± 1.56<br>27.00 ± 1.74 | 27.82 ± 1.32<br>28.95 ± 0.76 | 29.40 ± 0.90 | 25.70 ± 3.10 |
| Hb (g/dL) | Non-pregnant<br>pregnant | 8.54 ± 0.54<br>9.68 ± 0.64 | 9.86 ± 0.40<br>9.35 ± 0.26 | 9.80 ± 0.30 | 11.40 ± 1.60 |
| MCV (FI) | Non-pregnant<br>pregnant | 27.12 ± 2.49<br>20.57 ± 1.37 | 25.89 ± 1.50<br>27.94 ± 0.88 | NA | NA |
| MCH (Pg.) | Non-pregnant<br>pregnant | 11.41 ± 0.88<br>7.34 ± 0.39 | 9.51 ± 0.85<br>8.31 ± 0.29 | NA | NA |
| MCHC (g/dL) | Non-pregnant<br>pregnant | 39.85 ± 1.99<br>36.07 ± 1.69 | 33.47 ± 0.50<br>33.87 ± 0.55 | 33.10 ± 0.10 | 44.70 ± 8.20 |
| WBC ($\times 10^9$/L) | Non-pregnant<br>pregnant | 16.51 ± 0.87<br>25.27 ± 1.97 | 9.42 ± 1.25<br>13.08 ± 0.65 | 13.50 ± 0.80 | 10.60 ± 2.80 |
| NEU (%) | Non-pregnant<br>pregnant | 31.50 ± 5.45<br>42.43 ± 8.65 | 3.76 ± 0.82<br>5.66 ± 1.24 | 33.5 ± 1.70 | 36.40 ± 2.50 |
| EOS (%) | Non-pregnant<br>pregnant | 0.70 ± 0.36<br>0.86 ± 0.55 | 1.20 ± 1.13<br>1.67 ± 0.75 | 65.80 ± 1.10 | 3.90 ± 1.50 |
| BASO (%) | Non-pregnant<br>pregnant | 0.00 ± 0.00<br>0.28 ± 0.28 | 0.00 ± 0.00<br>0.00 ± 0.00 | 0.80 ± 0.20 | 7.40 ± 1.70 |
| LYMPH (%) | Non-pregnant<br>pregnant | 71.60 ± 6.44<br>56.42 ± 8.96 | 3.58 ± 1.34<br>4.88 ± 1.31 | 65.80 ± 1.10 | 51.60 ± 3.00 |

NA= Not Available, RBC= Red Blood Cells, WBC= White Blood Cells, Hb= Haemoglobin, PCV= Packed Cell Volume, MCV=Mean Corpuscular Volume, MCH= Mean Corpuscular Haemoglobin, and MCHC= Mean Corpuscular Haemoglobin Concentration.

## 4. Discussion

The PVC, RBC, and Hb values obtained in this study are comparable to those obtained by Makinde et al., (1983), Daramola et al., (2005), and Igado et al., (2011) in West African Dwarf goats as well as those reported in other goat breeds (Tambuwai, et al., 2000; Waziri et al., 2010) and fall within the normal reference value according to Fraser et al., (1991). The observed increased RBC mean values of pregnant WAD at the advanced stage of gestation are consistent with the previous reports of Makinde et al., (1983); Igado et al., (2011) who reported a significant increase in RBC values of pregnant WAD goats compared to the non-pregnant WAD goat. The result also corresponds with the findings of Sandabe and Yahi, (2000) and Waziri et al., (2010) who reported a significant difference in the RBC values obtained for the pregnant and non-pregnant Sahel goats. However, Waziri et al., (2010) and Igado et al., (2011) considered different stages of gestation. This finding is further supported by the report of Durotope and Oyewale (2000) who concluded an increase in heamatological parameters in pregnant and lactating WAD ewes relative to non-pregnant or non-lactating ewes.

The observed increase may be due to increased erythropoiesis (the activities of erythropoietin hormone being produced by the kidneys for the production of RBC) as reported by Olver, (2022). Increased erythropoiesis has been reported in pregnant goats (Makinde et al., 1983) and sheep (Durotope and Oyewale, 2000). The similarity values of MCH, MCHC, and MCV amongst pregnant and non-pregnant goats studied agreed with reports of Waziri et al., (2010) in the Sahel goats but do not conform with reports of Makinde et al., (1983) and Igado et al., (2011), who reported an increase in the MCV of WAD goats in late pregnancy. However, the discrepancies may be attributed to differences in ages, sample size, project design, and environmental changes as reported by Kamalu et al., (1988).

The increased leukocyte is in line with the reports of Sandabe and Yahi (2000), Waziri et al., (2010) in the Sahel does and Igado et al., (2011) in WAD goats, all of who reported a significant increase in the total leukocyte counts at the last trimester of gestation. The rise might be linked to an increase in the activity of the bone marrow as well as the physiological stress that is brought on by pregnancy. According to Dellmann and Brown, (1987), Kosaki et al., (1988), and Paulsen et al., (2005), stress can stimulate the release of certain factors known as Leucocytosis Inducing Factors (LIF) and Colony Stimulating Factors (CSF).

These factors are known to increase haemopoietic activities as well as the number of blood cells that are circulating in the body. As it was revealed from this study, the majority of leucocytes present are lymphocytes and neutrophils with the lymphocytes having a higher percentage than neutrophils. The observations could be supported by reports by Tambuwal et al., (2002) in Red Sokoto goats, Daramola et al., (2005) in WAD goats, and Waziri et al., (2010) in Sahel goats, all of who observed dominance of lymphocytes and neutrophils over other types of leukocytes.

The higher lymphocyte counts observed in the animals studied are also favored by the report of Egbe-Nwiyi et al., (2000) observations on normal goat blood. The result might be attributed to stress and immune response to the environment as reported by Bagath et al., (2019) which harbors various detectable and undetectable parasitic and bacterial organisms. The ALP values observed in this study were considerably higher than those reported by Daramola et al., (2005) but close to the values reported by Waziri et al., (2010) in the Sahel does while the ALT and AST values were within the range reported in Nigeria WAD goats by Daramola et al., (2005).

The similarity values observed in the ALP, ALT, and AST among the pregnant and non-pregnant goats indicated that liver enzymes were not clinically affected during pregnancy. The observed increased urea at advanced pregnancy of the WAD goats is in line with the reports of Sobiech et al., (2008) and Khatun et al., (2011) who reported a significant serum urea increase in advanced pregnancy of ewes. The findings of Saeed et al., (2009) on pregnant camels also supports the result of the present study.

The increased values of urea during late gestation could be attributed to the high thyroid activity in pregnant females which steers increased protein catabolism (Soares et al., 2018). The serum sodium (Na), potassium (K), phosphorus (P), bicarbonate ($HCO_3$), and calcium (Ca) values obtained were within the range of those reported by Daramola et al., (2005) and it is comparable with the normal values reported for goats by Fraser et al., (1991) and Kadzere, (1996).

However, all the electrolytes except Ca indicated no significant difference among the pregnant and non-pregnant does. The significant decrease in serum Ca levels in pregnant does relative to the non-pregnant agree with the works of (Liesegang et al., 2007) who stated that Ca levels decreased during gestation and lactation. The cause of the decreases may be linked to the flux of Ca to the fetus or into the milk resulting in a serum calcium decrease in goats and sheep during parturition and the enhanced bone remodeling in early lactation (Liesegang et al., 2007).

The low serum levels of glucose in pregnant WAD does compare to non-pregnant could be attributed to excessive utilization of energy reserve by pregnant does. This is in agreement with the works of Sandabe et al., (2004) who recorded that glucose concentration was lower in pregnant goats. Waziri et al., (2010) also reported decreased levels of glucose as the pregnancy advanced and that the decrease became significant from the twelfth

week.

## Conclusion

The results of this study showed that haematological and serological imbalances are uncommon to arise in WAD goats during pregnancy. This conclusion suggests that WAD goats have a stronger capacity to deal with the physiological stress that is associated with pregnancy. However, this study has the potential to serve as baseline data for comparison in situations of dietary inadequacies, disease conditions, and investigations of pregnancy status. This will be of tremendous benefit to animal scientists and veterinarians.

## Conflict of interest

The authors declare no conflict of interest

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