INNSPUB

**International Journal of Biosciences | IJB |**
**ISSN: 2220-6655 (Print); 2222-5234 (Online)**
**Website: https://www.innspub.net**
**Email contact: info@innspub.net**
**Vol. 28, Issue: 3, p. 13-21, 2026**

RESEARCH PAPER OPEN ACCESS

# Pathophysiological mechanisms, clinical outcomes and hematobiochemical alterations in sheep infected with mono-infections and co-infections of *Dicrocoelium lanceatum* in Azerbaijan

**Aygun A. Azizova*, Mahir N. Nasibov**

*Veterinary Scientific Research İnstitute, Ministry of Agriculture of the Republic of Azerbaijan, Baku, Azerbaijan*

**Key words:** *Babesia ovis*, *Dicrocoelium lanceatum*, Mono and associative invasion, Biochemical parameters, Hematological parameters

**Received:** February 15, 2026 **Accepted:** February 27, 2026 **Published:** March 04, 2026

**DOI:** https://dx.doi.org/10.12692/ijb/28.3.13-21

**ABSTRACT**

Dicroceliosis is an important parasitic disease of small ruminants that can cause significant physiological disturbances and economic losses. The present study investigated the pathophysiological mechanisms, clinical outcomes, and hematobiochemical alterations in sheep naturally infected with *Dicrocoelium lanceatum*, including cases with concurrent babesiosis. A total of 120 sheep were examined, of which 39 animals were infected with *D. lanceatum*. Hematological analysis in mono-infected sheep revealed slight reductions in hemoglobin (53.69 ± 5.75 g/dl) compared with healthy animals (56.81 ± 11.34 g/dl), as well as decreases in packed cell volume (34.62 ± 5.01% vs 38.52 ± 7.75%) and mean corpuscular volume (65.51 ± 8.11 vs 69.71 ± 11.92 fL). White blood cell counts showed only minor variation (12.31 ± 1.94 $\times 10^3$/µl in infected sheep vs 12.15 ± 1.88 $\times 10^3$/µl in healthy animals). In contrast, sheep with concurrent infection of *D. lanceatum* and *Babesia ovis* exhibited more pronounced hematological and biochemical disturbances. In co-infected animals, white blood cell counts increased markedly (16.8–28.2 $\times 10^3$/µl) compared with healthy sheep (8.4–14.6 $\times 10^3$/µl), while hemoglobin levels decreased to 3.8–5.6 g/dl. Biochemical analysis revealed elevated liver enzyme activities, including AST (116–309 U/L) and ALP (136–454 U/L), along with increased total bilirubin levels (0.1–1.1 mg/dl) and decreased albumin concentrations (1.9–2.5 g/dl). These findings indicate that while mono-infection with *D. lanceatum* induces moderate hematological alterations, concurrent infection with babesiosis leads to severe systemic disturbances characterized by anemia, leukocytosis, and hepatic dysfunction. Early diagnosis and integrated parasite control strategies are therefore essential to reduce disease severity and associated economic losses in sheep production.

***Corresponding author:** Aygun A. Azizova ✉ azizova_aygun@inbox.ru

## INTRODUCTION

Parasitic diseases represent a major constraint to sheep production worldwide, causing substantial economic losses through reduced productivity, increased mortality, and treatment costs. In Azerbaijan, particularly in the Shirvan–Salyan economic region, parasitic infections remain a serious problem for small ruminant farming systems. Epidemiological investigations have shown that babesiosis and dicroceliosis are among the most prevalent and clinically significant parasitic diseases in sheep, with peak incidence observed during the spring and summer seasons. These infections frequently result in considerable morbidity and mortality, especially in lambs (Azizova, 2024).

Babesiosis, caused by the hemoprotozoan parasite *Babesia ovis*, is a tick-borne disease characterized by severe hemolytic anemia, fever, jaundice, and lethargy. The disease primarily affects young animals and may lead to significant pathological changes in internal organs. Post-mortem examinations of lambs aged 6–8 months have shown that babesiosis often occurs either as a mono-infection or in association with other parasitic diseases such as dicroceliosis in animals up to one year of age. In such cases, heavy parasite burdens of *B. ovis* and *Dicrocoelium lanceatum* are commonly detected in organs including the spleen and liver.

Clinically, babesiosis is manifested by pallor of mucous membranes, hemoglobinuria, splenomegaly, and decreased body weight gain. Hematological abnormalities, including reductions in hemoglobin concentration, packed cell volume, and red blood cell counts, reflect the intensity of hemolysis caused by the parasite. In addition, immunosuppression associated with babesiosis increases the susceptibility of infected animals to secondary infections. When babesiosis occurs concurrently with dicroceliosis, these pathological and physiological disturbances may become more severe, leading to further deterioration of the animal's health status.

Dicroceliosis, caused by the trematode *D. lanceatum*, is another widespread parasitic disease affecting domestic and wild ruminants. The parasite has a complex life cycle involving two intermediate hosts, terrestrial snails and ants, which play an important role in the environmental transmission of infective stages (Ansari-Lari and Moazzeni, 2006). Infection with *D. lanceatum* is associated with chronic disease characterized by reduced growth, decreased production of meat, milk, and wool, and impaired immune function. In severe cases, infection may lead to mortality and significant economic losses in livestock production systems. The pathological effects of dicroceliosis mainly involve damage to the liver and bile ducts, resulting from both mechanical irritations caused by the parasites and the toxic metabolic products they release (Manga-González and Ferreras, 2014). Biochemical disturbances commonly observed in infected animals include elevated activities of liver enzymes such as AST, ALT, GGT, and ALP, as well as alterations in albumin and bilirubin levels. Hematological changes may also occur, including leukocytosis, neutrophilia, and lymphopenia (Gonzalez-Lanza *et al.*, 2000; Otranto and Traversa, 2002).

Recent advances in diagnostic techniques have improved the detection of parasitic infections in sheep. In addition to conventional microscopic identification of trematode eggs, modern immunological methods such as enzyme-linked immunosorbent assay (ELISA) and immunoelectrophoresis have been introduced, enhancing the accuracy and reliability of dicroceliosis diagnosis (Duchacek and Lamka, 2003). Effective control of these parasitic diseases requires comprehensive monitoring programs and targeted intervention strategies to reduce their prevalence and impact on sheep health and productivity. Previous studies conducted in Azerbaijan have highlighted the importance of integrated approaches for the management and prevention of babesiosis and dicroceliosis in sheep populations (Azizova, 2024; Mammadova and Azizova, 2025; Mammadova *et al.*, 2025).

Therefore, the aim of the present study was to investigate the clinical manifestations, pathophysiological mechanisms, and hematobiochemical alterations in sheep infected with

mono- and co-infections of *Dicrocoelium lanceatum* and Babesia ovis, with particular emphasis on evaluating changes in key blood parameters associated with associative invasion.

## MATERIALS AND METHODS

### Study area and animals

The study was conducted on sheep raised in farms located in the study region where parasitic infections are commonly reported. A total of 120 sheep of different ages and both sexes were included in the investigation. The animals were examined clinically and categorized based on their health status and parasitological findings. Sheep showing signs consistent with parasitic infection were selected for further laboratory examination, while clinically healthy animals served as the control group.

### Clinical examination

All animals were subjected to a detailed clinical examination. General physical condition, mucous membrane color, body temperature, appetite, and other visible signs of disease were evaluated. Particular attention was given to symptoms commonly associated with babesiosis and dicroceliosis, including weakness, anemia, emaciation, and signs of hepatic dysfunction.

### Parasitological examination

Diagnosis of parasitic infection was confirmed using standard parasitological techniques. Fecal samples were collected directly from the rectum of each animal and examined for the presence of Dicrocoelium lanceatum eggs using sedimentation methods. Blood samples were also examined microscopically for the detection of Babesia ovis using thin blood smears stained with Giemsa stain. Animals found positive for both parasites were classified as having associative invasion, while animals infected with only one parasite were classified as mono-infected.

### Blood sampling

Blood samples were collected from the jugular vein of each animal using sterile disposable needles and vacuum tubes. Two types of samples were obtained. Blood collected into tubes containing anticoagulant (EDTA) was used for hematological analysis, whereas blood collected into plain tubes was allowed to clot and then centrifuged to obtain serum for biochemical analysis.

### Hematological analysis

Hematological parameters were determined using standard laboratory methods. The parameters analyzed included hemoglobin concentration (Hb), red blood cell count (RBC), white blood cell count (WBC), and erythrocyte sedimentation rate (ESR). These indicators were used to assess the degree of anemia, inflammatory response, and overall hematological status of the animals.

### Biochemical analysis

Serum biochemical parameters were measured to evaluate liver function and metabolic disturbances associated with parasitic infection. Particular emphasis was placed on liver enzymes and bilirubin levels, including alkaline phosphatase (ALP) and total bilirubin, which are commonly used indicators of hepatic damage and hemolysis.

### Statistical analysis

The obtained hematological and biochemical data were analyzed using standard statistical methods. Results were expressed as ranges or mean and standard deviation values where appropriate. Comparisons between healthy and infected animals were performed to identify significant changes associated with parasitic infection. The analyzed parameters were summarized and presented in tables to illustrate the observed hematobiochemical alterations.

## RESULTS

A total of 120 sheep were examined during the study. Among them, 39 animals were infected with *Dicrocoelium lanceatum*, whereas 91 sheep were clinically healthy. Hematological and biochemical parameters of the healthy and infected animals were analyzed and are summarized in Tables 1–5.

**Hematological alterations in sheep with *Dicrocoelium lanceatum* infection**

The hematological profiles of healthy and infected sheep are presented in Table 1. Noticeable differences were observed between the two groups. Hemoglobin (Hb) values were slightly lower in infected animals (53.69 ± 5.75 g/dl) compared with healthy sheep (56.81 ± 11.34 g/dl). Red blood cell (RBC) counts showed minor variation between groups, with values of 5.75 ± 1.06 ×10⁶/µl in infected sheep and 5.64 ± 0.99 ×10⁶/µl in healthy animals.

Leukocyte parameters demonstrated more pronounced changes. White blood cell (WBC) counts tended to increase in infected sheep, indicating hematological alterations associated with the parasitic infection. Variations were also observed in lymphocyte and other leukocyte fractions when compared with healthy animals.

**Table 1.** The hematological parameters of sheep infected with *D. lanceatum* (comparison with healthy sheep)

| Parameters | | Healthy sheep (n=91) | Sick sheep (n=39) |
|---|---|---|---|
| Hb (g/dl) | | 56.81 ±11.34 | 53.69±5.75 |
| RBC(x10⁶/µl) | | 5.64 ±0.99 | 5.75±1.06 |
| PCV (%) | | 38.52 ±7.75 | 34.62±5.01 |
| MCV (fl) | | 69.71 ±11.92 | 65.51±8.11 |
| MCH (pg) | | 104.31 ±17.00 | 94.53±10.54 |
| MCHC (g/dl) | | 149.43 ±11.35 | 148.66±10.25 |
| WBC (10³/µL) | | 12.15 ±1.88 | 12.31±1.94 |
| White cell parameters | Lymphocytes | 37.91 ±4.66 | 36.72±4.74 |
| | Monocytes | 4.31 ±1.93 | 4.11±1.91 |
| | Eosinophils | 15.62 ±3.65 | 15.94±2.72 |
| | Basophils | 0 | 0 |
| | Neutrophils | 41.52 ±3.78 | 41.06±3.21 |

**Table 2.** The biochemical parameters of sheep infected with *D. lanceatum* (compared to healthy sheep)

| Parameters | Healthy sheep (n=91) | Sick sheep (n=39) |
|---|---|---|
| Total protein (g/dL) | 9.00 ± 1.56 | 8.65±1.35 |
| Albumin (g/dL) | 2.62 ± 1.21 | 4.53±0.67 |
| BUN (mg/dL) | 25.38 ± 6.09 | 24.26±6.45 |
| Creatinine (mg/dL) | 0.77± 0.29 | 0.83±0.31 |
| Total Bilirubin(mg/dL) | 0.78 ± 0.31 | 0.81±0.32 |
| Direct Bilirubin(mg/dL) | 0.24 ± 0.12 | 0.24±0.12 |
| Alkaline phosphatase (ALP) | 180.96 ±4.11 | 187.15±76.52 |
| Alanine aminotransferase (ALT) (U/I) | 28.12 ± 15.72 | 30.01±15.61 |
| Aspartate aminotransferase | 130.96 ±4.75 | 142.14±43.53 |
| γ-glutamyl transferase (GGT)(U/I) | 25.35 ± 4.46 | 25.12±4.33 |
| Lactate dehydrogenase(LDH) (U/I) | 736.17 ±105.86 | 701.82 ± 77.69 |

**Biochemical parameters in mono-infection**

Biochemical indicators of healthy and infected sheep are summarized in Table 2. Total protein levels showed a slight decrease in infected animals (8.65 ± 1.35 g/dL) compared with healthy sheep (9.00 ± 1.56 g/dL). Albumin concentrations demonstrated noticeable variation between groups, with higher mean values recorded in infected sheep (4.53 ± 0.67 g/dL) compared with healthy animals (2.62 ± 1.21 g/dL).

Additional biochemical indicators associated with liver function also showed measurable differences between healthy and infected animals, suggesting physiological alterations associated with the parasitic infection.

**Hematological changes in sheep with associative infection**

A subset of animals was diagnosed with mixed infection of *Babesia ovis* and *Dicrocoelium lanceatum*. Hematological parameters of these animals are presented in Table 3. Compared with healthy sheep, animals with associative infection exhibited marked hematological disturbances.

**Table 3.** The hematological parameters of sheep in association invasion with *D. lanceatum* and *B. ovis* (comparison with healthy sheep)

| Parameters | Healthy sheep (n=15) | Sick sheep (n=9) |
|---|---|---|
| WBC ($10^3$/μL) | 8.4-14.6 | 16.8-28.2 |
| Lymphocytes (%) | 17-56 | 12-44 |
| Monocytes (%) | 0-8 | 1-9,2 |
| Neutrophils (%) | 34-61 | 25-52 |
| Eosinophils (%) | 0-24 | 3.3-27.5 |
| RBC ($10^6$/μL) | 4.4-7.7 | 2.1-3.6 |
| MCV (fL) | 52.94-120.83 | 55.64-123.75 |
| HCT (%) | 25-38 | 8.6-11.3 |
| Hb (g/dl) | 9.0-14.0 | 3.8-5.6 |
| PCV (%) | 30-58 | 12-39 |
| MCHC (g/dL) | 113.4-169.5 | 106.1-161.3 |
| MCH (pg) | 58.6-163.6 | 49.4-155.2 |

**Table 4.** The biochemical parameters of sheep in associative invasion with *D. lanceatum* and *B. ovis* (compared with healthy sheep)

| Parameters | Healthy sheep (n=15) | Sick sheep (n=9) |
|---|---|---|
| Total protein g/d | 6.0 – 7.7 | 5.2-7.1 |
| Total Bilirubin (mg/dl | 0-0.5 | 0.1-1.1 |
| Direct Bilirubin (mg/dl) | 0-0.27 | 0.2-0.56 |
| Indirect Bilirubin (mg/dl) | 0-0.12 | 0.3-1.2 |
| Albumin g/dl | 2.4-3 | 1.9-2.5 |
| Globulin g/dl | 3.5-5.7 | 2.3-4.4 |
| Creatinine mg/dl | 1.2-1.9 | 1.8-2.7 |
| BUN | 8–21 | 15-36 |
| Alanine aminotransferase (ALT) (U/L) | 24-35 | 29-41 |
| Aspartate aminotransferase (AST) | 60–280 | 116-309 |
| Alkaline phosphatase (ALP) | 68–387 | 136-454 |
| LDH (U/L) | 238–440 | 264-476 |

White blood cell counts in infected sheep ranged between 16.8 and 28.2 ×$10^3$/μL, which was considerably higher than the range observed in healthy animals (8.4–14.6 ×$10^3$/μL). Lymphocyte percentages also differed between groups, ranging from 12–44% in infected animals compared with 17–56% in healthy sheep.

**Biochemical alterations in associative infection**

Biochemical parameters associated with mixed infection are presented in Table 4. Total protein values in infected sheep ranged from 5.2–7.1 g/dL, whereas healthy animals showed slightly higher levels (6.0–7.7 g/dL).

Similarly, total bilirubin concentrations varied between groups. In infected animals, values ranged from 0.1–1.1 mg/dL, while healthy sheep showed lower values (0–0.5 mg/dL).

**Hematobiochemical alterations during associative invasion**

The analysis of blood parameters during associative invasion with babesiosis and dicroceliosis revealed pronounced hematological and biochemical disturbances (Table 5). Hemoglobin levels showed a critical decrease, declining from 9.0–14.0 g/dl in healthy animals to 3.8–5.6 g/dl in infected sheep. This reduction is associated with erythrocyte destruction caused by blood parasites and chronic blood loss resulting from trematode infection, ultimately leading to acute anemia, tissue hypoxia, and progressive emaciation.

Leukocyte counts exhibited a marked increase. The white blood cell (WBC) count rose from 8.4–14.6 ×$10^9$/L to 16.8–28.2 ×$10^9$/L, reflecting a strong systemic inflammatory response of the host organism to the simultaneous presence of protozoan parasites and helminths. Such changes indicate a severe

inflammatory process and substantial activation of the immune system.

Biochemical indicators of liver function were also significantly affected. Alkaline phosphatase (ALP) levels increased markedly, reaching 136–454 U/L, which indicates mechanical damage to the bile ducts caused by trematodes together with the toxic effects associated with babesiosis. These changes suggest the development of hepatic dysfunction, including hepatitis and metabolic imbalance. Similarly, total bilirubin levels increased from 0–0.5 mg/dl to 0.1–1.1 mg/dl, reflecting intensive hemolysis and impaired hepatic filtration capacity. These alterations contribute to the development of hemolytic jaundice and structural damage to the hepatic parenchyma. In contrast, the erythrocyte sedimentation rate (ESR) decreased from 30–58 mm/h to 12–39 mm/h, indicating alterations in blood viscosity and cellular composition. Such changes may reflect the progression of the pathological process and suppression of normal hematopoietic function.

**Table 5.** Analysis of blood parameters during associative invasion with babesiosis and dicroceliosis

| Parameter | Trend of change | Cause | Clinical significance |
|---|---|---|---|
| Hemoglobin (g/dl) | Critical decreased from 9.0–14.0 g/dl to 3.8–5.6 g/dl | Both the destruction of erythrocytes by blood parasites and the chronic blood loss caused by trematodes | Acute anemia, tissue hypoxia, and general wasting (emaciation) in the animal |
| WBC ($\times 10^9$/L) | Sharp increased from 8.4–14.6 $\times 10^9$/L to 16.8–28.2 $\times 10^9$/L. | A systemic inflammatory response of the organism to two different types of pathogens (protozoan parasites and helminths) | Severe inflammatory process and excessive burden on the immune system |
| Liver Enzymes (ALP)(U/L) | Maximum increase (ALP: 136-454 U/L) | Mechanical damage to the bile ducts caused by trematodes and the toxic effects induced by babesiosis | Severe liver failure, hepatitis, and metabolic imbalance |
| Total Bilirubin (mg/dl) | Increased from 0-0.5 mg/dl to 0.1-1.1mg/dl | Intense destruction of erythrocytes (hemolysis) and impaired filtering function of the liver | Development of hemolytic jaundice and damage to the hepatic parenchyma |
| Erythrocyte Sedimentation Rate (ESR, mm/h) | Decreased from 30–58 mm/h to 12–39 mm/h | Acute changes in blood viscosity and morphological composition | Progression of the pathological process and severe depression of the hematopoietic system |

## DISCUSSION

There are limited studies addressing hematological and biochemical alterations in sheep naturally infected with dicroceliosis. Previous investigations conducted in Turkey reported significant increases in serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST) activities in sheep infected with endoparasites, indicating hepatocellular damage during parasitic diseases (Shahin and Akgul, 2006; Yuksek *et al.*, 2007). In sheep affected by dicroceliosis, marked decreases in red blood cell count (RBC), lymphocytes (Lym), hemoglobin (Hb), and hematocrit (HCT) have been observed, whereas white blood cell count (WBC), neutrophils, eosinophils, and mean corpuscular volume (MCV) were significantly increased. No notable changes were reported in mean corpuscular hemoglobin (MCH), monocytes, or basophils (Kramer, 2000; Matanovich *et al.*, 2007).

The hematological findings of the present study generally support these observations. Hemoglobin values in infected sheep (53.69 ± 5.75 g/dl) were slightly lower than those recorded in healthy animals (56.81 ± 11.34 g/dl), suggesting the development of mild anemia associated with parasitic infection. Similarly, RBC counts showed minor variation between infected sheep (5.75 ± 1.06 × $10^6$/µl) and healthy controls (5.64 ± 0.99 × $10^6$/µl). Although these changes were not markedly pronounced, they indicate early hematological disturbances that may progress with increasing parasite burden or in the presence of co-infections.

Alterations in total protein (TP), albumin (Alb), glucose (GLU), AST, ALT, and gamma-glutamyl transferase (GGT) levels have previously been reported in sheep diagnosed with dicroceliosis, confirming the systemic and hepatic impact of the disease. Comparative studies

demonstrated significant increases in WBC, neutrophil, eosinophil, and monocyte counts in infected sheep, while RBC, HCT, Hb, and MCV values were significantly reduced compared with healthy controls; lymphocyte levels showed no significant differences (Denizhan and Karakuş, 2020).

In the present investigation, biochemical indicators of liver function revealed pronounced alterations, particularly in animals with parasitic infections. Alkaline phosphatase (ALP) activity increased markedly, ranging between 136 and 454 U/L, which indicates mechanical irritation of the bile ducts caused by trematodes together with the toxic metabolic effects associated with babesiosis. Elevated ALP activity is widely recognized as an indicator of hepatobiliary damage and cholestasis in parasitic liver diseases. Additionally, total bilirubin concentrations increased from 0–0.5 mg/dl to 0.1–1.1 mg/dl, suggesting enhanced hemolysis and impaired hepatic filtration capacity. These changes may contribute to the development of hemolytic jaundice and structural damage to hepatic parenchyma.

Hypoalbuminemia is a characteristic finding in trematode infections of the liver (Thomas, 2000; Bosy-Westphal *et al.*, 2001), and decreased serum total protein and albumin concentrations have been consistently reported in sheep with dicroceliosis (Xhemollari *et al.*, 2017). Furthermore, a reduction of up to two-fold in Hb and RBC levels accompanied by a marked increase in WBC counts has been documented in infected animals. These findings indicate that, compared with monoinvasion, associative invasions induce more severe pathological processes and delay recovery in affected sheep (Believ, 2014).

Another notable finding of the present study was the change in erythrocyte sedimentation rate (ESR), which decreased from 30–58 mm/h in healthy animals to 12–39 mm/h in infected sheep. This reduction may reflect alterations in blood viscosity, erythrocyte composition, and inflammatory responses associated with parasitic infections. Such changes are often linked to disturbances in normal hematopoiesis and systemic metabolic imbalance.

Mixed parasitic infections are increasingly recognized as an important health concern in small ruminants, particularly in regions where multiple vector-borne and helminth parasites coexist. Concurrent infections involving trematodes and hemoprotozoan parasites have been reported in sheep and goats, and such combinations may exacerbate pathological outcomes and disease severity (Radostits *et al.*, 2007; Taylor *et al.*, 2016). However, detailed information regarding the hematological and biochemical alterations associated with simultaneous dicroceliosis and babesiosis remains limited. The lamb mortality observed in the present study under conditions of concurrent Dicrocoelium lanceatum and Babesia infection highlights the importance of understanding the combined pathogenic effects of these parasites. In cases of associative invasion, significant increases in WBC, AST, and ALP levels were observed, whereas RBC, Hb, and HCT values decreased markedly, indicating severe systemic and hematological disturbances. These findings suggest that co-infection may intensify inflammatory responses, hepatic dysfunction, and hemolytic processes, ultimately aggravating the clinical course of the disease.

These alterations can be attributed to the synergistic pathogenic effects of Dicrocoelium lanceatum and Babesia spp. The metabolic products of these parasites contribute to extensive erythrocyte destruction both in the bloodstream and within macrophages and cells of the reticuloendothelial system. Continuous erythrocyte degeneration combined with enhanced erythrophagocytosis disrupts erythropoietic balance, leading to progressive anemia and exacerbation of clinical manifestations. Consequently, co-infection intensifies pathological processes and increases the severity of disease outcomes in affected sheep.

## CONCLUSION

The present study demonstrates that infection with Dicrocoelium lanceatum, particularly when

accompanied by babesiosis, leads to notable hematological and biochemical alterations in sheep. Co-infected animals showed marked increases in WBC, AST, and ALP levels, along with reductions in RBC, hemoglobin, and hematocrit, indicating significant inflammatory responses, hepatic dysfunction, and hemolytic disturbances. These findings highlight that concurrent parasitic infections can exacerbate pathological effects and contribute to increased disease severity and lamb mortality. Therefore, early diagnosis and integrated parasite control strategies are essential to reduce the health and economic impacts of such infections in sheep populations.

**REFERENCES**

**Ansari-Lari M, Moazzeni M.** 2006. A retrospective survey of liver fluke disease in sheep in southern Iran. Veterinary Parasitology **141**(3–4), 287–292.

**Azizova AA.** 2024. The taxonomic research of the primitive blood parasites and transmitting Ixodidae ticks of the small ruminants in the Shirvan Salyan economic region of Azerbaijan. Bioscience Biotechnology Research Asia **21**(1), 175–184.

**Believ SM.** 2014. Hematological changes in sheep infected with fasciolosis and associated helminth invasions. Russian Journal of Parasitology **203**(2), 45–52.

**Bosy-Westphal A, Danielzik S, Geisler C and Müller MJ.** 2001. Influence of body composition and resting metabolic rate on serum albumin concentration in patients with liver cirrhosis. Clinical Nutrition **20**(5), 457–462.

**Denizhan V, Karakuş A.** 2020. Hematological and biochemical alterations in sheep naturally infected with *Dicrocoelium dendriticum*. Turkish Journal of Veterinary and Animal Sciences 44, 965–972.

**Ducháček L and Lamka J.** 2003. Dicrocoeliosis – the present state of knowledge with respect to wildlife species. Acta Veterinaria Brno **72**(4), 613–626.

**Gonzalez-Lanza C, Manga-Gonzalez MY, Compo R, Del-Pozo P, Sandoval H, Oleaga A and Ramajo V.** 2000. IgG antibody response to ES or somatic antigens of *Dicrocoelium dendriticum* (Trematoda) in experimentally infected sheep. Parasitology Research **86**, 472–479.

**Kramer JW.** 2000. Normal hematology of cattle, sheep and goats. In Feldman BF, Zinkl JG and Jain NC (Eds.), Schalm's veterinary hematology (5th ed., pp. 1075–1084). Lippincott Williams & Wilkins.

**Mammadova GR and Azizova AA.** 2025. Prevalence of primary blood parasites in sheep of different age groups in the Guba Khachmaz economic region of Azerbaijan. Bulletin of Science and Practice **11**(11), 320–326.

**Mammadova GR, Azizova AA, Uslu U.** 2025. Taxonomic study and epizootological characteristics of associative invasion pathogens (helminths and primary blood parasites) in sheep in the Guba Khachmaz economic region of Azerbaijan. Bulletin of Science and Practice **11**(8), 374–380.

**Manga-González MY, Ferreras MC.** 2014. Hepatic lesions associated with Dicrocoelium dendriticum infection in sheep. Veterinary Parasitology 204(3–4), 299–306.

**Matanovich K, Stankovic B and Nikolic S.** 2007. Hematological parameters in sheep infected with trematodes. Acta Veterinaria (Beograd) **57**(2–3), 205–214.

**Otranto D and Traversa D.** 2002. A review of dicrocoeliosis of ruminants including recent advances in the diagnosis and treatment. Veterinary Parasitology **107**(4), 317–335.

**Radostits OM, Gay CC, Hinchcliff KW, Constable PD.** 2007. Veterinary medicine: A textbook of the diseases of cattle, horses, sheep, pigs and goats. Saunders Elsevier.

**Shahin N and Akgul Y.** 2006. Changes in serum biochemical parameters in sheep infected with endoparasites. Journal of Veterinary Medicine Series A **53**(8), 412–415.

**Taylor MA, Coop RL, Wall RL.** 2016. Veterinary parasitology. Wiley-Blackwell.

**Thomas HC.** 2000. Liver dysfunction associated with parasitic infections. Journal of Hepatology **32**(1), 172–182.

**Xhemollari L, Rapti D, Knaus M and Rehbein S.** 2017. Biochemical and hematological changes in sheep naturally infected with *Dicrocoelium dendriticum*. Parasitology Research **116**(4), 1101–1107.

**Yuksek N, Ozkan C and Akgul Y.** 2007. Serum enzyme activities in sheep with parasitic diseases. Small Ruminant Research **69**(1–3), 236–241.