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Mini Review

Bacterial Diseases of Ruminants in Iraq: Epidemiology, Clinical Manifestations, and Current Control Strategies

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Abstract Bacterial diseases represent an important and persistent threat to ruminant health, animal welfare, livestock production, and public health in Iraq, with consequences for household livelihoods, food security, and the sustainability of agricultural enterprises. This narrative review examines the epidemiology, pathogenesis, clinical manifestations, diagnostic approaches, and current prevention and control strategies for major bacterial infections affecting cattle, sheep, and goats. The diseases considered include brucellosis, bovine tuberculosis, mastitis associated with *Mycoplasma bovis* and other bacterial pathogens, Q fever caused by *Coxiella burnetii*, anthrax caused by *Bacillus anthracis*, leptospirosis, and salmonellosis. Particular attention is given to published Iraqi investigations of *Brucella* molecular diversity and seroprevalence, molecular findings from mastitic cattle, and the public health relevance of zoonotic transmission. Where Iraqi surveillance evidence is limited, studies from nearby Middle Eastern countries are identified explicitly as regional comparisons rather than treated as estimates for Iraq. Diagnostic methods, vaccination programmes, farm-level biosecurity, food safety, and responsible antimicrobial use are evaluated in relation to practical control needs. The review emphasizes that better integrated veterinary and public health surveillance, improved access to reliable diagnostic testing, coordinated animal-health programmes, and sustained engagement with livestock keepers are necessary to reduce disease burdens and protect rural communities.

Index Terms bacterial diseases; ruminants; Iraq; brucellosis; bovine tuberculosis; *Mycoplasma bovis*; zoonoses; epidemiology; disease control

I. Introduction

Ruminant livestock plays an important role in Iraq's agricultural economy, as sheep, goats, and cattle provide meat, milk, hides, household income, and other resources essential to rural livelihoods. The country's geographic location, variable climatic conditions, cross-border animal movements, and differences in farm management can influence the occurrence and transmission of infectious diseases. Several bacterial infections remain difficult to control where routine veterinary services, diagnostic facilities, herd-level surveillance, vaccination coverage, and practical biosecurity measures are insufficient. The importance of structured surveillance and epidemiological investigation has been demonstrated by studies of *Brucella melitensis* strains recovered from Iraqi livestock [1].

The importance of bacterial disease extends well beyond direct losses from reduced production, reproductive failure, mortality, and veterinary treatment costs. Several causative organisms are zoonotic and can infect people who work closely with livestock or consume unsafe animal products. Such exposures are particularly relevant for farmers, veterinarians, animal handlers, slaughterhouse personnel, and rural households. This review critically evaluates available evidence concerning the epidemiology, pathogenesis, clinical manifestations, diagnosis, prevention, and control of selected bacterial diseases in Iraqi ruminants. It distinguishes direct evidence from Iraqi investigations from findings reported in neighbouring countries and identifies areas in which current surveillance remains incomplete. A narrative synthesis of published studies and authoritative veterinary guidance is used; no new animal-level dataset was collected or analysed for this review.

II. Brucellosis

A. Etiology and epidemiology

Brucellosis is an important contagious and zoonotic infection caused by bacteria of the genus *Brucella*. *B. melitensis* is particularly associated with infection in sheep and goats, while *B. abortus* is classically associated with cattle, although host species overlap and cross-species infections can occur. This distinction is important for surveillance, interpretation of laboratory findings, and selection of veterinary control programmes [2]. Brucellosis continues to be a substantial reproductive-health and public-health concern in Iraq. Molecular characterization of strains recovered from domestic ruminants has demonstrated genetic relationships among Iraqi *B. melitensis* isolates and strains circulating elsewhere in the region; these findings support epidemiological tracing, but

should not be taken as proof of any single transmission route [1].

Evidence from northern Iraq illustrates the continued burden of infection in selected animal populations. A molecular investigation of blood samples from sheep and goats with a history of abortion in Duhok Province reported PCR-positive proportions of 35.45% among sheep samples and 23.8% among goat samples [3]. These are estimates from the particular sampled groups and should not be interpreted as population-wide prevalence in all Iraqi sheep and goats. A systematic review and meta-analysis of investigations conducted around Mosul over approximately four decades estimated overall brucellosis seroprevalence at 14.14% in food-producing animals, including 14.46% in sheep, 12.99% in goats, 11.69% in cattle, and 22.64% in buffaloes [4]. The review identified substantial heterogeneity across studies; therefore, local estimates and long-term pooled values require careful interpretation rather than direct comparison as equivalent measures.

B. Clinical manifestations and pathogenesis

The principal manifestations of ruminant brucellosis involve the reproductive system. In pregnant females, infection may produce late-gestation abortion, stillbirth, retained fetal membranes, placentitis, and subsequent reproductive losses. In males, epididymitis, orchitis, and reduced fertility may occur. Although affected animals may show severe reproductive consequences, many infected animals appear clinically normal between reproductive events and can continue shedding organisms. The capacity for persistent infection and environmental contamination makes detection and management at flock or herd level especially challenging [2]. Reproductive signs alone are insufficient for diagnosis because several other pathogens can also cause abortion and infertility.

C. Zoonotic significance and public health impact

Human brucellosis can arise through contact with infected animals, placental tissues and aborted fetuses, or through the consumption of unpasteurized milk and dairy products. Risks increase when livestock owners, veterinary personnel, and household members lack adequate access to protective equipment, safe disposal services, and timely medical evaluation. A retrospective paediatric study in Duhok examined 72 eligible records selected from 1,032 suspected childhood brucellosis cases recorded between 2018 and 2021, reporting an approximately 7% figure and the highest annual reported figure of 7.8% in 2020 [5]. The precise study denominator and case-selection criteria must be considered when interpreting those percentages; they are not an estimate of brucellosis prevalence among all children in Duhok. Better livestock control, pasteurization, and awareness of occupational exposure are central to reducing zoonotic transmission [2].

D. Diagnostic approaches

Serological approaches used for ruminant brucellosis include the Rose Bengal test, complement fixation testing, and enzyme-linked immunosorbent assays. Each method has particular applications and limitations, so test interpretation must consider vaccination history, animal species, infection stage, and the surveillance objective. Molecular diagnostic methods, including appropriately validated real-time PCR assays, can support detection of *Brucella* DNA in relevant clinical samples. Culture remains important in reference laboratories but demands stringent biosafety practices owing to the zoonotic hazard. Multilocus sequence typing and core-genome approaches provide additional tools for examining relationships among isolates during epidemiological investigations; they do not replace standard clinical and herd-level testing [1], [2].

III. Bovine Tuberculosis

Bovine tuberculosis is associated principally with infection by members of the *Mycobacterium tuberculosis* complex, especially *M. bovis*, and is relevant to both livestock health and zoonotic disease prevention. Infected cattle may remain without obvious clinical signs for prolonged periods, while advanced disease can include progressive weight loss, reduced productivity, chronic respiratory signs, and lesions affecting lymph nodes or internal organs. Transmission is frequently associated with respiratory exposure, animal movements, and close contact within herds; consumption of unpasteurized dairy products also presents a human-health concern [6]. The present review does not identify a sufficiently consistent set of nationally representative Iraqi data from which to estimate current bovine-tuberculosis prevalence. Consequently, the available evidence should not be used to claim a specific nationwide incidence or trend. Risk-based surveillance, investigation at slaughter, validated herd testing, traceability, and careful management of infected animals are important components of control. Guidelines issued by the World Organisation for Animal Health (WOAH) emphasize that programmes must be adapted to the epidemiological, economic, and operational conditions of the affected country [7].

IV. Mastitis and Associated Bacterial Pathogens

A. Epidemiology of mastitis in Iraq

Clinical and subclinical mastitis remain economically important causes of impaired milk production and reduced dairy-herd efficiency. Subclinical infection may persist without obvious abnormalities of the udder or milk, requiring screening by appropriate tests and attention to somatic-cell-count patterns. A study of milk samples from cows with suspected clinical mastitis in Basrah Province identified several bacterial organisms, particularly *Staphylococcus aureus* and *Escherichia coli*, through phenotypic and molecular methods [8]. The study provides evidence concerning its sampled cows, but it does not establish the prevalence of all forms of mastitis across Iraq. Pathogen distribution can vary with milking procedures, herd hygiene, bedding, animal movement, and other farm-specific management factors [9].

B. Mycoplasma bovis mastitis

Mycoplasma bovis, a wall-less bacterium in the class Mollicutes, is an important cause of clinical and subclinical bovine mastitis. Infections may be persistent, difficult to recognize early, and challenging to control within dairy herds. An investigation in Wasit Province used molecular, phylogenetic, and immunohistochemical approaches to evaluate bovine mycoplasmosis in mastitic cattle. It also examined inflammatory changes, including tumour necrosis factor-alpha (TNF-α) expression and tissue lesions in affected udders [10]. These findings provide local support for the relevance of *M. bovis*; however, their magnitude and clinical significance should be interpreted within the original study population. Diagnostic approaches require suitable molecular testing or specialized culture, together with practical measures to prevent introduction and movement of infected animals into healthy herds [9].

C. Other mastitis-associated pathogens

Other bacterial causes of bovine mastitis include *S. aureus*, *E. coli*, various streptococci, *Klebsiella* species, *Serratia marcescens*, and *Pseudomonas aeruginosa*. The Basrah investigation identified *S. aureus*, *E. coli*, *Bacillus* species, and *Enterobacter* species in its study samples [8]. It would therefore be inaccurate to attribute the entire wider pathogen list specifically to that study. Epidemiologically, pathogens such as *S. aureus* and *Streptococcus agalactiae* are classically associated with contagious spread during milking, whereas *E. coli* and *Streptococcus uberis* are commonly linked to environmental sources including bedding, manure, and contaminated housing. Because the separation between these categories is not absolute, control programmes should address both milking hygiene and environmental exposure [9].

D. Impact on livestock production

Mastitis can reduce the volume and marketable quality of milk, increase veterinary expenditures, require temporary disposal of milk during legally mandated drug-withdrawal periods, and increase the risk of premature culling in animals with chronic infection. Even when visible signs are absent, subclinical disease may increase somatic cell counts and compromise udder health and milk processing quality. Better detection, evidence-based treatment decisions, hygienic milking procedures, and sustained herd monitoring are therefore economically important in addition to their benefits for animal welfare [9].

V. Q Fever (Coxiellosis)

A. Etiology and epidemiological significance

Q fever is caused by *Coxiella burnetii*, an obligate intracellular bacterium capable of surviving environmental exposure and causing zoonotic disease. The organism has been documented in several livestock populations across the Middle East, but there are insufficient data in the sources reviewed here to derive a reliable prevalence estimate specifically for Iraqi cattle, sheep, or goats. In a study conducted in western Iran, investigators detected bacterial DNA in 2 of 250 small-ruminant blood samples (0.8%; both positive samples came from sheep) and in 34 of 244 collected ticks (13.9%) [11]. These results describe a neighbouring country's sampled animals and ticks and should not be extrapolated to Iraq without additional field research.

B. Transmission and host range

Cattle, sheep, and goats are important reservoirs of *C. burnetii*. Large quantities of the organism may be released in placental tissues, birth fluids, and other reproductive materials, particularly during abortion and parturition. Environmental contamination can generate infectious aerosols and dust, creating risk for veterinary workers and farm households. Ticks may also be involved in animal epidemiology, although their significance varies by setting. In the Iranian study, the highest recorded percentages among sampled ticks occurred in *Dermacentor marginatus* (18.3%) and *Haemaphysalis concinna* (12.5%) [11]. Measures that reduce direct contact with contaminated birth materials are particularly important for protecting humans [12].

C. Clinical manifestations and public health significance

Many infected ruminants appear healthy, but reproductive consequences may include abortion, stillbirth, and delivery of weak offspring. In humans, Q fever can cause a febrile illness accompanied by atypical pneumonia or hepatitis and may lead to more severe disease in susceptible individuals. Workers handling livestock, placentas, and contaminated farm materials require particular attention to exposure reduction. Iraqi evidence of *C. burnetii* in camels demonstrates that the pathogen can occur in the national animal population, but camel observations cannot establish the prevalence in Iraqi ruminants [13]. Proper management of animal births, appropriate diagnostic services, and coordinated animal-human surveillance are therefore essential [12].

VI. Anthrax

A. Epidemiology in the Middle East

Anthrax is caused by the spore-forming bacterium *Bacillus anthracis* and is an important disease of domestic and wild herbivores. Reports from the Middle East demonstrate the need for continued veterinary surveillance, although outbreak frequencies differ across countries and years. A study published in 2026 investigated 13 confirmed anthrax outbreaks that had occurred in Jordan between 2018 and 2020. It examined 822 total animal and environmental samples; specifically, 75 of 195 carcass samples (38.5%) were positive for the study's chromosomal marker, and 81% of these positives carried the tested pXO1 marker [14]. This 38.5% finding concerns carcass samples rather than all 822 specimens, and the study cannot establish anthrax prevalence among Iraqi animals. Such geographically specific evidence is useful for regional awareness but must be distinguished clearly from confirmed Iraqi surveillance.

B. Transmission and environmental persistence

Anthrax spores can persist in soil for extended periods, potentially exposing grazing animals through contaminated soil, vegetation, or water. Human exposure can occur through contact with affected animals, carcasses, hides, and contaminated animal products. The organism's ability to form resistant spores means that inappropriate carcass handling and environmental contamination can perpetuate local disease risk. In suspected outbreaks, affected premises and animals require prompt notification to authorized veterinary and public health services, with movement restrictions and approved control measures implemented under relevant regulations [15].

C. Clinical manifestations and safe diagnosis

In susceptible ruminants, anthrax can present as sudden death, sometimes preceded by brief signs of severe systemic illness. Suspicious post-mortem findings can include abnormal bleeding or rapid decomposition, although these features are not individually diagnostic. Carcasses suspected of anthrax must not be opened or subjected to routine field necropsy because exposure of the organism to air can increase environmental spore contamination. Diagnostic specimens should be obtained only by appropriately trained and authorized personnel and referred to suitable laboratories under established biosafety procedures. Isolation or culture should never be described as a routine farm-level action; safe management and rapid veterinary notification take priority [15].

VII. Other Important Bacterial Diseases

A. Leptospirosis

Leptospirosis is caused by pathogenic members of the genus *Leptospira* and can affect livestock reproduction as well as human health. Available published prevalence data for Iraq are incomplete, so the current national burden cannot be quantified reliably from the reviewed literature. A regional literature review reported substantial evidence gaps in the Middle East and emphasized the need for better epidemiological surveillance [16]. In cattle and other ruminants, infection may cause abortions, weak offspring, stillbirths, infertility, or clinically silent carriage. Appropriate investigation can include serology or PCR testing selected in relation to the clinical presentation. Control requires attention to contaminated water, reservoir hosts, animal movement, and veterinary decisions concerning vaccination and antimicrobial management [17].

B. Salmonellosis

Salmonella infections in cattle, sheep, and goats may cause fever, diarrhoea, dehydration, enteritis, septicaemia, and occasionally abortion. Clinically normal carrier animals can shed the organism intermittently, complicating efforts to prevent transmission. Young animals, stressed animals, and populations with poor sanitation are especially vulnerable to clinically important disease. Transmission to humans may occur through contaminated foods or animal contact, reinforcing the need for food hygiene and protective farm practices. In this review, these ruminant-specific clinical statements are supported by veterinary reference material rather than by experimental rabbit infections or studies involving pet dogs, which do not directly establish ruminant disease patterns in Iraq [18].

VIII. Diagnostic Approaches and Surveillance

Control of bacterial infections in Iraqi livestock requires a combination of clinical evaluation, appropriate specimen selection, and access to validated serological, microbiological, and molecular techniques. Serological tests can provide evidence of exposure or immune response, but a positive result must be interpreted in the context of vaccination, clinical signs, and epidemiological history. Microbiological culture can identify organisms where appropriate facilities and biosafety procedures are available, although slow-growing or fastidious bacteria require specialized laboratory methods. Molecular tests, including real-time PCR, can support timely detection of pathogen-specific DNA, while sequencing and phylogenetic investigations can improve understanding of transmission and strain relationships [1], [10]. Because some pathogens reviewed here present substantial laboratory-acquired infection risks, specimen handling must follow disease-specific safety requirements rather than a single generalized workflow. Consistent data recording across governorates, livestock species, and diagnostic methods would substantially improve the interpretability of surveillance findings.

IX. Control and Prevention Strategies

Vaccination, when available and suitable for the local epidemiological situation, is an important component of animal-disease prevention. For brucellosis, *B. melitensis* Rev.1 is the established reference vaccine for sheep and goats, whereas *B. abortus* S19 is a cattle vaccine; the latter should not be presented as a routine vaccine for sheep. Vaccine selection, timing, administration, and use in pregnant animals must be determined by trained veterinary authorities under applicable national programmes, because live vaccines carry safety and diagnostic implications [2], [19]. In areas where anthrax is endemic or outbreak risks are documented, suitable livestock vaccination and authorized carcass management are important, but programmes must be coordinated with official animal-health services [15].

Broader farm biosecurity should include assessment and isolation of newly introduced animals, safe handling and disposal of potentially infectious reproductive materials, cleanliness around calving and lambing, appropriate milk hygiene, protection of feed and water from contamination, and controlled movement during suspected outbreaks. Pasteurization and consumer education are particularly relevant to zoonoses associated with raw dairy products. Routine surveillance, clear reporting arrangements, veterinary training, access to laboratory confirmation, and engagement with livestock owners should operate together rather than as isolated interventions. Antimicrobial treatment should be based on veterinary evaluation, the likely pathogen, evidence from diagnostic testing where feasible, and responsible antimicrobial stewardship.

Antibiotics are not a substitute for vaccination, biosecurity, or systematic control of persistent herd-level infections [2], [9], [18].

X. Conclusion

Bacterial diseases remain important constraints on sustainable livestock production, animal welfare, rural incomes, food security, and public health in Iraq. Published molecular and epidemiological investigations have improved knowledge of *Brucella* infections, while local mastitis research has provided further insight into bacterial pathogens affecting dairy cattle. Nevertheless, important evidence gaps remain for several diseases, including the national distribution of bovine tuberculosis, Q fever in ruminants, leptospirosis, and anthrax. Regional studies provide useful context but cannot replace adequately designed Iraqi surveillance. Brucellosis is among the better documented zoonotic and reproductive diseases examined in this review, and emerging evidence about *Mycoplasma bovis* mastitis underscores the need for broader and more consistent diagnostic capacity. Sustainable control will require coordinated disease reporting, species-appropriate vaccination, safe management of infected animals and reproductive materials, better herd hygiene, responsible use of antimicrobials, and reliable laboratory services. Close cooperation among veterinary authorities, public health agencies, researchers, and livestock producers is essential for translating evidence into feasible interventions and reducing the burden of bacterial disease in Iraqi ruminant populations.

Competing Interests

The author declares no competing interests.

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Data Availability

This narrative review did not generate or analyse a new primary dataset.

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