



Hematological and Biochemical Dysregulation During Acute *Babesia ovis* Infection in Sheep

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ABSTRACT

Babesiosis, caused by *Babesia ovis*, is a significant tick-borne disease affecting small ruminants, characterized by hemolytic anemia, liver dysfunction, and metabolic imbalances. The current study aimed to investigate the clinical, hematological, and biochemical alterations linked to naturally occurring ovine babesiosis in the Shirvan-Salyan region of Azerbaijan. A total of 21 Garadolog-breed lambs, comprising 11 females and 10 males, all under 1 year old and weighing 15-18 kg, were purposively sampled from three farms. The present study included animals exhibiting clinical signs such as hyperthermia and anemia, as well as healthy animals from the same flocks for comparison. A total of 21 Garadolog sheep were examined, consisting of eight with severe clinical signs of babesiosis and thirteen that appeared healthy. Because clinical signs were observed in the flock, all animals underwent a thorough examination. Babesiosis was confirmed by microscopic examination of Giemsa-stained blood smears, and hematological as well as serum biochemical parameters were determined using automated analyzers. The infected sheep exhibited significant reductions in red blood cell count, hemoglobin concentration, hematocrit, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration, alongside leukocytosis, eosinophilia, and monocytosis, indicating severe hemolytic anemia. Blood smear examination revealed anisocytosis and poikilocytosis, indicating erythrocyte destruction and a regenerative response. Serum biochemical evaluation revealed elevated levels of bilirubin, blood urea nitrogen, creatinine, total cholesterol, and triglycerides, as well as increased levels of alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, and lactate dehydrogenase. Conversely, the levels of total protein, albumin, and globulin decreased, indicating compromised liver synthetic function and changes in protein metabolism. The present study demonstrated that acute *Babesia ovis* infection in Garadolog lambs was characterized by distinct clinical signs, including primarily hyperthermia, icterus, and significant parasitemia, alongside specific systemic disturbances.

Keywords: *Babesia ovis*, Biochemical parameter, Hemolytic anemia, Liver dysfunction, Metabolic disorder

INTRODUCTION

Babesia ovis (*B. ovis*), a protozoan hemoparasite belonging to the family Babesiidae and order Piroplasmida, is among the most widely distributed tick-borne pathogens in mammals (following *Trypanosoma* spp.) and the causative agent of ovine babesiosis, an economically important disease affecting sheep in the Mediterranean Basin, the Middle East, North Africa, and Central and Western Asia (Homer et al., 2000; Uilenberg, 2006). The disease is characterized by fever, hemolytic anemia, jaundice, hemoglobinuria, lethargy, and hepatic and renal dysfunction, resulting in reduced productivity, increased treatment costs, and mortality in severely affected animals (Schnittger et al., 2012).

The primary vectors of *B. ovis* are ticks of the genus *Rhipicephalus* (specifically *R. bursa* and *R. turanicus*), with *R. bursa* uniquely confirming transovarial transmission and playing a key role in parasite transmission (Bonnet et al., 2021; Martínez-García et al., 2021; Firat et al., 2024). Although other tick species are also evaluated as potential vectors, infection typically begins when infected ticks inoculate sporozoites into the host's bloodstream during blood feeding (Jalovecka et al., 2019).

Previous studies conducted in Azerbaijan indicated that pathological examinations of small ruminants that died from babesiosis often detect concurrent parasitic co-infections, including dicroceliosis, echinococcosis, and gastrointestinal and respiratory strongyloidiasis (Azizova, 2022). Recent studies indicated that babesiosis is a globally emerging infectious disease, with certain causative species spreading as their tick vectors expand their geographic range (Bajer et al., 2022). In 2015, the World Health Organization (WHO) recognized vector-borne diseases as a major public health issue (WHO, 2014). Although human babesiosis is relatively rare compared with other vector-borne diseases, its



incidence has been increasing worldwide in recent decades (Kumar et al., 2021). A global meta-analysis including 22 countries and 69 studies reported that human babesiosis increased between 2006 and 2021, indicating a high public health concern (Karshima et al., 2022). The emergence of zoonotic babesiosis in Asia is of particular concern and requires the implementation of appropriate control measures (Islam et al., 2022).

Microscopic analysis of Giemsa-stained blood smears is a vital, affordable, and rapid diagnostic method for field studies, even though molecular methods such as polymerase chain reaction (PCR) provide higher sensitivity. Furthermore, PCR can simultaneously assess parasitemia and erythrocyte morphology, underscoring its value for routine veterinary and epidemiological surveillance in resource-limited areas (Nyifi and Bilbonga, 2023; Sumbria et al., 2024).

Hematological and serum biochemical parameters are crucial for diagnosing ovine babesiosis (Esmaeilnejad et al., 2012). Similarly, serum biochemical markers, including elevated alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), bilirubin, blood urea nitrogen (BUN), and creatinine, along with oxidative stress markers, indicate hepatic and renal dysfunction. These markers are valuable for assessing disease severity and prognosis in babesiosis (Nevidnyk-Pravda and Ushakova, 2025). A recent study on Lohi sheep in Pakistan confirmed highly significant erythron alterations, along with marked changes in BUN, creatinine, and total bilirubin, in animals infected with *B. ovis* compared with uninfected controls (Sajid et al., 2023). Studies on bovine babesiosis confirmed the multiorgan impact of *Babesia* infection (Alqhtani et al., 2026). Epidemiological studies in Türkiye have consistently shown that ovine babesiosis is prevalent among sheep flocks (Dumanli et al., 1997; Aktaş et al., 2001; Emre et al., 2001; Çiçek et al., 2004; Ceylan and Sevinc, 2020).

Shirvan-Salyan region in Azerbaijan features a semi-arid climate, vast lowland pastures, and traditional sheep farming, creating favorable conditions for the maintenance of *Rhipicephalus* ticks and the spread of tick-borne diseases. By integrating multi-organ pathology with hematological and metabolic profiling in indigenous breeds, the present study addressed an important regional research gap and established the first reference framework to enhance the management and control of ovine babesiosis in Azerbaijan. Therefore, the present study aimed to investigate the clinical, hematological, and biochemical alterations associated with naturally occurring ovine babesiosis in local sheep within this endemic region.

MATERIALS AND METHODS

Ethical approval

The present study was carried out with the consent of the farm owners and in compliance with established animal welfare standards. Furthermore, the protocol was approved by the Ethics Committee of the Azerbaijan Veterinary Scientific Research Institute (Ministry of Agriculture of the Republic of Azerbaijan).

Study area and animal selection

This clinical and epidemiological study was conducted in the Shirvan-Salyan region of Azerbaijan. A total of 21 Garadolag-breed lambs, comprising 11 females and 10 males, all under 1 year old and weighing 15–18 kg, were purposively sampled from three farms. The present study included animals exhibiting clinical signs such as hyperthermia and anemia, as well as healthy animals from the same flocks for comparison. All animals were maintained under traditional pastoral conditions, including open grazing and communal watering. A clinical examination of the animals was conducted to assess their health status. Each sheep underwent a thorough physical examination prior to inclusion in the study, including assessment of body condition score, measurement of vital signs (heart rate, respiratory rate, rectal temperature), and examination of mucous membranes. These assessments ensured the absence of clinical abnormalities and infectious diseases. The study population was divided into two distinct groups. The infected group consisted of eight sheep (6 females and 2 males) that exhibited clinical signs of acute babesiosis, including hyperthermia, icterus, and lethargy, which were subsequently confirmed by microscopic examination. The control group comprised 13 sheep (5 females, 8 males) that were clinically healthy and tested negative for hemoparasites. The adequacy of the sample size was assessed using a power analysis in G*Power to ensure statistical reliability according to Formula 1 (Faul et al., 2007).

$$1 - \beta = 0.80, \alpha = 0.05 \text{ (Formula 1)}$$

In this study, statistical significance was determined using a significance level of $\alpha = 0.05$, which represents the probability of making a Type I error—that is, incorrectly rejecting a true null hypothesis (a false positive). A Type II error, denoted by β , represents the probability of failing to reject a false null hypothesis (a false negative). The expression $1 - \beta = 0.80$ indicates that the statistical power of the test is 80%, meaning there is an 80% probability of correctly detecting a true effect or difference when one actually exists.

Sample collection and microscopic examination

The diagnosis of ovine babesiosis was based on clinical findings and microscopic examination of Giemsa-stained thin blood smears (Suleiman and Al-lahaibi, 2024). In clinical screening, sheep exhibiting one or more of the following signs- including a rectal temperature exceeding 40.5°C, pale or icteric mucous membranes, lethargy, anemia, and generalized weakness were suspected of babesiosis. Blood samples of approximately 5 mL were obtained from all animals via jugular venipuncture. The samples were collected into EDTA-K3 tubes for hematological examination and into plain tubes for serum biochemistry analysis. For parasitological verification, thin blood smears were prepared from capillary blood obtained from the ear vein of each individual. These smears were air-dried, fixed in 100% methanol for 5 minutes, and subsequently stained with a 10% Giemsa solution (pH 7.2) for 30 minutes. Preparations were examined at 1000× magnification using a Bell light microscope (Bell Technologies, Italy). *Babesia ovis* identification was based on its characteristic paired, obtuse-angled pyriform morphology, following established diagnostic criteria (Uilenberg, 2006; OIE, 2018). Clinically healthy sheep with negative blood smears for *Babesia ovis* served as the control group. Furthermore, ticks were collected from the ears, perineum, and axillary regions of infected animals and identified as *R. bursa* using established taxonomic features (Walker et al., 2003).

Hematological profiling

Hematological analysis was performed within 4 hours post-collection using a calibrated Mindray BC-3000 Plus automated analyzer (Mindray Bio-Medical Electronics Co., Shenzhen, China). Measured parameters included white blood cell (WBC), red blood cell (RBC), hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). Differential leukocyte counts were performed automatically and confirmed by manual microscopic examination of stained smears, following established veterinary diagnostic protocols (Meyer and Harvey, 2004; Weiss and Wardrop, 2010).

Biochemical assays

Serum was separated by centrifugation at 3000×g for 10 minutes at room temperature and stored at -20°C until analysis. Serum biochemical profiles were measured using a Mindray BS-120 Vet automated clinical chemistry analyzer (Shenzhen, China). Diagnostic kits manufactured by BioSystems S.A. (Barcelona, Spain) were used for all analyses, strictly following the manufacturer's analytical protocols. The biochemical assessment measured total protein using the Total Protein kit (BioSystems, Barcelona, Spain) and albumin using the Albumin kit (BioSystems, Barcelona, Spain), with globulin calculated as the difference between total protein and albumin. Total and direct bilirubin concentrations were measured directly using BioSystems bilirubin assay kits, whereas indirect bilirubin was calculated as the difference between total and direct bilirubin. Renal function, lipid metabolism, and hepatic enzymes were assessed by measuring BUN, creatinine, total cholesterol, triglycerides, ALT, AST, ALP, and lactate dehydrogenase (LDH) concentrations using commercial enzymatic colorimetric kits from BioSystems S.A. (Barcelona, Spain), strictly following the manufacturer's analytical protocols.

Statistical analysis

Statistical analysis was performed using SPSS (version 13.0, Chicago, IL, USA). Data were presented as mean ± standard deviation (SD). The Shapiro-Wilk test was applied to assess normality. The independent Student's t-test was used to compare the infected and control groups, while Pearson's correlation coefficient (r) was used to assess relationships between hematological variables and liver/renal biomarkers. Results were considered statistically significant at p-value less than 0.05.

RESULTS

Clinical parameters, including heart rate, respiratory rate, and rectal temperature, were obtained from eight sheep naturally infected with *B. ovis* and compared with those of 13 clinically healthy sheep in the control group. The normal physiological ranges for these parameters were interpreted according to established veterinary reference values (Radostits et al., 2007; Constable et al., 2017). There was a significant disparity in clinical parameters between infected and healthy sheep. Animals with babesiosis exhibited elevated heart rates, respiratory rates, and body temperatures; clinically apparent jaundice was also observed (Table 1). All clinical parameters were significantly higher in the infected sheep than in the healthy controls ($p < 0.05$).

Microscopic examination of Giemsa-stained peripheral blood smears obtained from sheep exhibiting clinical suspicion of babesiosis demonstrated the presence of ring-shaped *B. ovis* parasites, approximately 1.2-2.2 µm in size, as well as paired pyriform *B. ovis* parasites, approximately 1.3-2.6 µm in size, within erythrocytes (Figure 1).

Hematological and biochemical profiles were compared between sheep infected with *B. ovis* and healthy ones (Table 2). Compared with the control group, sheep naturally infected with *B. ovis* demonstrated significantly higher total

leukocyte (WBC) and eosinophil counts ($p < 0.05$). In contrast, RBC, HCT, Hb, PCV, and MCH counts were significantly reduced in sheep infected with *B. ovis* compared to the healthy sheep ($p < 0.05$). No significant differences were observed in lymphocyte, monocyte, MCV, or MCHC counts between the groups ($p > 0.05$). A significant decrease in the neutrophil percentage was observed in the infected sheep compared with the control group ($p < 0.05$). In addition, microscopic examination of peripheral blood smears from sick animals revealed morphological changes in erythrocytes, including anisocytosis and poikilocytosis (Figure 2).

Serum biochemical parameters for all sheep were evaluated (Table 3). Significant increases in total, direct, and indirect bilirubin, BUN, creatinine, ALT, AST, ALP, and LDH were observed in naturally infected sheep ($p < 0.05$), indicating hemolysis with concurrent hepatic and renal dysfunction. In contrast, total protein, globulin, cholesterol, triglyceride did not differ significantly between infected and healthy sheep ($p > 0.05$). Serum albumin concentration was significantly lower in infected sheep (3.53 ± 0.24 g/dL) than in healthy controls (4.33 ± 0.11 g/dL; $p < 0.05$).

Table 1. Clinical parameters of naturally *Babesia ovis*-infected sheep and healthy control sheep in the Shirvan-Salyan region of Azerbaijan during June 2023

Parameters	Healthy sheep	Infected sheep	p-value
Heartbeat /minuts	78.57 ± 12.49	116.82 ± 7.39	< 0.05
Respiratory rate /minuts	26.94 ± 5.46	58.25 ± 2.43	< 0.05
Body temperature /°C	39.33 ± 0.16	40.89 ± 0.92	< 0.05

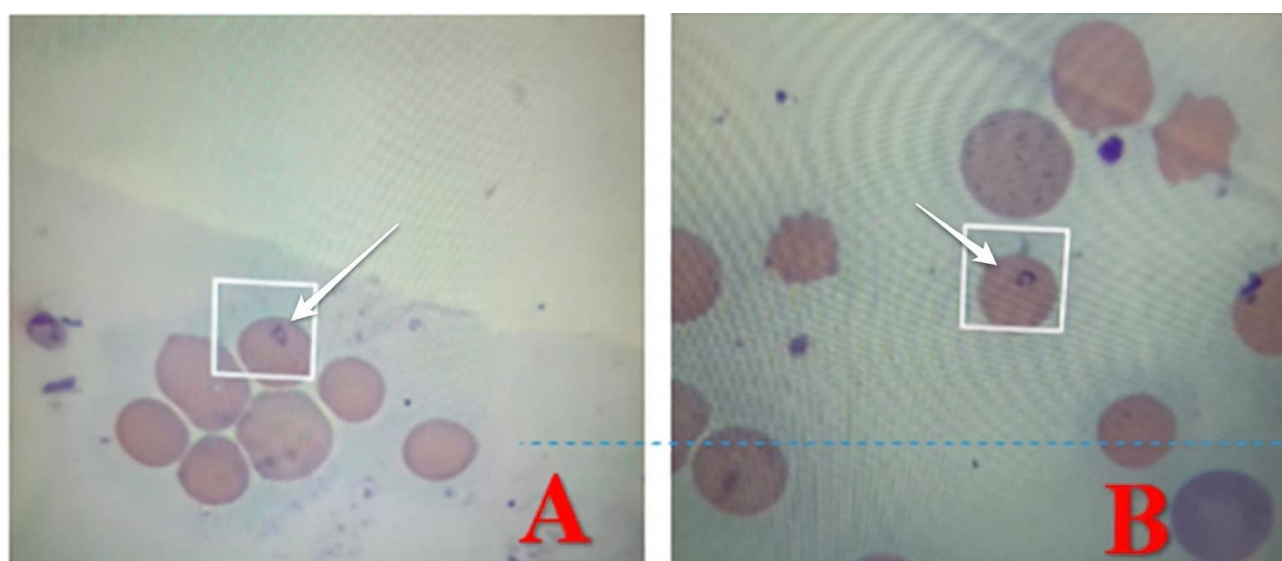


Figure 1. *Babesia ovis* in Garadolog lamb erythrocytes. **A:** Typical acute-stage paired pear-shaped merozoites from Garadolog lambs in the Shirvan-Salyan region of Azerbaijan (Giemsa stain, 1000 $\times$ magnification); **B:** Microphotograph of *Babesia ovis* ring-shaped forms within erythrocytes. The small, round trophozoites, and some showing chromatin dots (Giemsa staining, 1000 $\times$ magnification).

Table 2. Hematological parameters of naturally *Babesia ovis*-infected sheep and healthy sheep in the Shirvan-Salyan region of Azerbaijan, June 2023

Parameters	Healthy sheep	Infected sheep	p-value
WBC ($10^9/\mu\text{L}$)	8.92 ± 3.14	12.31 ± 2.88	< 0.05
Lymphocytes (%)	65.75 ± 2.13	62.40 ± 2.65	> 0.05
Monocytes (%)	2.20 ± 0.02	2.60 ± 0.10	> 0.05
Neutrophils (%)	30.42 ± 1.25	24.19 ± 1.34	< 0.05
Eosinophils (%)	5.40 ± 0.23	8.30 ± 0.12	< 0.05
RBC ($10^6/\mu\text{L}$)	6.73 ± 0.84	3.42 ± 0.99	< 0.05
MCV (fL)	37.40 ± 1.65	39.74 ± 0.86	> 0.05
HCT (%)	26.40 ± 4.51	20.30 ± 5.74	< 0.05
Hb (g/dL)	11.70 ± 1.13	6.98 ± 0.85	< 0.05
PCV (%)	31.40 ± 2.34	22.73 ± 1.77	< 0.05
MCHC (g/dL)	32.50 ± 6.30	28.20 ± 5.40	> 0.05
MCH (pg)	13.90 ± 0.44	10.40 ± 0.21	< 0.05

WBC: White blood cells, RBC: Red blood cells, MCV: Mean corpuscular volume, HCT: Hematocrit, Hb: Hemoglobin, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration. Data are expressed as mean $\pm$ SD. Statistical significance was defined as $p < 0.05$, with $p > 0.05$ denoting lack of statistical significance.

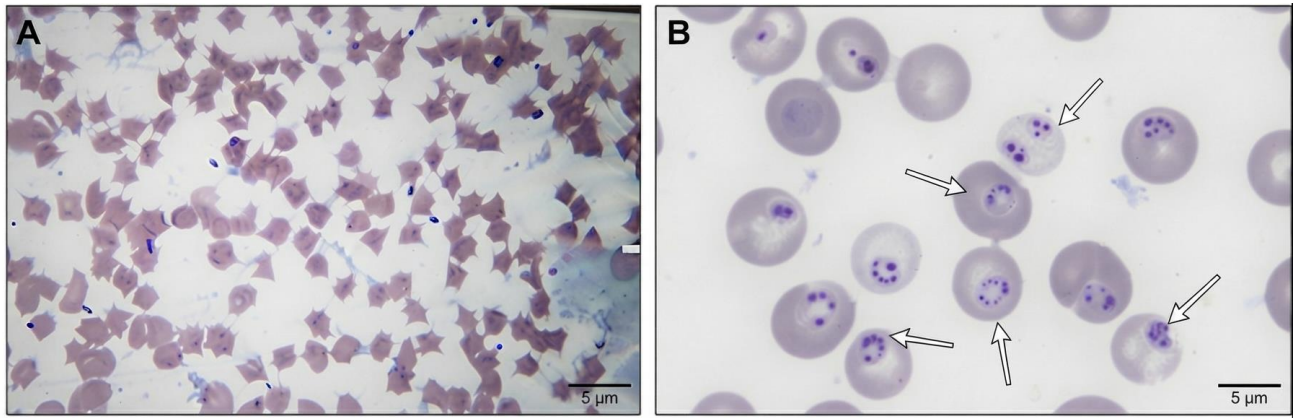


Figure 2. Anisocytosis and poikilocytosis in erythrocytes of a Garadolog lamb infected with *Babesia ovis* from the Shirvan-Salyan region of Azerbaijan (Giemsa stain, 1000× magnification).

Table 3. Biochemical parameters of naturally *Babesia ovis*-infected sheep and healthy control sheep in the Shirvan-Salyan region of Azerbaijan, June 2023

Parameters	Healthy sheep	Sick sheep	p-value
Total protein (g/d)	6.33 ± 0.82	5.87 ± 0.77	> 0.05
Total bilirubin (mg/dL)	0.42 ± 0.23	1.58 ± 0.34	< 0.05
Direct bilirubin (mg/dL)	0.25 ± 0.14	0.44 ± 0.17	< 0.05
Indirect bilirubin (mg/dL)	0.13 ± 0.15	1.29 ± 0.14	< 0.05
Albumin (g/dL)	4.33 ± 0.11	3.53 ± 0.24	< 0.05
Globulin (g/dL)	2.75 ± 0.66	1.64 ± 0.31	> 0.05
Creatinine (mg/dL)	1.41 ± 0.32	1.82 ± 0.43	< 0.05
BUN (mg/dL)	24.73 ± 1.67	57.93 ± 4.22	< 0.05
Cholesterol (mg/dL)	4.81 ± 1.19	5.52 ± 1.08	> 0.05
Triglyceride (mg/dL)	5.72 ± 1.32	5.98 ± 1.24	> 0.05
ALT (U/L)	28.84 ± 3.29	34.49 ± 1.45	< 0.05
AST (U/L)	144.28 ± 11.76	196.82 ± 18.84	< 0.05
ALP (U/L)	118.3 ± 5.53	286.8 ± 8.37	< 0.05
LDH (U/L)	353.4 ± 21.32	469.7 ± 28.86	< 0.05

BUN: Blood urea nitrogen, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, ALP: Alkaline phosphatase, LDH: Lactate dehydrogenase. Data are expressed as mean ± SD. Statistical significance is indicated by $p < 0.05$, non-statistical significance by $p > 0.05$.

DISCUSSION

Babesia ovis infection caused notable hematological changes in the affected sheep. Infected animals exhibited notably lower RBC, Hb, and HCT levels than healthy controls, while their MCV was markedly higher. These observations were aligned with previous findings on small ruminants in Khorasan province, Iran, and Eastern Turkey (Ceylan, 2020; Razmi, 2022; Ulucesme et al., 2023). Similar hematological alterations, including reductions in RBC count and Hb concentration, have been reported in horses infected with *Theileria equi* (formerly *Babesia equi*) and in dogs infected with *Babesia gibsoni* (Karasová et al., 2022; Salinas-Estrella et al., 2022).

The mean rectal temperature of the healthy control sheep ($39.33 \pm 0.16^\circ\text{C}$) was within the normal physiological range reported for sheep ($38.3\text{--}39.9^\circ\text{C}$). The rectal temperature in healthy lambs, though within normal limits, aligns with the slightly elevated basal metabolic rate typical of young animals compared to adult sheep (Radostits et al., 2007; Constable et al., 2017). The relatively high value could be due to environmental factors during sampling, as animals were observed in the semi-arid Shirvan-Salyan region during the warm season. Furthermore, handling and restraint prior to blood collection may have caused temporary stress, resulting in a slight elevation in rectal temperature (Merck and Co., Inc., 2024). The hematological findings in the present study were consistent with previous reports regarding erythrocyte-related parameters in *B. ovis*-infected animals. The notable reductions in RBC count, Hb, and HCT levels confirmed the anemic characteristic of ovine babesiosis, aligning with findings reported in naturally and experimentally infected sheep (Esmailnejad et al., 2012; Sajid et al., 2023). In contrast, leukocyte responses, particularly neutrophil alterations, were not consistent across studies. While some investigations have reported increased neutrophil counts during *B. ovis* infection, the present study demonstrated a remarkable reduction in neutrophil percentage, indicating that the leukocyte response may vary according to infection stage, parasite burden, host-related factors, and the timing of sample collection (Esmailnejad et al., 2012; Haq et al., 2021; Korelidou et al., 2026). Differences in study design, such as using naturally versus experimentally infected animals, and in infection duration and severity may also lead to disparities in leukocyte

profiles. Therefore, the consistent decrease in erythrocyte-related parameters across studies indicated that anemia is a relatively stable hematological characteristic of *B. ovis* infection. In contrast, changes in leukocyte and neutrophil levels are more variable and might indicate the host's dynamic response to the infection.

The anemia associated with *B. ovis* infection is primarily attributed to intravascular and extravascular hemolysis, as well as to immune-mediated erythrocyte destruction triggered by antibodies against erythrocyte membrane antigens (Zahidullah et al., 2023). The detection of anisocytosis and poikilocytosis in blood smears was consistent with regenerative hemolytic anemia and indicated increased erythrocyte production. The increase in MCV may result from the release of larger immature erythrocytes (reticulocytes) from the bone marrow during recovery from anemia. Meanwhile, the decrease in MCHC level was associated with the lower Hb concentration of these immature cells (Abdalla et al., 2020; Sajid et al., 2023). Therefore, these findings indicated that anemia in *B. ovis* infection results from both intravascular and extravascular hemolysis, accompanied by immune-mediated erythrocyte destruction and increased erythrophagocytosis by macrophages (Tufani et al., 2017; Djokic et al., 2021). These hematological changes reflected the pathophysiological response to *B. ovis* infection.

The observed biochemical alterations indicate hepatic dysfunction, impaired renal function, and systemic metabolic disturbances associated with *B. ovis* infection. Similar increases in serum bilirubin, BUN, creatinine, and hepatic enzyme activities, with decreases in serum protein concentrations, have been reported in naturally and experimentally infected sheep with *B. ovis* (Esmaeilnejad et al., 2012; Sevinc et al., 2013). The biochemical profile observed in the present study indicated that *B. ovis* infection was associated with systemic metabolic alterations involving renal function, lipid metabolism, and serum protein homeostasis. The notable increases in serum creatinine, cholesterol, and triglyceride concentrations were consistent with the findings of Bozan et al. (2024) in sheep with babesiosis, supporting the occurrence of renal and metabolic disturbances during infection. Elevated creatinine and BUN levels may indicate impaired kidney function caused by hemoglobin-related kidney injury, decreased renal blood flow due to anemia, or dehydration. Similarly, the increases in cholesterol and triglycerides may indicate altered lipid metabolism and reduced lipid clearance in response to hepatic dysfunction and systemic inflammation (Sivajothi et al., 2022). Alterations in serum protein concentrations supported the systemic inflammatory and metabolic effects of babesiosis. Some studies have reported elevated total protein and globulin concentrations; these differences among studies may be attributable to disease stage, parasite load, and the intensity of the host's immune response (Adewumi et al., 2022; Salinas-Estrella et al., 2022). In contrast, the reduction in albumin concentration observed in the present study was consistent with the negative acute-phase response during babesiosis and may be associated with impaired hepatic protein synthesis and reduced feed intake during the acute stage of infection (Kuleš et al., 2021). Therefore, the current findings indicated that the biochemical response to *B. ovis* infection was not limited to hemolysis but also encompassed renal dysfunction, hepatic and lipid metabolic disturbances, systemic inflammation, and nutritional alterations.

Mortality was observed in lambs aged 5 to 6 months, accompanied by severe anorexia, indicating that young animals are especially vulnerable to the systemic effects of *B. ovis* infection. Similar pathological mechanisms have been documented in naturally and experimentally infected sheep. *Babesia ovis* infection results in more severe clinical signs and a less favorable prognosis in lambs than in adult sheep (Sevinc et al., 2013). The hematological and biochemical changes observed in the present study were consistent with the findings of Esmaeilnejad et al. (2012), who reported that progressive hemolysis led to hepatic dysfunction, renal impairment, and metabolic disturbances in ovine babesiosis.

CONCLUSION

Babesia ovis is a significant etiological agent of ovine babesiosis in Azerbaijan. The current study demonstrated that sheep naturally infected with this pathogen exhibited notable hematological and biochemical changes, including anemia, elevated bilirubin levels, increased BUN and creatinine, elevated hepatic enzyme activities, elevated lipid levels, and decreased serum protein concentrations and erythrocyte indices. The current findings indicated hemolysis, hepatic dysfunction, altered renal function, and systemic metabolic disturbances associated with *B. ovis* infection. The combined evaluation of clinical signs, hematological and serum biochemical parameters improved the diagnosis and clinical assessment of ovine babesiosis and provided baseline data for disease monitoring in endemic areas of Azerbaijan. Therefore more study should be conducted in different regions of Azerbaijan to evaluate *Babesia ovis* hematological and biochemical dysregulation.

DECLARATIONS

Authors' contributions

Aygun Azizova contributed to the design, conceptualization, collection of samples, sample analysis, and manuscript preparation. Ugur Uslu participated in the statistical analysis and drafting of the manuscript. Gular Mammadova was

involved in sample collection, sample analysis, and manuscript writing. Elnura Aslanova contributed to the design and manuscript preparation. Yusif Yusifli participated in sample collection. All authors have reviewed and approved the final edition of the manuscript.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available upon reasonable request from the corresponding author.

Competing interests

The authors declare no conflicts of interest regarding the publication of this manuscript. There are no financial, personal, or professional relationships with individuals or organizations that could have inappropriately influenced or biased the findings presented in this work.

Ethical considerations

The authors declared that this manuscript is original, has not been published previously, and is not under consideration for publication elsewhere. All authors have read and approved the final version of the manuscript and agree to its submission. The use of artificial intelligence (AI)-assisted tools (Grammarly) was limited to language editing and readability improvements. All authors critically reviewed and revised the AI-edited language edition of the manuscript and the final manuscript, and take full responsibility for their accuracy, originality, and integrity before submission and accepted manuscript before publication.

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