Review

Current Insights into Theileriosis of Small Ruminants: Pathogenesis, Diagnosis, and Management

Ahmed Hamzah Mosa[1]*, Hamed A. H. Aljabory[1], Ali Dhiaa Marza[1] and Noor R Abady[2]

[1]Department of Internal and Preventive Veterinary Medicine, College of Veterinary Medicine, Al-Qasim Green University, Babylon 51013, Iraq; [2]Department of Microbiology, College of Veterinary Medicine, Al-Qasim Green University, Babylon 51013, Iraq.

Abstract | Theileriosis is a tick-borne protozoan disease mainly affecting sheep and goats in tropical and subtropical regions. *lestoquardi* is the most pathogenic species, causing severe and often fatal infections, while *T. ovis* results in milder, subclinical forms. The disease is transmitted mainly by species of Hyalomma and Rhipicephalus ticks. After transmission, sporozoites invade host lymphocytes, leading to cell proliferation and immunosuppression. Then, merozoites invade red blood cells, and cause anaemia and other various hematological disorders. Clinical signs include fever, anaemia, lesions and swollen lymph nodes, and respiratory distress, which will differ in severity in each species. Although a definitive diagnosis can be made based on presenting clinical symptoms, blood smear examination, PCR, and serological tests are available. If antiprotozoal drugs like buparvaquone are administered early enough with supportive treatment, recovery can be quite substantial. Tick control, through the use of acaricides and rotational grazing, is crucial for preventing Theileriosis outbreaks, which have significant economic impacts due to animal health deterioration and reduced productivity. Vaccination against Theileria, particularly *T. lestoquardi*, is an area of research but important hurdles need to be overcome surrounding the immune evasion of the parasite. Molecular studies on Theileria genetics and their interactions with host coagulation and immune responses may pave the way for improved diagnostics and treatments, highlighting the potential of vaccines and molecular-based tools for effective future control of the disease.

Editor | Muhammad Abubakar, National Veterinary Laboratories, Park Road, Islamabad, Pakistan.
Received | September 02, 2025; **Accepted** | October 02, 2025; **Published** | December 18, 2025
***Correspondence** | Ahmed Hamzah Mosa, Department of Internal and Preventive Veterinary Medicine, College of Veterinary Medicine, Al-Qasim Green University, Babylon 51013, Iraq; **Email:** ahmedvet@vet.uoqasim.edu.iq
Citation | Mosa, A.H., H.A.H. Aljabory, A.D. Marza and N.R. Abady. 2025. Current insights into theileriosis of small ruminants: Pathogenesis, diagnosis, and management. *Veterinary Sciences: Research and Reviews*, 11(2): 239-245.
DOI | https://dx.doi.org/10.17582/journal.vsrr/2025/11.2.239.245
Keywords | Theileria, Tick-borne disease, Sheep, Goats, Hyalomma, Rhipicephalus, Diagnosis

Introduction

Theileriosis is a protozoan disease transmitted by ticks that primarily affects small ruminants, particularly sheep and goats; it poses an important veterinary and economic risk to livestock health management in tropical and subtropical countries. Theileriosis is caused by Theileria species, primarily transmitted by ixodid tick species such as Hyalomma and Rhipicephalus. Of the Theileria species, *T. lestoquardi* is the most pathogenic and leads to severe and typically fatal disease, while *T. ovis* usually leads to subclinical or mild infections (Mohammadi *et al*., 2022). Theileriosis severely affects animal health and productivity, causing anemia, immunosuppression, stunted growth, and death, leading to major economic losses for smallholder farmers (Elhawary *et al*., 2024). The life cycle of Theileria consists of both a vertebrate and invertebrate host. After the transmission from an infected tick, sporozoites enter host lymphocytes where they develop into schizonts, which lead to aberrant lymphoid proliferation and immunosuppression. Subsequently, Merozoites are released and enter red blood cells to form intraerythrocytic piroplasms leading to anemia and other hematologic diseases (Ahmed *et al*., 2021). This life cycle and dual pathology explanation make sense of the characteristic clinical signs associated with the disease, such as fever, lymphadenopathy, anemia, and respiratory distress which is seen in affected sheep and goats (Hussein *et al*., 2023). Epidemiologically, Theileria has been identified in different regions of the Middle East, Africa, and Asia, where bioclimatic conditions are favorable for tick vector proliferation. Several recent studies including molecular work from Iraq and Egypt. In a similar vein, numerous studies in Iran and Pakistan emphasized the considerably high level of ovine theileriosis occurrence and genetic diversity of Theileria types in circulation, coupled with evidence of ongoing tick-parasite relationships between Theileria spp., in a constantly changing environment (Rashid *et al*., 2025; Jalali *et al*., 2022). Ovine and caprine theileriosis can be diagnosed through clinical, microscopic and molecular diagnostic methods. Basic Giemsa-stained blood smears have been and remain useful in identifying circulating intraerythrocytic piroplasms, but are not highly sensitive for chronic carriers. Advancements in diagnostics, using polymerase chain reaction (PCR) and real-time PCR as reproducible means with much greater sensitivity and specificity to isolate species (Elhawary *et al*., 2024). Serological methods used for epidemiological surveys and to identify subclinical carriers (e.g. ELISA, IFAT) are integral in substantiating transmission routes (Gad *et al*., 2024). Initiating treatment at a timely moment gives the treatment the best chance of working. Buparvaquone remains the drug of choice with definitive efficacy noted for both schizonts and piroplasms. Supportive therapies may include oxytetracycline, anti-inflammatory drugs, and blood transfusion in severe cases (Hussein *et al*., 2023). However, because the disease is vector-borne, preventing the diseases relies heavily on controlling the tick vector. To reduce the incidence of disease, the goal of prevention can be accomplished with an amalgamation of methods including regular application of acaricides, rotational grazing and flock management. The research around vaccines in small ruminants remains scarce, including the developments of the vaccines against T. lestoquardi (Rashid *et al*., 2025). To sum up, theiloreiosis in sheep and goats remains a significant barrier to health and production in small ruminants as a global concern. Recent studies have reiterated the requirement for molecular diagnostics, epidemiological surveillance, and integrated control programmes. Continued surveillance to document the distribution and genetic diversity of Theileria species in small ruminants is essential. Despite existing studies, comprehensive and up-to-date data are limited, highlighting the need for this review to inform sustainable control strategies and mitigate the economic impact of the disease.

Causes of theileriosis in sheep and goats

Theileriosis in sheep and goat is due to protozoan parasites belonging to the genus Theileria, which are transmitted, mainly, by ixodid ticks, with species of Hyalomma and Rhipicephalus being the primary vectors. The most pathogenic of the genus, T. lestoquardi, causes acute disease and includes a high percentage of fatal infections, in contrast, T. ovis is commonly associated mild or even subclinical disease. There are contributing factors that can result in outbreaks of Theileria including: level of tick infestation at the farm level; overall management on-farm; not enough tick and/or vector management; and conditions that favour tick survival. Other factors that could lead to increase susceptibility to Theileria infection and more serious clinical outcome: Stress on the host; inadequate nutrition; coincidence of other infections with Theileria (Hussein *et al*., 2023; Rashid *et al*., 2025).

Theileriosis structure

Protozoa are single-celled eukaryotic organisms that are defined by having a nucleus, cytoplasm and organelles specialized for locomotion and feeding (e.g. flagella, cilia and pseudopodia). Protozoa have a low complexity degree but high adaptability to extreme conditions, parasitizing host animals and surviving in aquatic or terrestrial environments, Figure 1.

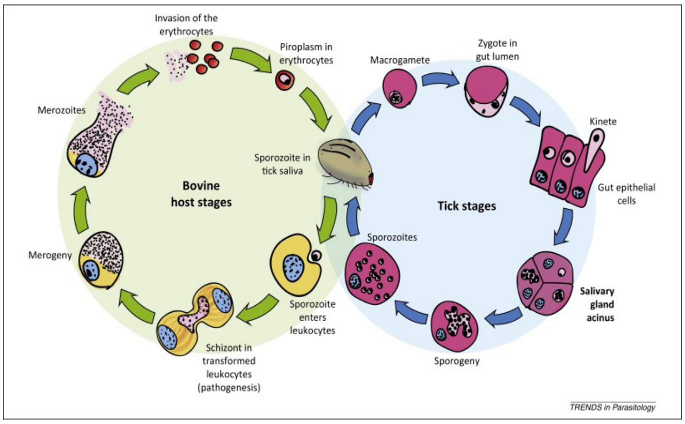

Figure 1: *Morphological forms of parasites inside erythrocytes.*

Genome of theileria and gene expression

Theileria species, including *T. lestoquardi* and *T. annulata*, possess small apicomplexan genomes, 8–9 Mb, that are organized into four chromosomes (Pain *et al*., 2020). The genome encodes approximately 3,800–4,000 protein-coding genes. Many of these genes play key roles in host–parasite interactions, antigenic variation, and immune evasion (Khan *et al*., 2021). Most apicomplexans do not have the same capability to transform host leukocytes as Theileria parasites (i.e., Theileria transform leukocytes into non-functional proliferating immune cells). The transformation is accomplished by parasite secreted proteins that alter normal host cell signaling pathways (e.g. NF-κB, JNK, PI3K/Akt, etc.) that lead to uncontrolled cell proliferation and inhibition of host cell apoptosis (Hussein *et al*., 2023). Gene expression in Theileria is stage-specific. During its schizont stage in leukocytes, T. annulata upregulated gene expression corresponding to the proteins that are related to transformation; whereas in the piroplasm stage in erythrocytes, the expression shifted towards genes related to immune evasion and development in red blood cells (Rashid *et al*., 2025). The epigenetic regulation of gene expression via mechanisms such as histone modification and non-coding RNAs also has a role in regulating gene expression during parasite stage transitions (Ahmed *et al*., 2021). Advances in transcriptomic and proteomic studies of protozoan parasites have revealed candidates for vaccine and drug development, and in some cases, these advance our understanding of parasite biology. Molecules such as surface antigens (Tams1 in *T. annulata* and its homologs in *T. lestoquardi*, and immunogens from secreted effector proteins) have been described as immunogenic marker candidates (Elhawary *et al*., 2024). To develop targeted therapeutics, a deeper understanding of genomes and gene expression patterns is essential. Such insights can directly inform the design of vaccines and the discovery of novel drugs, improving strategies for disease control.

Theileria replication

Theileria parasites, transmitted by ticks, are known to cause diseases such as East Coast fever in cattle. The microorganism invades leukocytes, mainly lymphocytes, and undergoes schizogony within the host cell. This results in uncontrolled cell proliferation and other characteristics of Theileria infection. Eventually, merozoites are produced that infect red blood cells and complete the transmission cycle. The parasites display exciting attributes, which include the ability to hijack miosis in the host cell as well as replicate freely in host cytoplasm (Shaw *et al*., 2020). The transmission cycle is complete when infected blood is begested by a tick, which produces sporozites (Köhler *et al*., 2022).

Theileria epidemiology

Theileria parasites are responsible for diseases in animals, such as East Coast Fever of cattle. The epidemiology of is influenced by factors such as tick distribution, environmental conditions, and host immunity. For example, high tick burdens drive infections in parts of Africa, climatic variations affect prevalence in Asia, and small ruminant management practices influence outbreaks in the Middle East. Disease outbreaks seem to occur in association with seasonal changes and in areas where there are large numbers of ticks. Control strategies, such as tick management and vaccination, have significantly reduced disease prevalence in endemic areas. For instance, recent studies report a decline in infections from 25–30% to under 10% in some regions following integrated control programs. Recent publications have highlighted the importance of vector ecology and host-pathogen relationships in the development of disease management (Gwakisa *et al*., 2021; Seitzer *et al*., 2023).

Pathogenesis

In summary, The pathway to pathogenesis with Theileria from a sporozoite after transmission via a tick can typically be found to be linked to T-cell (as it is the ones that are infected). Once within the T-cell, Theileria replicates, allowing the division of host cells out of control. Once active, Theileria propagates throughout the host, blocking the immune response in a variety of ways, causing tissue damage and powerful immune inhibition leading to tell-tale signs for the particular disease such as fever, anemia, and severe immune deficiency. Recently, there seems to be consensus of recognizing the importance in understanding the molecular nitty-gritty of the parasite, and how it is able to impact the signaling pathways of host cells, in hopes of providing future therapeutic strategies (Jongejan *et al*., 2022; Tanaka et al., 2023).

Clinical signs of theileriosis in sheep and goats

Theileriosis is a protozoan parasitic disease caused by species, affecting both sheep and goats, primarily transmitted by ticks. The clinical presentation varies based on the species and the severity of the infection.

Clinical signs in sheep

Infection in sheep is usually mild, but it can cause significant illness in some cases. Clinical signs of moderate to severe infection includes high fever (up to 41°C), lethargy, inappetance, and anemia, resulting in pale mucous membranes (especially in the gums and eyes). Lymph node swelling (particularly in the neck and abdomen) is also common during moderately-severe disease (Akhtar *et al*., 2020). Other signs that may develop as the illness progresses includes weight losses, jaundice (yellowish mucous membranes), and dyspnea in more severe cases.

Clinical signs in goats

Goats generally exhibit more severe clinical signs of Theileriosis than sheep, including high fever, anemia, jaundice, depression, and lethargy. swollen lymph nodes (especially in the cervical and inguinal regions) will likely be present. There may be edema in limbs or abdomen. Some goats may even experience diarrhea (Ali *et al*., 2022). Severe cases may lead to respiratory distress due to the reduction of oxygenated blood due to the anemia.

Immune response to theileriosis in sheep and goats

Theileria infections of sheep and goats elicit an immune response involving innate and adaptive immunity components (Bouzid *et al*., 2020). The innate immune response initiated when the innate immune system recognizes the parasite is predominantly mediated through macrophages and dendritic cells leading to an early immune response. Natural killer (NK) cells maintain control of the parasite through targeting infected cells (Jiang *et al*., 2021). The adaptive immune response is primarily responsible for controlling the Theileria infection, as the CD4+ T helper and CD8+ cytotoxic T lymphocytes (CTLs) are activated in parallel to one another and have a role in attacking infected host cells, which ultimately reduces the parasite population. Additionally, B-cells form antibodies which neutralize the parasite, while opsonins for targeted cells removal (Hoffmann *et al*., 2022). The parasite has evolved various mechanisms to circumvent immune recognition by the host through altering the surface antigen composition of the parasite while also altering host cell signalling (Hoffmann *et al*., 2022). Theileria species also elicit partial immunity, leaving the parasite infection as a real possibility and that partial immunity is still an obstacle in vaccine development (Ahmed *et al*., 2023).

Diagnosis of theileriosis in sheep and goats

The diagnosis of *Theileriosis* in sheep and goats relies on a combination of clinical signs, laboratory tests, and advanced molecular techniques.

Clinical diagnosis

History and clinical signs: The presumptive diagnosis is performed by detecting common clinical signs of fever, anemia, jaundice, lymphadenopathy, and respiratory signs; clinical signs are often more evident in acute or severe cases (Akhtar *et al*., 2020).

Blood smear examination

Microscopic examination: The normal standard for diagnosis is microscopic examination of a blood smear. If Theileria parasites are seen within red blood cells this is diagnostic. This test is simple, however, the sensitivity may be problematic in cases of low parasitemia (Ali *et al*., 2022).

Polymerase chain reaction (PCR)

PCR is a highly sensitive and specific method for detecting Theileria DNA in blood samples. However, its use can be limited by high costs, the need for specialized equipment, and access to well-equipped laboratories. PCR can also differentiate between different types of Theileria e.g., T annulata and T ovis which infect goats and sheep respectively (Jiang *et al*., 2021).

Serological tests

Antibody detection: ELISAs are useful for detecting antibodies which were produced following Theileria exposure, as this indicates exposure to the parasite, but not necessarily active infection (Bouzid *et al*., 2020).

Treatment of theileriosis in sheep and goats

The goal for the treatment of Theileriosis, in sheep and goats, is to lower the parasite burden, lessen the degree of the clinical disease, and prevent any pathological consequences. Treatment modalities are based on the magnitude of the disease and the host species involved.

Antiprotozoal drugs

Buparvaquone: One of the most effective treatments for *Theileriosis*, it targets the parasite's mitochondrial electron transport chain. It is typically administered via intramuscular injection. Dosage commonly used is 2.5 mg/kg body weight, repeated after 48 hours if necessary (Ali *et al*., 2022). Supportive therapy with fluids such as isotonic saline may be indicated in dehydrated animals. Diminazene Aceturate: Effective in multiple species, especially sheep, this drug inhibits energy metabolism, leading to parasite death. It can be given intramuscularly or intravenously at 3.5 mg/kg body weight (Akhtar *et al*., 2020). In cases of severe anemia, blood transfusion may be required. Imidocarb Dipropionate: Commonly used for *annulata* infections in goats, often as a second-line treatment when other therapies fail. The recommended dose is 5 mg/kg intramuscularly (Jiang *et al*., 2021). Supportive care, including fluids and anti-inflammatory drugs, is advised in severe cases.

Supportive care

Blood transfusions: Transfusions are often needed in cases of severe anemia to restore red blood cell count and oxygen-carrying capacity. Monitoring packed cell volume (PCV) and clinical signs such as weakness or pale mucous membranes can help determine when a transfusion is necessary (Bouzid *et al*., 2020). Fluids and electrolytes: Intravenous fluid therapy is essential for rehydration and kidney support, especially in animals with diarrhea or dehydration. Hydration status, skin tenting, mucous membrane moisture, and urine output should be regularly monitored to guide fluid therapy.

Symptomatic treatment

Anti-inflammatory drugs: Non-steroidal anti-inflammatory drugs (NSAIDs), such as flunixin meglumine, can reduce fever, inflammation, and pain in affected animals. A typical dose is 1–2 mg/kg body weight administered intravenously or intramuscularly. Potential side effects include gastrointestinal irritation, ulceration, and kidney stress, particularly with prolonged use. Antibiotics: In immunocompromised animals, secondary bacterial infections may occur, warranting antibiotic therapy. Common choices include oxytetracycline (10 mg/kg intramuscularly) or enrofloxacin (5 mg/kg subcutaneously/intramuscularly). Side effects may include gastrointestinal upset or hypersensitivity reactions, and careful use is recommended to avoid antimicrobial resistance (Hoffmann *et al*., 2022).

Tick control

As illustrated, Theileriosis is transmitted by ticks, and controlling tick populations is important so as to prevent potentially additional outbreaks. We recommend the use of acaricides and tick repellent, as part of an integrated tick management scheme (Bouzid *et al*., 2020).

Conclusion

Theileriosis continues to be a serious risk for sheep and goats, particularly in tropical and subtropical regions. *Theileria* spp. parasites cause Theileriosis, leading to significant clinical symptoms, including anemia or immunosuppression. Early case recognition and treatment, particularly with buparvaquone as a supportive therapy, can increase the chance of successful treatment. Nevertheless, prevention is essential through effective tick control operations. Although there have been advances in terms of diagnostics and available treatments, the absence of an effective vaccine, coupled with the ability of the parasites to avoid host immunity, presents unique challenges. Further research into the genetic makeup of the parasites as well as vectors, and etc, will be vital to controlling this disease and, ultimately, minimizing the degree of financial losses to livestock production in affected regions.

Acknowledgment

The authors gratefully acknowledge the support of the College of Veterinary Medicine, Al-Qasim Green University, Babylon, Iraq, for providing resources and facilities for this study. Special thanks to colleagues and staff who contributed to discussions and technical assistance during the preparation of this review.

Novelty Statement

This review highlights recent molecular insights into infections in small ruminants, emphasizing host parasite interactions, immune evasion, and implications for vaccine development and targeted therapeutics.

Author's Contribution

Ahmed Mosa: Conceptualization, manuscript drafting, literature review, and corresponding author responsibilities.
Hamed A. H. Aljabory: Literature search, data curation, and manuscript editing.
Ali Dhiaa Marza: Critical review, figure, table preparation, and manuscript revision.
Noor R Abady: Contribution to microbiological insights, molecular data synthesis, and manuscript.

Generative AI and AI-assisted technology statement
No Generative AI and AI-assisted technologies were used in the writing process.

Conflict of interest
The authors have declared no conflict of interest.

References

Ahmed, J., Yin, H. and Schnittger, L., 2021. Small ruminant theileriosis. Parasitol. Res., 120(4): 1361–1376.
Ahmed, M., Yousaf, M. and Zubair, M., 2023. Vaccine development strategies for Theileriosis in livestock. Vet. Immunol. Immunopathol., 261: 113000.
Akhtar, M., Khan, M.S. and Ashraf, M., 2020. Theileriosis in small ruminants: Epidemiology, diagnosis, and treatment. Vet. Parasitol., 276: 1-10.
Ali, A., Khalid, A. and Khan, J., 2022. Clinical signs and diagnosis of infections in goats. J. Anim. Sci., 99(5): 365-370.
Bouzid, S., Li, Y. and Yi, S., 2020. T-cell immune responses in ruminant infections: Implicat. Contr. Vet. Res., 51(1): 89-100.
Elhawary, N.M., El-Garhy, M.F., Mahmoud, A.M. and Gad, M.A., 2024. Molecular characterization of species in sheep and goats in Egypt. BMC Vet. Res., 20(1): 111–119.
Gad, M.A., Elhawary, N.M. and Mahmoud, A.M., 2024. Prevalence and molecular detection of ovine theileriosis in Egypt. *Vet. Sci., 11*(2): 77.
Hassan, M.A., Hamzah, H.H. and Ghazi, A.M., 2023. Molecular detection of *Lestoquardi* and *Anaplasma phagocytophilum* in sheep from Iraq. *Trop. Anim. Hlth. Prod., 55*(3): 215–223.
Hoffmann, M., Gazi, M. and Thomas, J., 2022. Immune evasion strategies by species in ruminants. Front. Vet. Sci., 9: 789531.
Hussein, H.H., Salih, D.A. and El-Hussein, A.R.M., 2023. Clinical and molecular aspects of malignant theileriosis in sheep. Front. Vet. Sci., 10: 1123334.
Jalali, S.M., Kargar, S. and Shayan, P., 2022. Molecular prevalence and phylogeny of ovine theileriosis in northern Iran. Vet. Parasitol. Region. Stud. Rep., 30: 100726.
Jiang, D., Zhang, J. and Liu, Z., 2021. Mechanisms of immune evasion by parasites. Parasit. Immunol., 43(2): 125-136.
Jongejan, F., Perry, C., Brühlmann, F.,. 2022. Pathogenesis of infection in cattle: Mechanisms of immune evasion and cell transformation. Int. J. Parasitol., 52(3): 175-183.
Khan, M.K., Rashid, M. and Iqbal, F., 2021. Advances in genomics and host–parasite interactions of spp. Curr. Parasitol. Rep., 8(2): 73–83.
Köhler, S.M., Williams, D. and Anderson, M., 2022. Theileria and the biology of host transformation. Parasit. Vectors, 15(1): 75.
Lawrence, K.E., Gedye, K., Hickson, R., Wang, B., Carvalho, L., Zhao, Y., and Pomroy, W.E. 2021. The role of sheep (Ovis aries) in maintaining Theileria orientalis Ikeda type infection. Veterinary Parasitology, 291, 109391.
Mohammadi, G.R., Sharifiyazdi, H. and Rahbari, S., 2022. An overview of ovine and caprine theileriosis: Current status and control challenges. J. Parasit. Dis., 46(2): 245–256.
Rashid, M., Khan, M.N. and Iqbal, F., 2025. Molecular epidemiology of lestoquardi in small ruminants in Pakistan. Vector-Borne Zoonot. Dis., 25(1): 33–41.
Seitzer, U. 2023. Advances in understanding transmission and control strategies. Parasit. Vectors, 16(1): 32.
Shaw, M.K., Satchwell, M. and Boulanger, N., 2020. Parva: Molecular mechanisms and host-cell interactions. Trends Parasitol., 36(6): 479-490.

Tanaka, T., Yamagishi, J. and Suzuki, Y., 2023. Molecular insights into Theileria-induced manipulation of host signaling pathways: Toward novel therapeutic approaches. Frontiers in Cellular and Infection Microbiology, 13, 1189054

Woods, K., Perry, C., Brühlmann, F., & Olias, P. (2021). Theileria's strategies and effector mechanisms for host cell transformation: From invasion to immortalization. Frontiers in Cell and Developmental Biology, 9, 662805.