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Bovine Trypanosomiasis: Etiology, Epizootiology, Clinicopathological Alterations, Diagnostic Advances, Therapeutics, and Vaccine Prospects

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Key Points

- **Causative agents and transmission:** Bovine trypanosomosis is caused by protozoan parasites, including *Trypanosoma evansi*, *T. congolense*, *T. vivax* and *T. brucei brucei*. Transmission occurs through tsetse flies or mechanically by biting flies, depending on the parasite and geographical region.
- **Effects on health and productivity:** The disease can cause fever, anemia, weight loss, reproductive disorders, reduced milk and meat production, and neurological signs in advanced cases.
- **Integrated control is essential:** Parasitological, serological and molecular diagnostics, appropriate trypanocidal treatment, supportive care, vector management and drug-resistance surveillance are central to disease control.

Abstract

Bovine trypanosomosis is an economically important vector-borne protozoal disease affecting cattle in tropical and subtropical regions. It is primarily associated with *Trypanosoma evansi*, which causes Surra, and *T. congolense*, *T. vivax* and *T. brucei brucei*, which are associated with African animal trypanosomosis or Nagana. Transmission occurs through tsetse flies or mechanically by biting flies, while disease severity depends on parasite species, host susceptibility and environmental conditions. Clinical manifestations include intermittent fever, anemia, progressive weight loss, lymphadenopathy, reproductive disorders and reduced livestock productivity. Laboratory abnormalities may include decreased packed cell volume, hemoglobin and leukocyte counts, altered serum proteins, hypoglycemia and increased liver enzymes. Diagnosis involves blood smear examination, parasite concentration techniques, serological assays and molecular tests. Treatment relies on trypanocidal drugs and supportive care, although emerging drug resistance presents a major challenge. As no commercial field

vaccine is currently available, effective control requires integrated chemotherapy, vector management, surveillance and continued research into improved diagnostics and vaccine development.

Keywords: Bovine trypanosomosis; *Trypanosoma evansi*; Surra; Nagana; Anemia; Vector-borne diseases; Molecular diagnosis; Trypanocidal drugs; Drug resistance; Vector control

1. Introduction

Bovine trypanosomosis is an economically important disease of cattle caused by flagellated protozoa of the genus *Trypanosoma*. Surra, caused by *T. evansi*, occurs across Asia, the Middle East, Africa and South America, while Nagana is mainly associated with *T. congolense*, *T. vivax* and *T. brucei brucei* in sub-Saharan Africa. The disease reduces milk and meat production, draught power and reproductive performance, and increases treatment costs. *T. evansi* has also been linked to rare atypical human infections (Contreras Garcia et al., 2022; Kangethe et al., 2022).

2. Causative Agents

The principal pathogenic species are *T. evansi*, *T. congolense*, *T. vivax* and *T. brucei brucei*. They differ in morphology, tissue distribution and pathogenicity. *T. congolense* and *T. vivax* are predominantly intravascular, whereas *T. evansi* and *T. brucei brucei* may also invade extravascular tissues and the central nervous system. *T. theileri* is generally considered a benign bovine trypanosome and should be differentiated from pathogenic species during diagnosis (Contreras Garcia et al., 2022).

Table 1. Major *Trypanosoma* species affecting cattle

Species	Disease association	Main features
<i>T. evansi</i>	Surra	Wide distribution; blood, lymphatic tissues and sometimes CNS
<i>T. congolense</i>	Nagana	Predominantly intravascular; often severe anemia
<i>T. vivax</i>	Nagana / Secadera	Intravascular; may cause acute disease or chronic wasting
<i>T. brucei brucei</i>	Nagana	Bloodstream and tissue infection; may involve CNS
<i>T. theileri</i>	Usually non-pathogenic	Generally benign; distinguish from pathogenic species

3. Transmission

African animal trypanosomes are transmitted cyclically by *Glossina* (tsetse) flies. *T. evansi* and *T. vivax* in regions outside the tsetse belt are commonly transmitted mechanically by biting flies, including *Tabanus* and *Stomoxys*. Vampire bats may contribute to *T. evansi* transmission in parts of Latin America. Reuse of contaminated needles or instruments and

occasional vertical transmission may also contribute to infection spread (Kangethe et al., 2022; Seyoum et al., 2022).

4. Predisposing Factors

Risk is influenced by age, breed, physiological stress, body condition, coat phenotype, geography and season. Adult cattle may experience greater exposure because of grazing and work-related movement. Lactation, pregnancy and heavy draught work can worsen clinical disease. Some indigenous African cattle breeds, such as N'Dama, show trypanotolerance, whereas susceptible breeds may develop more severe disease. Vector abundance often increases during wet seasons, raising transmission risk in endemic areas (Rajavel et al., 2022; Seyoum et al., 2022; Tsolo et al., 2024).

5. Effects on Health and Production

Infection can reduce milk yield, weight gain, carcass quality and draught capacity. Reproductive effects include infertility, irregular estrus, abortion and poor semen quality. Severe anemia, immune dysfunction and secondary infections can further compromise animal health and responses to routine vaccination (Contreras Garcia et al., 2022; Kangethe et al., 2022).

6. Clinical Signs

Clinical presentation varies from acute to chronic. Common signs include intermittent fever, pale mucous membranes, progressive weight loss, enlarged lymph nodes, ocular discharge and subcutaneous edema. Advanced *T. evansi* infection may involve the nervous system, causing incoordination, tremors, circling, recumbency or convulsions. Chronic cases often show wasting and persistent anemia (Rajavel et al., 2022; Seyoum et al., 2022).

7. Hematological and Biochemical Changes

Anemia and reduced packed cell volume (PCV) are major findings. Leukopenia, lymphopenia and thrombocytopenia may occur, along with hypoglycemia, hypoalbuminemia, hyperglobulinemia and increased liver enzymes. These changes reflect red-cell destruction, inflammation, altered metabolism and organ involvement (Tafese et al., 2012; Seyoum et al., 2022; Tsolo et al., 2024).

Table 2. Common laboratory changes in bovine trypanosomosis

Parameter	Typical change	Possible explanation
PCV, hemoglobin and erythrocyte count	Decreased	Red-cell destruction and impaired production
Leukocytes and platelets	May decrease	Immune changes and cellular consumption
Serum glucose	May decrease	Parasite glucose use and altered energy metabolism
Albumin and A:G ratio	Decreased	Reduced synthesis,

Parameter	Typical change	Possible explanation
		catabolism or protein loss
Globulins	Increased	Sustained immune stimulation
AST, ALT and bilirubin	May increase	Hepatic stress and hemolysis
BUN and creatinine	May increase	Dehydration or renal involvement

8. Diagnosis

Clinical signs alone are insufficient because trypanosomosis resembles other hemoparasitic diseases. Diagnosis may use wet blood films, stained smears and concentration methods such as the Woo microhematocrit and Murray buffy-coat techniques. Serological tests, including CATT and antibody ELISA, support herd screening but may remain positive after infection has cleared. PCR-based assays improve species detection, while newer approaches such as 7SL sRNA RT-qPCR and TevRPA-CRISPR are being investigated for sensitive detection of active infection (Contreras Garcia et al., 2022; Álvarez-Rodríguez et al., 2025).

Table 3. Comparison of diagnostic approaches

Method	Main use	Key limitation
Blood film / stained smear	Direct parasite detection	Low sensitivity in chronic or low-parasitemia cases
Woo / buffy-coat technique	Concentrates parasites; also measures PCV	Requires equipment and prompt examination
CATT / antibody ELISA	Herd screening and serosurveillance	May not distinguish active from past infection
PCR / PCR-RFLP	Sensitive detection and species differentiation	Requires laboratory infrastructure
7SL sRNA RT-qPCR / TevRPA-CRISPR	Emerging methods for active infection detection	Availability and field validation remain limited

9. Treatment and Chemoprophylaxis

Treatment depends on parasite species, local drug availability and veterinary guidance. Trypanocides used in different regions include diminazene aceturate, isometamidium chloride and quinapyramine; other agents may be reserved for selected cases. Regimens and approvals vary by country and product. Suspected treatment failure should prompt veterinary reassessment because resistance to diminazene and isometamidium has been reported (Tchamdja et al., 2017).

Supportive care may include fluids, nutritional support, hematinics and treatment of concurrent conditions. Severely anemic or hypoglycemic animals require prompt veterinary evaluation. Accurate diagnosis, correct dosing, adherence to withdrawal periods and avoidance of repeated under-dosing are important for safe and effective treatment.

Table 4. Trypanocidal drugs reported for cattle

Drug	General role reported	Important consideration
Diminazene aceturate	Primarily curative	Resistance and product-

Drug	General role reported	Important consideration
		specific dosing require consideration
Isometamidium chloride	Curative and prophylactic use in some settings	Use depends on species, local guidance and resistance patterns
Quinapyramine	Used particularly for Surra in some regions	Follow local product authorization and veterinary directions
Homidium compounds	Reported for selected African trypanosome infections	Use may be restricted in some regions
Suramin / melarsomine	Reported for selected or refractory <i>T. evansi</i> cases	Specialist veterinary oversight is required

10. Vaccines and Future Prospects

No commercial field vaccine is currently available for bovine trypanosomosis. Vaccine development is hindered by antigenic variation of the variant surface glycoprotein (VSG) and parasite-associated disruption of host B-cell memory. Experimental approaches include invariant flagellar antigens, conserved structural proteins, parasite proteases and radiation-attenuated organisms. Some have shown promise in laboratory models, but reliable protection in cattle has not been established (Chandra *et al.*, 2023; Alzan *et al.*, 2024).

Table 5. Selected experimental vaccine approaches

Strategy	Target / concept	Current limitation
Metacyclic VSG	Surface antigens of infective stages	Antigenic diversity limits protection
Invariant flagellum antigens	Conserved flagellar proteins	Protection in cattle requires further validation
MISP / BARP proteins	Tsetse-stage surface proteins	MISP alone has not provided reliable protection
Structural antigens	Tubulin, flagellar-pocket antigens and VSG-related structures	Evidence is largely preclinical
Anti-disease proteases	Congopain and sialidases	May reduce disease effects without eliminating infection
Radiation-attenuated parasites	Whole-cell experimental immunization	Requires further safety and efficacy studies

11. Conclusion and Future Perspectives

Bovine trypanosomosis remains an important constraint on livestock health and productivity. Effective control requires timely diagnosis, appropriate trypanocidal treatment, supportive care, vector suppression and surveillance for drug resistance. Emerging molecular diagnostics may improve detection of active infections, while genetic selection and invariant-antigen vaccine research offer longer-term possibilities. Integrated, locally adapted control strategies are essential to reduce losses in endemic regions.

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