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Blood biochemical profile and level of cortisol among lame indigenous breeds of goats in Nigeria

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Abstract
The investigation was undertaken to study some biochemical changes and cortisol levels in lameness among indigenous breeds of goats in Nigeria. Serum samples of 72 lame goats randomly selected were sampled from some villages in Ibadan, Oyo state, Nigeria. Analysis of the serum samples for biochemical parameters was estimated by commercially available standardized diagnostic kits. Glucose was analyzed using the spectrophotometry procedure. Cortisol level was estimated by Immuno chemiluminescence microparticle assay method using diagnostic products of IMMULITE diagnostic products corporation, Los Angles. Cross-bred goats possessed better values for most of the biochemical analytes, a significant difference was seen in ALT with a higher value of 14.5±3.54 in Cross-bred goats at ($P<0.05$). We found no significant difference in the male and female analytes, with the exception of AST, ALT, and GGT which have significant differences of higher values at ($P<0.05$) of 15.25±2.77, 12.06±2.02 and 8.69±2.21 respectively. There was a significant difference in the value of low-density lipoprotein with a higher value of 119.6±11.34 in the 2-2$^{1/}$2year age category. Severely affected lame goats had significant differences at ($P<0.05$) with higher values of some analytes as follows; K 3.4±0.37, Cl 100±3.54, HCO3 24.6±1.14, BUN 19.8±2.28, Creatinine 0.52±0.08, TP 6.48±0.15, Albumin 2.82±0.24. Cross-bred goats had the best value of 12.00±1.41 for cortisol. Male goats had the best cortisol value of 10.47±1.46. This study reveals the ruggedness and resilient ability of cross-bred goats which show that developing Nigerian indigenous breeds may be a viable option in the prevention and management of lameness in Nigeria.

Keywords: Biochemical, Cortisol, Lameness, goats, Nigeria.

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Introduction

The livestock welfare situation in Nigeria remains very low due to the country's animal husbandry system in operation, as the business of livestock keeping is still generally in the hands of subsistence smallholder farmers. Also, the general practice of an extensive management system does not help in the welfare of this livestock. It is becoming mandatory and pertinent for stakeholders involved in the livestock sector to be more concerned about the welfare and stress assessment of their livestock, especially during common chronic diseases of livestock. One of these conditions commonly associated with pain and stress is lameness. Lameness is an important condition hampering productivity and a major welfare issue in livestock production worldwide and Nigeria is not an exception. Previous reports indicated that lameness takes the third position after infertility and mastitis in causing losses to dairy farmers (Weaver et al., 2005).

Lameness leads to reduced performance due to decreased food intake, diminished food and reproductive efficiency, loss of body weight, and lowered milk production and libido (Vermunt and Greenough, 1994; Harris et al., 1988). Most stockmen tend to overlook lameness, especially benign lameness that showed mild and irregular signs that were not always seen as important and often left untreated (Logue et al., 1998). This often leads to a reduction in farmers' income and propagates poverty among smallholder livestock farmers in particular.

It is a fundamental fact that some parameters in the blood can be good indicators in evaluating health status, physiological pathological deviations, prognosis, and diagnosis of various types of diseases in animals (Alade et al., 2005). Hagawane et al., (2009) reported the use of biochemical parameters such as total protein, albumin globulin ratio, glucose, urea, and cholesterol as pointers to the diagnosis of several pathophysiological and metabolic problems in buffaloes. Olaogun and Adedeji, (2018) also emphasized the importance of the assessment of biochemical analytes as prognostic and diagnostic tools for animal diseases. Quantification of levels of cortisol has been used in the estimation of stress and pain instigated by poor management, castration without local anesthesia, inappropriate environmental temperature, transportation, and ailment in livestock animals (Raff and Singh, 2012). Cortisol is considered one of the main hormones involved in stress response, and its main function is to favor protein metabolism to convert protein into amino acids, supporting gluconeogenesis. The cortisol synthesized by the adrenal cortex stimulates the degradation and release of glucose, amino acid, and fat in the liver, muscle, and adipose tissue (Sejian et al., 2010).

Evaluation of the level of cortisol as an important blood constituent used in quantifying stress in animals has also been described by other authors (Browning and Leite-Browning, 2013; Nzolo, 2014).

Cortisol and catecholamine production released have been used in the assessment of temperament and excitability in calves experiencing acute stress during weaning (Burdick et al., 2009; O'Neill and Webb, 2012). An increase in plasma concentration of cortisol has been used as an indicator of stress in horses (Fazio et al., 2008), cattle (Odore et al., 2004; Gupta et al., 2007), sheep (Cockram et al., 1997) and

goats (Aoyama et al., 2005; Kadim et al., 2006).

In our review of the literature, the possible variations of some biochemical metabolites and cortisol in lame goats under different breeds, sexes, ages, and severity have not been investigated in Nigeria. Also, the possible roles of these metabolites and hormones in assessing the welfare or resilience of livestock during painful conditions such as chronic lameness have not been reported among local breeds of goats in Nigeria. We, therefore, sought to establish and compare the levels of these parameters among different breeds, ages, sexes, and severity of lameness in goats. This study hypothesizes that there will be significant differences in the level of some biochemical parameters and cortisol among breeds, sex, age, and severity of infection in lame goats. Findings confirm the hypothesis with significant observations in the level of some biochemical parameters. However, no significant differences in the level of cortisol when comparisons were made between breed, sex, and age groups among lame goats. These findings further reiterate the need for the genetic improvement of indigenous breeds of animals in mitigating productivity and economic losses associated with some clinical conditions of animals such as lameness.

Materials and Methods

Location of the study area

The study was carried out in some villages in Akinyele's local government area of Oyo State, Nigeria. Akinyele local government is one of the sub-urban local governments in Ibadan, with many villages inhabited by predominantly smallholder farmers (crops and animals). It covers an area of about 518km^2. The local government is geographically located at latitude 7°53'09" N and longitude 3°91'10" (Efenakpo et al., 2016). The mean maximum temperature is 26.46^{o}C, the minimum is 21.42^{o}C, and the relative humidity is 74.55%. The mean annual rainfall is 10mm minimum in January and 188mm maximum in June with a total annual rainfall of 1233mm. (Marchi et al., 2019).

Studied Animals and Sample collection

The breeds of goats that were sampled include; Red Sokoto, West African Dwarf, and Cross-bred goats. Each of these breeds was morphologically examined, identified, and classified according to body coat coloration, body conformation, height, and other distinguishable characteristics. Sex was established based on their reproductive organs. The degree of severity was classified based on the extent of the lesion and gait of the animal, and rostral dentition was used to establish their ages, as recently described by (Olaogun and Jeremiah, 2018). Samplings were conducted very early in the morning before the sun rose to avoid the effect of heat stress on the level of cortisol.

About 5ml of blood was collected from each animal by venipuncture aseptically into the plain tube. This was allowed to clot and centrifuged at 3000 rpm for 15minutes with a clinical table centrifuge, and sera were harvested within a few hours of collection for biochemical analysis. 2 ml of blood was taken into tubes containing sodium fluoride for the estimation of blood glucose. Complete serum biochemical parameters and cortisol hormone analysis were done at the haematology/biochemistry unit, Adeoyo State Hospital Laboratory, Ibadan. Oyo State, Nigeria.

Evaluation of serum electrolytes

Sodium and potassium were estimated using a cunning flame photometric procedure as described by (Mencaly et al., 1976). Serum chloride was estimated by the colorimetric approach as described elsewhere by (Visweswariah et al., 1972), while serum bicarbonate was estimated by the titrimetric method as described by (Mencaly et al., 1976).

Estimation of serum metabolites, protein, lipids, and glucose

Serum urea was estimated by the colorimetric enzymatic method described by (Tussky et al., 1961). Serum creatinine was estimated by the Jaffe's reaction using a commercially prepared kit (Randox Laboratory Limited, Antrim, United Kingdom). Serum protein was estimated by colorimetry method based on biuret reaction, using a commercially prepared kit (Randox Laboratory Limited Antrim, United Kingdom) according to the procedure of (Oser and Hawk, 1965). Albumin by Bromocresol green (BCG) method according to the procedure described by (Peters et al., 1982). Serum globulin concentration was estimated by subtracting the albumin concentration from the total protein concentration. Bilirubins were analyzed using the method described by (Ogunsami et al., 2002). Total cholesterol was estimated using the Liebermann- Burchardt technique as described by (Allain et al., 1974). Triglycerides estimation was done by endpoint method of (McGowan et al., 1983). The estimation of plasma (High-density lipoprotein) HDL-cholesterol was done by the precipitation method of (Lopez-Virella et al., 1979). The estimation of (Low-density lipoprotein) LDL-cholesterol was determined by using the formula of (Friedwald et al., 1972). Serum glucose was estimated by glucose oxidase enzymatic method using a commercially prepared kit (Randox Laboratory Limited, Antrim, United Kingdom) as applied by (Ekun et al.,2018).

Determination of serum enzymes

Plasma aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were determined by the Colorimetric method (Reitman and Frankel, 1957) as recently described by (Igbokwe et al., 2017; Olaogun and Onwuzuruike, 2018). Alkaline phosphatase (ALP) levels were evaluated by the kinetic method as described by (Edress et al., 2017). Gamma glutamate aminotransferases (GGT) were determined by the colorimetric method (Olaogun, 2021).

Measurement of serum cortisol

Serum cortisol levels were estimated by using a commercially prepared Eliza Kit (Human

Diagnostic Laboratory, Wiesbaden, Germany) according to (Akinloye et al., 2013)

Statistical analysis

All numerical data were processed using the statistical package for the social science SAS package (2004). ANOVA and Student's T-tests were used appropriately to establish significant differences between the variables. $P<0.05$ was considered to be statistically significant.

Results

No significant differences in the values of minerals analyzed between breeds were observed, but the values were generally higher in cross-bred goats, as follows: sodium 138±2.83 mmol/l, and potassium 4.0±0.14mmol/l, chloride 107.5±3.54mmol/l compared to the values in West African Dwarf goats with the parameters as follows: sodium136.33±4.04 mmol/l,potassium3.67±0.51mmol/l,chloride103.33±7.64mmol/l. Values of some

biochemical parameters were also higher in cross-bred goats compared to other breeds as follows; blood urea nitrogen 25.0±1.41mg/dl, creatinine 0.65±0.07mg/dl, total protein 6.9±0.14g/dl, globulin 3.9±0.14g/dl, conjugated bilirubin 0.1±0mg/dl, total cholesterol 132±5.66mg/dl, triglycerides 64±4.24mg/dl, low-density lipoprotein 115±14.14mg/dl. Glucose level was highest in West African dwarf goats with 74.33±8.39mg/dl when compared to other breeds. The values of some enzyme activities of lame goats in relation to breeds revealed that the values of all four enzymes analyzed were highest in Cross-bred goats compared to other breeds. They were expressed as follows: AST 17.5±4.95 IU/L, ALT 14.5±3.54* IU/L, ALP 45±9.9 IU/L, and GGT 9.5±3.54 IU/L. There was a significant difference in the value of ALT when compared with the values in other breeds. (Table 1).

Table 1: Mean±S.D of Biochemical parameters of different breed of lame goats

Parameters	Cross-bred	Red Sokoto	West African Dwarf	Reference Range
Sodium (mmol/L)	138.0±2.83	137.16±3.45	136.33±4.04	136-156[4]
Potassium (mmol/L)	4.0±0.14	3.71±0.35	3.67±0.51	6.5-9.4[4]
Chloride (mmol/L)	107.5±3.54	104.21±5.07	103.33±7.64	106-108[4]
Bicarbonate (mmol/L)	22.5±2.12	23.16±1.92	23±2	20-24[4]
Urea Nitrogen (mg/dl)	25.0±1.41	22.84±3.32	20.33±3.06	8-26[3]
Creatinine (mg/dl)	0.65±0.07	0.61±0.1	0.53±0.12	30-91(mmol/L)[4]
Total Protein (g/dl)	6.9±0.14	6.8±0.3	6.67±0.32	6.3-8.5[2]
Globulin (g/dl)	3.9±0.14	3.78±0.2	3.7±0.1	16-58(mmol/L)[4]
Albumin (g/dl)	3.0±0	3.01±0.21	2.97±0.25	2.8-4.3[2]
Total Bilirubin (mg/dl)	0.35±0.07	0.56±0.16	0.57±0.38	0.011–0.875[5]
Conjugated Bilirubin mg/dl	0.1±0	0.27±0.1	0.27±0.12	0.0–0.079[5]
Total Cholesterol (mg/dl)	132±5.66	125.68±10.75	123±14.73	40.1-127.1[3]
Triglyceride (mg/dl)	64±4.24	55.47±10.99	55.33±11.85	0.16-1.6[2]
HDLP (mg/dl)	39.5±4.95	41.53±6.96	39.67±8.08	N/A
LDLP (mg/dl)	115±14.14	112.89±14.61	113.67±13.8	N/A
Glucose (mg/dl)	71±4.24	73.53±6.8	74.33±8.39	49-91[1]
AST (IU/L)	17.5±4.95	13.89±2.49	15.33±2.89	80-170[1]
ALT (IU/L)	14.5±3.54*	10.79±1.87	12.33±2.08	20-360[1]
ALP (IU/L)	45±9.9	44.95±5.17	42.67±7.37	1.4-25.7[2]
GGT (IU/L)	9.5±3.54	7.74±2.26	8.67±2.31	N/A

ANOVA-Test * shows values with significant differences of (P=<0.05) HDLP= High-Density Lipoprotein; LDLP= Low-Density Lipoprotein; AST=Aspartate Aminotransferase; ALT= Alanine Aminotransferase; ALP= Alkaline Phosphatase; GGT= Gamma-Glutamyl Transferase.

Range references: N/A=not available, [1]Kiran et al. (2012), [2]Daramola et al. (2005), [3]Babeker and Elmansoury, (2013), [4]Njidda et al. (2013) and [5]Omidi et al. (2018)

There were no significant differences in the serum mineral concentration in relation to sex. Though the concentration of most of the minerals was higher in females when compared to their values in males. The values of some minerals in female lame goats were expressed as follows: sodium 137±4.04mmol/l, potassium 3.74±0.42mmol/l, chloride 104.38±5.63mmol/l, and bicarbonate 23±2mmol/l compared to the values in male goats indicated as follows: sodium136.94±3.09mmol/l,potassium3.74 ±0.33mmol/l,chloride104.38±5.12mmol/la nd bicarbonate 23.13±1.86mmol/l. Though, there were no significant differences in metabolites and lipid profile in relation to sex. The following indices were higher in female goats than male as follows: BUN 22.88±2.95 mg/dl, creatinine 0.61±0.08 mg/dl, conjugated bilirubin0.28±0.1mg/dl,cholesterol129±11. 1mg/dl,HDLP43.13±8.94mg/dlandLDLP1 20.5±8.98mg/dl. Whereas, the following parameters had higher values for males when compared to females as follows: total protein 6.83±0.3g/dl, globulin 3.79±0.18g/dl, albumin3.04±0.2g/dl, total bilirubin0.55±0.21mg/dl, triglycerides57.06±8.71mg/dl and glucose 73.69±6.35mg/dl. Three of the four serum enzymes analysed have significant differences in their values in male goats when compared to female goats as follows: AST 15.25±2.77*IU/L, ALT 12.06±2.02*IU/L, and GGT 8.69±2.21*IU/L. Whereas ALP45±3.85 IU/L was highest in females compared to males but with no significant difference. (Table 2).

Table 2: Mean±S.D of Biochemical parameters of male and female lame goats

Parameters	Male(Buck)	Female (Doe)	Reference Range
Sodium (mmol/L)	**136.94±3.09**	**137.5±4.04**	**136-156[4]**
Potassium (mmol/L)	**3.73±0.33**	**3.74±0.42**	**6.5-9.4[4]**
Chloride (mmol/L)	**104.38±5.12**	**104.38±5.63**	**106-108[4]**
Bicarbonate (mmol/L)	**23.13±1.86**	**23±2**	**20-24[4]**
Urea Nitrogen (mg/dl)	**22.63±3.52**	**22.88±2.95**	**8-26[3]**
Creatinine (mg/dl)	**0.6±0.11**	**0.61±0.08**	**30-91(mmol/L)[4]**
Total Protein (g/dl)	**6.83±0.3**	**6.71±0.26**	**6.3-8.5[2]**
Globulin (g/dl)	**3.79±0.18**	**3.78±0.2**	**16-58(mmol/L)[4]**
Albumin (g/dl)	**3.04±0.2**	**2.94±0.21**	**2.8-4.3[2]**
Total Bilirubin (mg/dl)	**0.55±0.21**	**0.54±0.16**	**0.011–0.875[5]**
Conjugated Bilirubin mg/dl	**0.24±0.11**	**0.28±0.1**	**0.0–0.079[5]**
Total Cholesterol (mg/dl)	**124.31±10.54**	**129±11.1**	**40.1-127.1[3]**
Triglyceride (mg/dl)	**57.06±8.71**	**54.38±14.3**	**0.16-1.6[2]**
HDLP (mg/dl)	**40.13±5.39**	**43.13±8.94**	**N/A**
LDLP (mg/dl)	**109.5±14.66**	**120.5±8.98**	**N/A**
Glucose (mg/dl)	**73.69±6.35**	**72.88±7.53**	**49-91[1]**
AST (IU/L)	**15.25±2.77***	**12.63±2**	**80-170[1]**
ALT (IU/L)	**12.06±2.02***	**9.75±1.83**	**20-360[1]**
ALP (IU/L)	**44.5±6.3**	**45±3.85**	**1.4-25.7[2]**
GGT (IU/L)	**8.69±2.21***	**6.63±1.92**	**N/A**

Student T-Test * shows values with significant differences of (P=<0.05) HDLP= High-Density Lipoprotein; LDLP= Low-Density Lipoprotein; AST=Aspartate Aminotransferase; ALT= Alanine Aminotransferase; ALP= Alkaline Phosphatase; GGT= Gamma-Glutamyl Transferase.

Range references: N/A=not available, [1]Kiran et al. (2012), [2]Daramola et al. (2005), [3]Babeker and Elmansoury, (2013), [4]Njidda et al. (2013) and [5]Omidi et al. (2018)

No significant differences were observed in the serum minerals of lame goats analyzed in relation to age. Sodium, potassium, and bicarbonate were higher in adult animals than in young animals with the values expressed as 137.4±3.41mmol/L,3.76±0.34mmol/L, and 23.1±1.79mmol/L respectively. There were no significant differences found in most of the biochemical analytes in relation to age, except in the value of low-density lipoprotein that had a significant difference with a significantly higher value of 119.6±11.34* under 2-2½-year-old category compared with other age groups of lame goats. Most of the biochemical analytes were higher in young lame goats than in adult lame goats. The parameters that were higher in less than 1year old goats compared to the 2-2½-year-old category were observed as follows: total protein 6.86±0.33g/dl, albumin 3.08±0.17g/dl, total bilirubin 0.59±0.2 mg/dl, triglycerides 57.7±9.71mg/dl, glucose 74.4±7.11mg/dl. Analysis of serum enzymes in lame goats in relation to age revealed a significant difference only in the value of ALT with a significantly higher concentration of 13.5±2.38*IU/L under the 1-1½-year-old category when compared to other age groups of lame goats. The concentration of the serum enzyme was all highest under 1-1½ year-old category with the indices expressed as follows: AST 16.25±3.3 IU/L, ALT 13.5±2.38 IU/L, ALP 48.5±7.05 IU/L and GGT 9.5±2.08 IU/L (Table 3).

Table 3: Mean±S.D of Biochemical parameters of lame goats under different ages.

Parameters	< 1 Year	1-1½ Year	2-2½ Year	Reference Range
Sodium (mmol/L)	**137.3±3.43**	**136±3.74**	**137.4±3.41**	**136-156[4]**
Potassium (mmol/L)	**3.72±0.37**	**3.68±0.43**	**3.76±0.34**	**6.5-9.4[4]**
Chloride (mmol/L)	**105.5±4.97**	**102.5±6.45**	**104±5.16**	**106-108[4]**
Bicarbonate (mmol/L)	**22.8±1.99**	**23.75±2.06**	**23.1±1.79**	**20-24[4]**
Urea Nitrogen (mg/dl)	**22.5±4.2**	**23±2.94**	**22.8±2.62**	**8-26[3]**
Creatinine (mg/dl)	**0.6±0.13**	**0.6±0.08**	**0.61±0.07**	**30-91(mmol/L)[4]**
Total Protein (g/dl)	**6.86±0.33**	**6.8±0.28**	**6.71±0.25**	**6.3-8.5[2]**
Globulin (g/dl)	**3.78±0.22**	**3.75±0.25**	**3.8±0.12**	**16-58(mmol/L)[4]**
Albumin (g/dl)	**3.08±0.17**	**3.05±0.1**	**2.91±0.23**	**2.8-4.3[2]**
Total Bilirubin (mg/dl)	**0.59±0.2**	**0.53±0.26**	**0.51±0.16**	**0.011–0.875[5]**
Conjugated Bilirubin (mg/dl)	**0.26±0.11**	**0.21±0.14**	**0.27±0.09**	**0.0–0.079[5]**
Total Cholesterol (mg/dl)	**123.6±11.69**	**128.75±6.7**	**127±11.47**	**40.1-127.1[3]**
Triglyceride (mg/dl)	**57.7±9.71**	**59.25±7.5**	**53.4±12.7**	**0.16-1.6[2]**
HDLP (mg/dl)	**41.3±5.66**	**39±3.56**	**41.8±8.78**	**N/A**
LDLP (mg/dl)	**105±14.51**	**117.5±8.7**	**119.6±11.34***	**N/A**
Glucose (mg/dl)	**74.4±7.11**	**72.5±7.19**	**72.8±6.49**	**49-91[1]**
AST (IU/L)	**15±2.79**	**16.25±3.3**	**13±2.11**	**80-170[1]**
ALT (IU/L)	**11.6±1.9**	**13.5±2.38***	**10.1±1.79**	**20-360[1]**
ALP (IU/L)	**44.1±6.15**	**48.5±7.05**	**43.7±3.95**	**1.4-25.7[2]**
GGT (IU/L)	**8.4±2.41**	**9.5±2.08**	**7±2**	**N/A**

ANOVA-Test * shows values with significant differences of (P=<0.05) HDLP= High-Density Lipoprotein; LDLP= Low-Density Lipoprotein; AST=Aspartate Aminotransferase; ALT= Alanine Aminotransferase; ALP= Alkaline Phosphatase; GGT= Gamma-Glutamyl Transferase.

Range references: N/A=not available, [1]Kiran et al. (2012), [2]Daramola et al. (2005), [3]Babeker and Elmansoury, (2013), [4]Njidda et al. (2013) and [5]Omidi et al. (2018)

Analysis of some minerals among lame goats based on level of severity indicated that there were significant differences in the values of potassium and chloride with significantly lower values of 3.4±0.37*mmol/L and 100±3.54*mmol/L respectively in severe lameness when compared to mild lameness. There were significant differences in the values of blood urea nitrogen, creatinine, total protein, and albumin among biochemical analytes analyzed in lame goats. The values were significantly reduced in severe lameness with the parameters expressed as follows: blood urea nitrogen 19.8±2.28*mg/dl, creatinine 0.52±0.08*mg/dl, total protein 6.48±0.15*g/dl, and albumin 2.82±0.24*g/dl. No significant differences were recorded for serum enzymes in relation to mild and severe forms of lameness in goats. The values were generally lowered than the reference values, but with slightly improved values of enzymes as follows: AST 14.79±2.76 IU/L, ALT 11.63±2.06 IU/L and GGT8.37±2.27 IU/L in mildly infected lame goats when compared to severely affected goats. (Table 4).

Table 4: Mean±S.D of Biochemical parameters of lame goats in mild and severe infection

Parameters	Mild	Severe	Reference Range
Sodium (mmol/L)	**137.79±3.08**	**134.6±3.44**	**136-156[4]**
Potassium (mmol/L)	**3.82±0.3**	**3.4±0.37***	**6.5-9.4[4]**
Chloride (mmol/L)	**105.53±4.97**	**100±3.54***	**106-108[4]**
Bicarbonate (mmol/L)	**22.68±1.83**	**24.6±1.14***	**20-24[4]**
Urea Nitrogen (mg/dl)	**23.47±3.1**	**19.8±2.28***	**8-26[3]**
Creatinine (mg/dl)	**0.63±0.09**	**0.52±0.08***	**30-91(mmol/L)[4]**
Total Protein (g/dl)	**6.87±0.26**	**6.48±0.15***	**6.3-8.5[2]**
Globulin (g/dl)	**3.82±0.16**	**3.66±0.22**	**16-58(mmol/L)[4]**
Albumin (g/dl)	**3.05±0.16**	**2.82±0.24***	**2.8-4.3[2]**
Total Bilirubin (mg/dl)	**0.56±0.16**	**0.5±0.31**	**0.011–0.875[5]**
Conjugated Bilirubin (mg/dl)	**0.26±0.1**	**0.24±0.15**	**0.0–0.079[5]**
Total Cholesterol (mg/dl)	**126.63±11.25**	**123±8.92**	**40.1-127.1[3]**
Triglyceride (mg/dl)	**57.95±10.18**	**49.4±10.64**	**0.16-1.6[2]**
HDLP (mg/dl)	**41±6.72**	**41.6±7.54**	**N/A**
LDLP (mg/dl)	**112.79±14.05**	**114.6±14.71**	**N/A**
Glucose (mg/dl)	**74.47±6.93**	**69.4±3.13**	**49-91[1]**
AST (IU/L)	**14.79±2.76**	**12.8±2.59**	**80-170[1]**
ALT (IU/L)	**11.63±2.06**	**10±2.55**	**20-360[1]**
ALP (IU/L)	**44.42±5.74**	**45.6±5.08**	**1.4-25.7[2]**
GGT (IU/L)	**8.37±2.27**	**6.6±2.07**	**N/A**

Student T-Test * shows values with significant differences of (P=<0.05) HDLP= High-Density Lipoprotein; LDLP= Low-Density Lipoprotein; AST=Aspartate Aminotransferase; ALT= Alanine Aminotransferase; ALP= Alkaline Phosphatase; GGT= Gamma-Glutamyl Transferase.
Range references: N/A=not available, [1]Kiran et al. (2012), [2]Daramola et al. (2005), [3]Babeker and Elmansoury, (2013), [4]Njidda et al. (2013) and [5]Omidi et al. (2018)

There was no significant difference in the cortisol level among breeds of lame goats, Cross-bred goats had the best value of 12.00±1.41ng/ml, followed by Red Sokoto with a value of 10.16±1.77ng/ml and West African Dwarf had the least value of 9.67±1.16ng/ml. (Table 5).

Table 5: Mean±S.D of Level of Cortisol among breeds of lame goats.

Parameters	Cross-bred	Red Sokoto	West African Dwarf	Reference Range
Cortisol (ng/ml)	**12.00±1.41**	**10.16±1.77**	**9.67±1.16**	**3-15**

ANOVA-Test *shows values with significant differences of (P=<0.05) ng/ml=Nanogram per milliliter. Range references: (Al-Busaidi et al. 2008; Aoyama et al. 2008; Sejian and Srivastava 2010; Ribeiro et al. 2016, 2018) =3-15ng/ml. (Ronchi et al. 2001) = 4.5- 15.6 ng/ml (Du Preez 2000) = 21.5 - 43.0 ng/ml

No significant difference was observed in the cortisol level in relation to sex among indigenous goats. Male goats had a relatively higher value of 10.47±1.46 ng/ml and females had a lower value of 9.75±2.25 ng/ml. (Table 6)

Table 6: Mean±S.D of Level of Cortisol among male and female lame goats.

Parameters	Male (Buck)	Female (Doe)	Reference Range
Cortisol (ng/ml)	**10.47±1.46**	**9.75±2.25**	**3-15**

Student T-Test * shows values with significant differences of (P=<0.05) ng/ml= Nanogram per milliliter. Range references: (Al-Busaidi et al. 2008; Aoyama et al. 2008; Sejian and Srivastava 2010; Ribeiro et al. 2016, 2018) =3-15ng/ml. (Ronchi et al. 2001) = 4.5- 15.6 ng/ml (Du Preez 2000) = 21.5 - 43.0 ng/ml

Also, there was no significant difference in the values of cortisol, when compared between age groups of lame goats. Though, the highest value of cortisol was found in the 1-1½years old category with the value expressed as 11.00±1.4 ng/ml, while the lowest value was seen in the 2 -2½year old category of goats with the value expressed as 9.90±2.17 ng/ml. (Table 7).

Table 7: Mean±S.D of Level of Cortisol among different ages of lame goats.

Parameters	< 1 year	1-1½ year	2-2½ year	Reference Range
Cortisol (ng/ml)	**10.30.3±1.42**	**11.00±1.41**	**9.90±2.17**	**3-15**

ANOVA-Test * shows values with significant differences of (P=<0.05) ng/ml= Nanograms per milliliter. Range references: (Al-Busaidi et al. 2008; Aoyama et al. 2008; Sejian and Srivastava 2010; Ribeiro et al. 2016, 2018) =3-15ng/ml. (Ronchi et al. 2001) = 4.5- 15.6 ng/ml (Du Preez 2000) = 21.5 - 43.0 ng/ml

Discussion

Most biochemical parameters, as revealed by this present study, were within the normal reference range (Plumb, 1999). The best values for sodium, potassium, chloride, and bicarbonate were seen in crossed-bred lame goats when compared with values, in other breeds in reference to normal values as described by (Njidda et al., 2013). Metabolites such as blood urea nitrogen and creatinine were highest in cross-bred goats among the three breeds of lame goats and appeared best when compared to normal values as described by (Babeker and Elmansoury, 2013). Cross-bred lame goats had the lowest values for total bilirubin and conjugated bilirubin among the three breeds of lame goats and these appeared best compared to reference values reported by (Omidi et al., 2018). Cross-bred goats also possessed the highest and better values for proteins and lipids among the three breeds of lame goats in reference to normal values reported by (Daramola et al., 2005). Serum enzymes were equally highest and better in cross-bred lame goats among the three breeds of lame goats in reference to normal values described by (Kiran et al., 2012). No significant differences in all the biochemical analytes were observed, apart from ALT among all the breeds of lame goats. This is in conformity with the earlier report of (Olaogun and Adedeji, 2018) who also reported no significant differences in all biochemical parameters analyzed among

bovine babesiosis-infected Nigerian breeds of cattle. Observation of most biochemical parameters falling within the normal reference range is in agreement with the earlier report by (Njidda et al., 2013) who also reported normal values for most biochemical parameters in goats of semiarid environment fed on natural grazing rangeland of Northern Nigeria.

Electrolyte values were better in female goats compared to male goats in reference to normal values for electrolytes as described by (Njidda et al., 2013). The higher value of sodium observed in females compared to male lame goats in this study is in contrast to the reports of (Njidda et al.,2013), who reported high Na levels in male goats compared to female goats. All metabolite values were within the normal reference values except for conjugated bilirubin which had a greater value than the normal range reported by (Omidi et al., 2018). Female lame goats possessed higher values for all metabolites compared to male lame goats except for total bilirubin; this is contrary to the observation of (Njidda et al., 2013) who reported higher metabolites values for males compared to females' goats in Northern Nigeria.

Increased significant differences were observed in the values of AST, ALT, and GGT in lame bucks compared to lame doe(s). This finding corroborates the reports of (Temizel et al., 2007), who also discovered that the serum enzymes were generally higher in male goats compared to female goats.

The BUN in this study had a higher value in adult goats compared to young ones. This agrees with the earlier report by (Javed et al., 2010) who reported that the total protein and BUN are relatively higher in adult animals compared to young growing animals. This might be due to high metabolized protein diets that might have been consumed by adult animals compared to young animals.

Findings from this study revealed a general decrease in the values of AST, GGT, and ALT, in adult animals compared to young animals. This is not in agreement with the reports of (Wada et al., 2014), who reported higher values of ALT in young goats compared to adult goats. This may be as a result of the well-developed immune system associated with adult animals whereas the young animal's immune system might have not yet fully developed.

The relatively higher values of cholesterol and LDL in adult lame goats compared to young lame goats as observed in this study. This disagrees with the earlier report of (Antunovic et al., 2011), who reported higher values of HDL and lower values of LDL in adult goats than in young goats. This might be due to the higher level of protein and lipid in the concentrate diet fed to the animals within their own study.

The biochemical analytes trend in relation to the severity of infection observed in this present study is similar to the previous findings of (Olaogun and Adedeji, 2018) who also observed improved biochemical parameters in mildly dermatophilosis-infected Nigerian cattle when compared with severely infected cattle.

Findings from this study also showed that the cross-bred goats had the highest values for cortisol among the breeds sampled, though all were within the reference range (Sejian and Srivastava 2010; Ribeiro et al., 2016, 2018; Ronchi et al., 2001; Anyoama et al., 2008). Since cortisol regulates virtually all biological functions that are affected by stress, including immune capacity, reproduction, metabolism, and behavior. Cross-bred goats

appeared to be more resilient among breeds of goats considering their levels of cortisol. Though Stubsjoen et al., (2015) reported a decreased level of cortisol in ovine foot-rot infection, and significantly higher hair cortisol concentration was observed in dogs with atopic dermatitis compared to healthy dogs as reported by (Park et al., 2016). The cortisol level in this study was neither high nor low but fell within the normal reference value.

The cortisol level in male and female lame goats when compared indicated higher values in male than in female goats. This might be due to increased activities associated with male animals, especially during breeding which may be hormonal in nature. This is in agreement with the earlier report of (Lafferty et al., 2015) who reported higher levels of cortisol in male than female American black bears. Increasing testosterone levels in adolescent males are associated with the manifestation of reproductively relevant behaviors, which may induce stressful events that may equally result in elevated cortisol concentration (Bergman et al., 2005). This contradicts the findings of (Fourie et al., 2016) who reported increased cortisol levels in females and non-human primates than in males. This may be partly explained by sex differences in the body condition index (Cattet et al., 2014). Raven and Taylor, (1996) also suggested that higher cortisol levels in males compared to females may be caused by the lower activity of the glucocorticoid metabolizing enzyme 11β-hydroxy steroid dehydrogenase 2, associated with females.

The reduced level of cortisol observed in adult lame animals compared to young lame goats might be due to an age-dependent variable that favors young animals more than old animals. This may be caused by lower corticosteroid-binding concentrations in infants, resulting in increased plasma concentrations of free cortisol as shown in humans (Grant et al., 2017). This correlates with the earlier work of (Linares et al., 2008) who reported in their work that, it could be admitted that some factors such as species, age, or even individual differences could have an influence on the basal plasmatic cortisol level. Roth et al., (2016) also indicated that there is an age-dependent decline in cortisol levels from young to adults. Elevated cortisol levels were also found in hair samples obtained from 15-day-old calves compared with those from 2-year-old cows (del Rosario et al., 2011)

Conclusion

The present study shows improved biochemical parameters in cross-bred goats when compared with other breeds of lame goats. Female goats (does) possessed better biochemical parameters compared to males (bucks). Also, improved or better biochemical parameters were observed in adult lame goats compared to young lame goats. Cross-bred lame goats, male lame goats, and young lame goats appeared more resilient, judging by their levels of cortisol observed. These parameters will be useful prognostic and diagnostic tools for clinicians and veterinarians in the management of lameness in Nigerian breeds of goats. We, therefore, recommend the development of the genetic potential of indigenous breeds of animals as part of measures for the prevention and management of lameness and animal diseases in general.

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Conflict of Interest

All authors declare no conflict of interest

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