

Clinical, haematological and biochemical features associated with foot rot infection in sheep in Oyo State, Nigeria

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ABSTRACT

Aim: Main purpose of the study was to establish the occurrence of foot rot in relation to breeds, sex and ages of sheep and determines the clinical, haematological and biochemical parameters of foot rot-infected sheep.

Method and materials: Thirty-six local sheep showing signs of foot rot and confirmed positive for the commonest bacterial aetiological organisms (*Dichelobacter nodosus* and *Fusobacterium necrophorum*) using bacteriological techniques and subsequently analysed using standard haematological and serum biochemical techniques.

Results: There were more foot rot cases in the Yankasa breed (50%) compared with the West African Dwarf (33.3%) and Ouda breeds (16.7%). Females (ewes) had the highest occurrence (69.4%) compared to males (rams) (30.6%), and adults (83.3%) compared to young (16.7%) sheep, respectively. More sheep were moderately infected (61.1%) compared to those with mild infections (22.2%) and those that were severely infected (16.7%). Erythrocytic parameters were generally low, and WBC, platelet, and lymphocyte were higher, while neutrophils, monocytes, and eosinophils remained normal compared to reference values, but there were no significant differences at ($P < 0.05$) among the breeds. Level of calcium was significantly higher in males compared to females ($P=0.023$). Findings in relation to ages revealed no statistical significance, except for ALP, which was significantly higher in adult compared to young, infected sheep ($P = 0.01$).

Conclusion: It was concluded that occurrence was higher in the Yankasa breed, females and adults compared to other breeds, males and young sheep. There was generalized lymphocytosis and hypercalcaemia generally in rot-infected foot sheep. The Yankasa breed, male (ram), and adult possessed the best haematological and biochemical parameters compared to other breeds, female and young sheep with foot rot infection.

Keywords: Occurrence, Haematology, Biochemistry, Foot rot, Sheep, Oyo state

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Introduction

Diseases related to the foot are some of most prevalent health concerns in herds, especially sheep flocks globally, resulting in significant challenges for both the sheep and their owners, including considerable economic losses (Atata *et al.*, 2024). Foot rot/ infectious pododermatitis, is an infection of foot frequently seen in sheep, goats, and cattle resulting in lameness.

Despite being first identified over 180 years ago, this intricate disease remains prevalent in various countries, and this poses significant welfare and economic challenges for sheep farmers globally (Zanolari *et al.*, 2021).

Foot rot arises from the synergistic effect of two anaerobic Gram-negative bacteria, specifically *Fusobacterium necrophorum* and *Dichelobacter nodosus* (Winter, 2008). *D. nodosus* serves as the main causative agent and is essential for the disease to occur, while *F. necrophorum* is regarded as a supplementary factor that affects the likelihood and establishment of the disease

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condition (Wani & Samanta, 2006). Depending on the virulence of the *D. nodosus* strains, the clinical presentation of foot rot can range from a mild form (benign foot rot) to a more severe variant (virulent foot rot) (Bennett *et al.*, 2009). In addition to *F. necrophorum* and *D. nodosus*, other bacteria may also play a role in the disease's development, including *Bacteroides fragilis*, *Prevotella spp*, and *Treponema spp*; these microorganisms have been found in foot rot incidents (Demirkan *et al.*, 2001). The organism thrives in damp conditions, with factors such as inadequate hoof trimming, poor hoof cleanliness, insufficient nutrition, stress, and concurrent illnesses contributing to physical injury to the interdigital skin, which creates an environment conducive to bacterial growth in the damaged tissue, leading to interdigital dermatitis (ID). This condition is marked by inflammation and the shedding of the outer epidermal layer of the foot (Ardüser *et al.*, 2019). The condition can progress to foot rot, resulting in the separation of the hoof horn capsule from the underlying tissues (Kuhnert *et al.*, 2019).

Management strategies for foot rot at the farm include consistent foot bathing and hoof trimming, the use of antibiotics (either systemic or topical), the removal of animals with chronic infections, vaccination, and selecting for genetic resistance (Bennett and Hickford, 2011). This condition leads to serious economic losses in countries globally (Wani and Samanta, 2006). In Nigeria, small ruminants, comprising the commonest Yankasa and Uda breeds, form a major component of the livestock industry, contributing significantly to food security and livelihoods, especially of the rural populace. However, prolonged warm and moist conditions that characterized the tropical climate serve as an optimal environment for the propagation and transmission of foot rot (Mustapha *et al.*, 2024). High prevalent challenge of foot rot with positivity rates for the major etiological organisms as high as 54.55% among screened sheep in Oyo State, Nigeria, have been reported (Olaogun *et al.*, 2025). This high incidence necessitates the prompt need for a more pragmatic diagnostic procedure to curtail the disease effectively.

While characteristic clinical signs including characteristic foul-smelling necrotic lesions and lameness are primary diagnostic indicators, they are most often subjective and may cause confusion with other podal diseases (Van Metre,

2017). Furthermore, relying absolutely on culture-based techniques can be time-wasting and delaying intervention. To get rid of these challenges, the profiling of haematological (blood cell) and serum biochemical indices presents a better view of the systemic response of the animal to infection and inflammation (Saravanan *et al.*, 2020). Previous study has revealed leukocytosis, anaemia, and altered concentrations of total protein and acute phase proteins as features associated with foot rot infection (Saravanan *et al.*, 2020). Importance of clinical, hematological, and biochemical analytes in assessing the degree and extent of pathological processes in animals in general have been previously reported (Olaogun and Oyetoyinbo, 2020; Olaogun *et al.*, 2024A, Olaogun *et al.*, 2024B). Deviations in the various blood metabolites such as Lymphocyte and eosinophil can be suggestive of the characteristics of an ongoing infectious process. In most instances, the death of sick animals is often associated with negative effects of infectious organisms or metabolic derangement that affect electrolyte levels, hormone levels, glucose, cholesterol, amino acids, and so on (Olaogun and Onwuzuruike, 2018). Despite the high prevalence of foot rot in Oyo State based on established laboratory diagnostics procedures, there remains a paucity of integrated data detailing the clinical, haematological and biochemical parameters of naturally infected sheep under local Nigerian management conditions. Hence, it becomes very germane to undertake this study, considering the essential roles of these parameters in making appropriate prognostic, therapeutic and disease progression/monitoring decisions.

Moreover, almost no reports are available on the clinical, hematological, and biochemical changes in different breeds, sex, age and level of severity of foot rot infected sheep in Oyo state, Nigeria.

This integrated approach is essential for establishing a reliable, evidence-based diagnostic baseline and for understanding the full physiological impact of the disease in the local context.

It was, therefore, investigated and documented the complete clinical presentation, haematological alterations and serum biochemical changes in naturally infected foot rot sheep within Oyo State, Nigeria. The findings of this study offer local veterinarians and researchers with critical data to

facilitate early, accurate diagnosis, refine treatment protocols, and ultimately mitigate the severe economic and welfare impact of foot rot on Nigerian sheep flocks.

Materials and Methods

The study was conducted in accordance with the recommendation of the ethical standards of the University of Ibadan's Research Ethics Committee (UI-ACUREC). The protocol and procedures adopted were reviewed and approved by the Ethical Standard of Research Committee, with (Ref. No. UI-ACUREC/045-0324/04).

Study location

The study was carried out at Akinyele livestock market in Oyo State, Nigeria. Oyo State is an inland state situated in the southwest geopolitical zone of Nigeria. It lies entirely in the tropics between latitude 7.1°N and 9.2°N and longitude 2.7°E and 4.56°E of the Greenwich Meridian and covers a land area of about 28,454 square kilometers. Oyo State has been in the front race as a livestock-producing community with sizeable commercial livestock farming, involving huge enterprises and many households. (Olusoji and Sunday, 2016; Olaogun *et al.*, 2025)

Studied animals

The breeds of sheep that were sampled include West African Dwarf, Yankasa and Uda. Each of these breeds was morphologically examined, identified, and classified according to their body conformation, height, and other distinguishable characteristics. Sex was established based on their reproductive organ's appearance. The ages of the animals were classified based on the record of birth and rostral dentition, while the degree of severity of foot rot was classified based on the extent of the lesion and gait of the animal, as previously described by (Olaogun and Jeremiah, 2018; Olaogun and Esan, 2024). A total of 36 sheep showing clinical symptoms of foot rot were sampled using a sterile swab stick to take swab samples from the infected wound on each of the sheep.

Clinical parameters and sample collection

The clinical parameters such as Rectal temperature (°C), Heart rate (beats/minute), Pulse rate (beats/minute), and Respiratory rate (breaths/minute) were taken using clinical thermometer, stethoscope, counting through the saphenous artery in the ventral part of the hind leg, and counting of the breathing from the nostrils respectively. 10 ml of blood was collected through jugular venipuncture from each animal using a

vacutainer set and subsequently divided into 5 mls each in BD vacutainer® (clot activator tube) and BD vacutainer® (EDTA) for whole blood and serum, respectively. They were then covered and rolled gently before being placed in slanting positions inside the thermos flask containing ice packs to prevent lysing of the cells. They were immediately transported to the general laboratory of the Department of Veterinary Medicine, University of Ibadan, Nigeria, for subsequent analyses.

Hematological and biochemical analyses

Microhematocrit, cyanmethemoglobin, hemocytometer and other hematological procedures were adopted for the hematological analyses as previously used by (Adedokun *et al.*, 2023). The following biochemical analytes include globulin, albumin, total protein, creatinine, triglycerides, glucose, cholesterol, aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, sodium, and potassium were analyzed using commercial test kits supplied by Fortress Diagnostics Limited (UK) as previously described by (Adedokun *et al.*, 2023; Charles and Adedayo, 2018; Olawuwo *et al.*, 2020)

Statistical analysis

The collected data were summarized using descriptive statistics to establish frequencies and percentages and presented in tables. Student's T-test was employed to compare the Mean \pm SD of Foot rot infected and non-infected sheep. All statistical tests were conducted using the statistical package for social sciences (SPSS) version 23.

Results and Discussion

The distribution of sampled animals for foot rot is revealed as follows: 18 Yankasa (58.1%), 7 WAD (22.6%), 3 Balami (9.7%), and 3 Ouda (9.7%). There were 23 females (74.2%) compared to 8 males (25.8%). Adults were 27 (87.1%) compared to young sheep that were 4 (12.9%) (Table 1).

The clinical parameters of foot rot-infected sheep show that all were within normal reference values. The mean \pm SD for rectal temperature, heart rate, pulse rate, and respiratory rate were 39.60°C \pm 0.45, 77.5 \pm 0.62 beats/minute, 100.3 \pm 0.32 beats/minute and 40.5 \pm 0.82 breaths/minute, respectively (Table 2). Haematological parameters of foot rot-infected sheep are as follows: The mean \pm SD of PCV for 3 breeds of foot rot-infected sheep were relatively lower compared to the ref values, with highest observed in Ouda (28.67 \pm 11.15) and lowest in WAD (21.67 \pm 4.27).

Table 1. Distribution of Foot Rot infection among different breeds, sexes and ages of sheep

Breed	Frequency(n=36)	Percentage (%)
Ouda	6	16.7
WAD	12	33.3
Yankasa	18	50.0
Sex	Frequency(n=36)	Percentage (%)
Male	11	30.6
Female	25	69.4
Age	Frequency(n=36)	Percentage (%)
Young	6	16.7
Adult	30	83.3
Level of severity	Frequency(n=36)	Percentage (%)
Mild	8	22.2
Moderate	22	61.1
Severe	6	16.7

Age	Frequency(n=36)	Percentage (%)
Young	6	16.7
Adult	30	83.3
Level of severity	Frequency(n=36)	Percentage (%)
Mild	8	22.2
Moderate	22	61.1
Severe	6	16.7

Table 2. Mean \pm SD of clinical parameters of Foot Rot infected sheep in Ibadan Nigeria

Clinical parameters	n = 36	Range	Reference values (Aiello et al., 2016)
Temperature ($^{\circ}$ C)	39.6 \pm 0.45	38.1 - 41.2	39 - 40
Heart rate (beats/min.)	77.5 \pm 0.62	69.8 - 82.5	70- 80
Pulse rate (beats/min.)	100.3 \pm 0.32	91.4 - 120.5	60 -180
Respiratory rate (breaths/min.)	40.5 \pm 0.82	35.2 - 60.7	12-72

The Hb parameters were all lower than the reference values, with the highest observed in Yankasa (8.10 \pm 3.77) and the lowest in WAD (6.75 \pm 1.33). RBC was highest in Yankasa (12.04 \pm 1.42) and lowest in WAD (10.81 \pm 1.86), but all fell within normal ref values. All leucocytic parameters were within the normal reference values, except for lymphocytes that were generally high in all three breeds, being highest in Ouda (61.67 \pm 3.51) and least observed in Yankasa (55.67 \pm 5.27). No significant differences were

observed within the three breeds for all the haematological parameters. (Table 3).

All biochemical parameters were within the normal reference values, But Yankasa sheep seems to have relatively better biochemical values. While WAD sheep seems to have the worst parameters when compared to the normal reference values among all foot rot infected Nigerian breeds of sheep. The parameters for Yankasa sheep are as follows; Total protein, Albumin, Globulin, AST, ALT, ALP, BUN, Creatinine, Glucose, Calcium, Sodium, and Potassium were 7.42 \pm 0.75, 2.93 \pm 0.28, 4.49 \pm 0.55, 211.11 \pm 52.01, 27.67 \pm 1.66, 272.33 \pm 97.55, 23.27 \pm 26.61, 1.23 \pm 0.21, 65.11 \pm 10.49, 11.51 \pm 3.05, 145.56 \pm 9.22, and 3.66 \pm 0.65 respectively. Whereas the parameters for WAD sheep are as follows; Total protein, Albumin, Globulin, AST, ALT, ALP, BUN, Creatinine, Glucose, Calcium, Sodium, and Potassium were 6.73 \pm 0.93, 2.87 \pm 0.35, 3.87 \pm 0.59, 165.00 \pm 81.19, 26.00 \pm 17.09, 171.67 \pm 149.07, 11.73 \pm 3.67, 1.20 \pm 0.17, 60.0 \pm 11.00, 11.50 \pm 1.20, 136.67 \pm 8.51, and 2.64 \pm 0.21 respectively. There were no significant differences observed in all biochemical parameters among the three breeds (Table 4).

Hematological parameters of male and female sheep infected with foot rot revealed the mean \pm S.D. of packed cell volume (PCV) is 29.00 \pm 7.24 for males and 22.23 \pm 4.95 for females. Hemoglobin (HB) was 9.30 \pm 2.63 for males and 6.72 \pm 1.24 for females. Red Blood Cells (RBCs) were 13.16 \pm 3.25 for males and 11.35 \pm 1.69 for females. White Blood Cells (WBCs) were 8100.00 \pm 3105.5 for males and 4507.69 \pm 1612.95 for females. Lymphocytes were 60.00 \pm 4.32 for males and 56.615 \pm 5.20 for females. Neutrophils were 36.00 \pm 8.16 for males and 38.78 \pm 4.87 for females. Monocytes were 2.00 \pm 0.65 for males and 2.39 \pm 0.87 for females. Eosinophils were 2.00 \pm 0.97 for males and 2.31 \pm 1.32 for females.

The hematological parameters appeared generally low in infected male and female sheep compared to normal reference values. Though there were no significant differences at $p < 0.05$ in the hematological parameters of male and female foot rot-infected sheep.

Table 3. Breeds of foot rot infected sheep and their Haematological parameters (Mean \pm SD)

Haematological parameters	OUDA N=6	WAD N=12	YANKASA N=18	P-value	Ref Value
PCV (%)	28.67 \pm 11.15	21.67 \pm 4.27	23.11 \pm 5.89	0.24	27-45
Hb(g/dl)	8.10 \pm 3.77	6.75 \pm 1.33	7.32 \pm 1.45	0.61	9-15
RBC (x10 ⁶ / μ l)	11.77 \pm 2.96	10.81 \pm 1.86	12.04 \pm 1.42	0.46	9-15
WBC (x10 ³ / mL)	4950.00 \pm 1227.80	4875.00 \pm 2341.10	4533.33 \pm 1854.56	0.92	4-8

Table 4. Breeds of foot rot infected sheep and their Biochemical parameters (Mean± SD)

Biochemical parameters	OUДА N=6	WAD N=12	YANKASA N=18	P-value	**Ref Value
Total protein(g/dL)	7.05±0.35	6.73±0.93	7.42±0.75	0.41	6.0–7.9
ALB(g/dL)	2.95±0.71	2.87±0.35	2.93±0.28	0.93	2.4–3.0
GLO(g/dL)	4.10±0.28	3.87±0.59	4.49±0.55	0.23	3.5–5.7
AST(U/L)	128.00±1.41	165.00±81.19	211.11±52.01	0.48	60–280
ALT(U/L)	27.00±98.99	26.00±17.09	27.67±1.66	0.94	26–34
ALP(U/L)	120.85±3.04	171.67±149.07	272.33±97.55	0.39	68–387
BUN (mg/dL)	11.10±0.00	11.73±3.67	23.27±26.61	0.69	8–20
CREAT (mg/dL)	1.60±2.83	1.20±0.17	1.23±0.21	0.68	1.2–1.9
GLU(g/dL)	58.10±6.23	60.0±11.00	65.11±10.49	0.67	50–80
Ca(mmol/L)	8.10±6.23	11.50±1.20	11.51±3.05	0.42	2.88–3.2
Na(mol/L)	144.00±1.41	136.67±8.51	145.56±9.22	0.34	139–152
K(mol/L)	3.23±0.89	2.64±0.21	3.66±0.65	0.77	3.9–5.4

ANOVA-Test * shows values with significant differences at (P=<0.05). Reference ranges according to (Aiello *et al.*, 2016)

Table 5. Haematological parameters (Mean± SD) of foot rot infected sheep male and female sheep

Haematological parameters	Male N=11	Female N=25	P-value	**Ref Value
PCV (%)	29.00±7.24	22.23±4.95	0.21	27–45
Hb(g/dl)	9.30±2.63	6.72±1.24	0.07	9–15
RBC (x10 ⁶ /μl)	13.16±3.25	11.35±1.69	0.32	9–15
WBC (x10 ³ /mcL)	8100.00±3105.5	4507.69±1612.95	0.05	4–8
Platelet (x10 ³ /mcL)	117000.00±46318.91	94307.69±32724.57	0.52	800–1,100
Lymphocytes (%)	60.00±4.32	56.615±5.20	0.54	40–55
Neutrophils (%)	36.00±8.16	38.78±4.87	0.59	10–50
Monocytes (%)	2.00±0.65	2.39±0.87	0.68	0–6
Eosinophils (%)	2.00±0.97	2.31±1.32	0.83	0–10

Table 6. Biochemical parameters (Mean± SD) of foot rot infected sheep male and female sheep

Biochemical parameters	Male N=1	Female N=3	P-value	**Ref Value
Total protein(g/dL)	6.60±0.98	6.73±1.22	0.093	6.0–7.9
ALB(g/dL)	2.80±0.32	2.90±0.36	0.83	2.4–3.0
GLO(g/dL)	3.80±0.72	3.83±0.86	0.98	3.5–5.7
AST(U/L)	92.00±76.28	172.33±102.49	0.57	60–280
ALT(U/L)	10.00±1.38	29.33±4.04	0.054	26–34
ALP(U/L)	81.00±45.18	216.33±130.47	0.46	68–387
BUN (mg/dL)	10.50±2.63	10.50±2.63	1.00	8–20
CREAT (mg/dL)	1.20±0.46	1.13±0.21	0.81	1.2–1.9
GLU(g/dL)	72.00±9.21	58.00±7.55	0.25	50–80
Ca(mmol/L)	11.50±3.20	3.97±1.00	0.023	2.88–3.2
Na+(mol/L)	132.00±10.83	141.00±11.53	0.57	139–152
K(mol/L)	3.80±1.27	7.27±2.77	0.59	3.9–5.4

Table 7. Haematological parameters (Mean± SD) of foot rot infected sheep in different age groups

Haematological parameters	Young N=2	Adult N=12	P-value	**Ref Value
PCV (%)	22.00±1.41	22.83±5.51	0.84	27–45
Hb(g/dl)	6.75±0.35	6.93±1.49	0.87	9–15
RBC (x10 ⁶ /μl)	11.42±1.27	11.49±1.81	0.96	9–15
WBC (x10 ³ /mcL)	7025.00±530.33	4387.50±1678.63	0.054	4–8
Platelet (x10 ³ /mcL)	10350.00±43133.51	94666.67±32100.22	0.73	800–1,100
Lymphocytes (%)	55.00±0.00	57.17±5.46	0.59	40–55
Neutrophils (%)	40.00±1.41	38.33±5.09	0.67	10–50
Monocytes (%)	2.00±1.41	2.42±0.79	0.54	0–6
Eosinophils (%)	3.00±0.00	2.17±1.34	0.41	0–10

In general, it was showed that male sheep possessed better hematological parameters than the female sheep clinically manifesting foot rot (Table 5). The mean ± S.D. of biochemical parameters in male and female sheep is presented as follows: Total protein

was 6.60±0.98 for males and 6.73±1.22 for females. Albumin was 2.80±0.32 for males and 2.90±0.36 for females. Globulin was 3.80±0.72 for males and 3.83±0.86 for females. Aspartate aminotransferase (AST) was 92.00±76.28 for males and 172.33±102.49

for females. (ALT) were 10.00 ± 1.38 for males and 29.33 ± 4.04 for females. Alkaline Phosphatase (ALP) was 81.00 ± 45.18 for males and 216.33 ± 130.47 for females. Blood Urea Nitrogen (BUN) was 10.50 ± 2.63 for males and 10.50 ± 2.63 for females. Creatinine (CREAT) was 1.20 ± 0.46 for males and 1.13 ± 0.21 for females. Glucose was 72.00 ± 9.21 for males and 58.00 ± 7.55 for females. A significant difference at ($P < 0.023$) was observed in mean \pm S.D. of calcium in male (11.50 ± 3.20) and female (3.97 ± 1.00) foot rot-infected sheep. Sodium was 132.00 ± 10.83 for males and 141.00 ± 11.53 for females. Potassium was 3.80 ± 1.27 for males and 7.27 ± 2.77 for females. In all, the biochemical parameters of Ram appeared better than those of Ewe in clinical ovine foot rot (Table 6).

Haematological features of young and adult sheep with foot rot infection showed as follows: for young sheep, it shows PCV 22.00 ± 1.41 , HB 6.75 ± 0.35 , RBCs 11.42 ± 1.27 , WBCs 7025.00 ± 530.33 , and Platelet 10350.00 ± 43133.51 . Lymphocytes 55.00 ± 0.00 , Neutrophils 40.00 ± 1.41 , Monocytes 2.00 ± 1.41 , and Eosinophils 3.00 ± 0.00 . Whereas adult sheep indicate the following: PCV 22.83 ± 5.51 , HB 6.93 ± 1.49 , RBCs 11.49 ± 1.81 , WBCs 4387.50 ± 1678.63 , and platelets 94666.67 ± 32100.22 . Lymphocytes 57.17 ± 5.46 , neutrophils 38.33 ± 5.09 , monocytes 2.42 ± 0.79 , and eosinophils 2.17 ± 1.34 . All biochemical parameters indicate no statistically significant differences when comparisons were made between the values of young and adult foot rot-infected sheep (Table 7).

The mean \pm SD of the biochemical profile of young and adult foot rot-infected sheep is as follows: Total protein was 6.35 ± 0.92 for young and 7.37 ± 0.67 for adult. Albumin was 2.70 ± 0.28 for young and 2.96 ± 0.25 for adults. Globulin was 3.65 ± 0.64 for young and 4.41 ± 0.42 for adults. Aspartate aminotransferase (AST) was 132.50 ± 82.73

for young and 212.75 ± 45.17 for adults. (ALT) was 25.00 ± 24.04 for young sheep and 27.75 ± 1.49 for adults. Alkaline Phosphatase (ALP) was 86.50 ± 30.41 for young and 277.75 ± 90.68 for adults. Blood Urea Nitrogen (BUN) was 9.80 ± 2.12 for young and 20.89 ± 23.12 for adults. Creatinine (CREAT) was 1.15 ± 0.21 for young and 1.22 ± 0.19 for adults. Glucose was 60.00 ± 15.56 for young sheep and 63.83 ± 9.28 for adults. Sodium was 132.50 ± 6.36 for young and 145.25 ± 7.89 for adults. Potassium was 3.75 ± 1.07 for young and 4.41 ± 0.71 for adults. However, there were no statistically significant differences at $P < 0.05$ between the (mean \pm SD) of biochemical parameters between the young and adult sheep infected with foot rot. But the biochemical parameters of adult sheep appeared better than those of young sheep in clinical ovine foot rot (Table 8).

Understanding hematological and serum biochemical parameters in ruminants is essential for enhancing treatment and establishing effective disease prevention strategies (Delano *et al.*, 2002). The study provides a clear epidemiological snapshot of the sampled sheep diagnosed with foot rot, presenting the distribution across breed, sex, and age. The significantly higher prevalence in Yankasa sheep compared to other breeds may be due to more population of Yankasa sheep in the study area, as most animals in the livestock market are from Northern Nigeria, where they are the predominant population. The bigger and heavier nature of Yankasa compared to other breeds may also be a contributing factor. This is in tandem with the previous observation of (Olaogun *et al.*, 2025) who also observed variation in susceptibility among Nigerian indigenous sheep and higher susceptibility among Yankasa breeds.

Table 8. Biochemical parameters (Mean \pm SD) of foot rot infected sheep in different age groups

Biochemical parameters	Young N=2	Adult N=12	P-value	**Ref Value
Total protein(g/ dL)	6.35 ± 0.92	7.37 ± 0.67	0.07	6.0–7.9
ALB(g/dL)	2.70 ± 0.28	2.96 ± 0.25	0.21	2.4–3.0
GLO(g/ dL)	3.65 ± 0.64	4.41 ± 0.42	0.08	3.5–5.7
AST(U/L)	132.50 ± 82.73	212.75 ± 45.17	0.06	60–280
ALT(U/L)	25.00 ± 24.04	27.75 ± 1.49	0.62	26–34
ALP(U/L)	86.50 ± 30.41	277.75 ± 90.68	0.01	68–387
BUN (mg/ dL)	9.80 ± 2.12	20.89 ± 23.12	0.52	8–20
CREAT (mg/ dL)	1.15 ± 0.21	1.22 ± 0.19	0.65	1.2–1.9
GLU(g/ dL)	60.00 ± 15.56	63.83 ± 9.28	0.62	50–80
Ca(mmol/L)	10.90 ± 0.85	11.04 ± 3.50	0.96	2.88–3.2
Na(mol/L)	132.50 ± 6.36	145.25 ± 7.89	0.05	139–152
K(mol/L)	3.75 ± 1.07	4.41 ± 0.71	0.27	3.9–5.4

The higher incidence in females is a common finding in many livestock disease surveys; this may be due to generalized high population of female in the study population. This observation is similar with the findings of (Storms *et al.*, 2022), who also observed more incidence of foot rot in Ewe compared to Rams. The reason for high incidence in ewe may also be associated with usage of female animal for breeding that make them to be generally more in a population. Transient immune-suppression associated with pregnancy and lactation may also increase susceptibility of female to infection (Zanolari *et al.*, 2021). The observation of more cases of foot rot in adult sheep compared to young sheep as seen in this study may reflect larger number of adults in the sample population compared to young animals, as should be expected in a market location. This does not conform with the general observation of (Angell *et al.*, 2018), who reported that the likelihood of foot rot in lamb is higher compared to yearling sheep (adults).

All clinical parameters (rectal temperature, heart rate, pulse rate, and respiratory rate) of the foot rot-infected sheep were within the normal reference range, and this is highly significant, and this seems in order with the ovine foot rot pathology as established by (Charles, 2024). The slightly higher respiratory rate and pulse rate may be attributed to the stress of restraint, sampling, or pain-induced effort rather than illness itself, especially when the rectal temperature remains normal. The relatively normal rectal temperature and stable heart rate confirm that ovine foot rot, even in its virulent form, is majorly a localized, superficial infection and not a systemic disease (Caetano *et al.*, 2018).

The haematological reports present a mixed picture: an indication of anemia across all breeds, despite a normal total white blood cell count (WBC), and a distinct pattern of lymphocytosis. The lack of significant difference between the three breeds suggests the haematological response is primarily dictated by the disease state and severity, rather than genetic background. The most notable finding is that the mean Packed Cell Volume (PCV) and Haemoglobin (Hb) values for all breeds were below the established reference ranges, indicating anemia.

This anemia is mostly unlikely to be because of acute blood loss. Instead, it is characteristic of the Anemia of Chronic Disease (ACD) or Anemia of Inflammation (Weiss and Goodnough, 2005). Since foot rot is not a systemic septic disease (as confirmed by the normal temperature in the

previous discussion), the anemia may be due to metabolic cost and chronic inflammatory toll induced by prolonged, most often painful necrotic lesion on the hoof. This chronic reduction in oxygen-carrying potential further necessitates overall poor performance (weight loss, lethargy) observed in affected sheep (Caetano *et al.*, 2018).

All biochemical parameters in this present study appeared within normal reference values, and this may be due to the fact that only very few of these cases of foot rot infection in these sheep are severe, to have induce systemic organ damage (liver or kidney) or major metabolic derangement (protein, glucose, or electrolyte imbalance) that would have been reflected in the results. This observation of no significant differences in the biochemical parameters is like the previous reports of (Kareem-Ibrahim *et al.*, 2023).

Hematological parameters are reduced in both male and female sheep compared to normal reference ranges, The female sheep exhibit markedly lower values for PCV, HB, and RBCs compared to the males. This suggests a more pronounced anemic state or a more severe systemic impact of the foot rot infection in the females. The severe leukopenia in females is the most concerning finding among the white cell parameters, potentially suggesting a more compromised immune status than in males. The generally poorer parameters in females could be attributed to several factors common in livestock, such as nutritional requirement especially during pregnancy or during lactation, and hormonal factors influence. This observation agrees with the earlier findings of (Olaogun and Oyetoyinbo, 2020) who equally observed improved hematological values in male compared to female goats with lameness. High resilience ability of male goats compared to female goats was stated as factor. But this does not conform with the findings of (Opara *et al.*, 2010) who observed better hematological values in females compared to males in their work on hematology and biochemistry of apparently healthy West African dwarf goats in Owerri Southeast, Nigeria.

For the proteins to be within the normal range for sheep, indicating mild or subacute inflammation. It has not elicited severe hypoalbuminemia or a massive hyperglobulinemia known of acute, severe systemic illness (Radostits *et al.*, 2007). The enzyme activity levels indicate significant tissue damage, with females showing far

more extreme elevations suggestive of a more severe systemic disease state. High values of AST in ewes as observed in this present study, indicating muscle damage (from severe lameness/recumbency) or hepatocellular injury secondary to severe systemic infection (Thrall *et al.*, 2012). The tripled nature of ALP (Alkaline Phosphatase) in ewes compared to Ram observed can either be due to cholestasis (bile flow impairment), bone growth, or corticosteroid induction. The very high value in ewes is likely related to biliary stasis secondary to severe liver involvement or possibly bone remodeling due to chronic lameness.

The biochemical parameters in Ram appeared normal, but the values were low in female sheep. This hypoglycemia in ewes is a sign of severe systemic stress or negative energy balance (ketosis/pregnancy toxemia), which can occur when an infection like foot rot causes inappetence, especially in pregnant or high-producing animals (Radostits *et al.*, 2007).

Severe hyperkalemia observed in ewes with normal value in Ram is a critical finding, potentially indicating severe dehydration, metabolic acidosis, or massive tissue breakdown (due to severe muscle damage or recumbency) (Thrall *et al.*, 2012). Severe Hypocalcemia in females ($P < 0.023$). This is a highly significant difference and a critical finding. The male value is normal, but the female value is severely low. In ewes, this is likely associated with parturient paresis (milk fever) secondary to the stress of infection, or severe nutritional depletion, which is life-threatening (Goff, 2008).

The hematological parameters of foot rot infected Nigerian sheep in reference to ages reveals that the adult sheep shows a significantly lower total WBC count (leukopenia). This suggests the adult immune system is more suppressed or exhausted by the chronic infection than the young sheep (Thrall *et al.*, 2012). The relatively higher neutrophils in both adults and young sheep observed in this study, reflecting a Neutrophilia/Left-Shift to combat the bacterial infection (*D. nodosus*). Young sheep have a marginally higher percentage, possibly indicating a more vigorous acute response. Lymphocytes remain the predominant cell type, which is normal for sheep. The decrease in lymphocytes relative to neutrophils (compared to a non-infected state) is consistent with an inflammatory response. The adult sheep demonstrate a greater immune deficit,

as evidenced by their significantly lower WBC count (leukopenia). The young sheep appear to maintain a more functional WBC count. Young animals are generally expected to have a more robust immune response. The relatively higher WBC count in the young sheep suggests they are better able to mobilize leukocytes against the infection than the adult sheep, whose immune system appears suppressed. The findings of this study suggest that age does not spare sheep from the debilitating hematological effects of chronic foot rot, and adults may face a greater risk of immunosuppression (leukopenia) (Weiss, 2021).

Conclusion

Yankasa sheep, Ewes and adults were more infected with foot rot. There was generalized lymphocytosis and hypercalcemia generally in foot rot-infected sheep. The hematological and biochemical parameters were generally lowered in Ewes, and adults compared to Rams, and young sheep respectively.

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