Int.J.Curr.Microbiol.App.Sci (2025) *14*(03): 118-127

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 Volume 14 Number 3 (2025)
Journal homepage: http://www.ijcmas.com

Review Article https://doi.org/10.20546/ijcmas.2025.1403.016

A Review about Prevalence of *Babesia* spp in Ruminants in Iraq

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Keywords

Babesia, protozoan parasite, livestock and agricultural animals

Article Info

Received:
16 January 2025
Accepted:
28 February 2025
Available Online:
10 March 2025

A B S T R A C T

Babesiosis is a protozoan parasite disease produced by several strains of Babesia. It is a severe tick-borne infection that affects both wild and domestic animals, as well as people in warm temperature regions. So far, more than one hundred Babesia spp had discovered in mammals. This paper include the review about the prevalence of *Babesia* species in ruminants throughout Iraqi governorates and this depended on Iraqi researches that have been published in different International and local journals, and this study reported a wide variation in parasite infection rates due to a variety of factors, including host availability, the presence of parasite transmission vectors as well as hosts, the age and breed of the host, environmental conditions, and different parasite diagnosis methods, all of which contribute to variation in the prevalence infection rate in Iraq.

Introduction

Hemoparasitism is a prevalent ailment in animals that has a detrimental impact on the reproduction, production, performance and health parameter of the affected animals. (Abdullah *et al.,* 2019; Jamil *et al.,* 2023). *Babesia* is a protozoan parasite from the genus Piroplasmida that causes a fatal illness in livestock and agricultural animals. Because the sickness has immediate economic repercussions such as decreased milk supply, loss of body weight, and animal death, it creates serious concerns for both farm animal economy and animal life (Menshawy, 2020). Babesiosis is a disease transmitted by ticks which impact on a variety of domesticated and wilderness animals, as well as people in region of tropical and subtropical. So far, about one hundred *Babesia spp* found in mammals (Razmi, 2022). *Babesia spp.* is causative agent of the disease's, while Ixodid ticks are its vectors. (Schnittger *et al.,* 2012). *Babesia* spp survive and reproduce as 'piroplasms' in the red blood cells of the vertebrate animals, and in contrast with erythrocytic phases (Service, 2001). The female tick often becomes infected after swallowing Babesia spp in a blood meal are transmitted to another host as next generation ofsporozoites found in the saliva, which includes adults, nymphs, and larvae Babesiosis' important clinical symptoms include fever, hemoglobinuria, anemia, and icterus (Service, 2001). Babesiosis is also known by a variety of other names, including Piroplasmosis, Texas fever, and Red water fever (Sahinduran, 2012). *Babesia bigemina* and *B. bovis* are the primary causes of bovine babesiosis, although additional species, including *B. divergens*, *B. major*, *B. jakimovi*, *B. ovata*, and *B. occultans*, may also be involved in cow infections. (Chauvin *et al.,* 2009). Babesiosis in sheep is caused by *B. ovis*, *B. motasi* and *B. crassa*. (Bilgic *et al.,* 2017; Uilenberg, 2006)

History of Babesia

In 1888, Babes researched epidemics of disease with indications of hemoglobinuria over cattle in Romanian, and in cattle blood, he was first diagnosed pirplasm (Babes, 1888). Firstly, he thought it was a bacterium called *Hematococeus bovis*, then renamed *Babesia bovis* later by Smith and Kilborne after five years verified the occurrence of an hemoprotozan parasites in dairy bovine with Texas cow disease (babesiosis), termed *Pyrosoma bigeminum* (*Babesia bigemina*) (Bock *et al.,* 2004).

Then the initial detection of Babesia transmitted througth transovarian via its tick vector was discovered, which was a momentous discovery (Smith and Kilborne, 1893). Babesiosis was progressively found in many regions in global and can zoonotic infection, especially within subtropical and tropical nations, as well as its economic implications (Kivaria *et al.,* 2007). In 1956, *B. divergens* produced the initial verified human case of fatal babesiasis (Skrabalo and Deanovic, 1959). Then, the relevance of babesiosis in humans as zoonotic infection has emerged (Hunfeld *et al.,* 2008).

There are various kinds of *Babesia* that cause human illnesses across the world, especially in North America is the most common *B. microti* (Gorenflot *et al.,* 1998) (Homer *et al.,* 2000). They were named *Pyrosoma bygeminum*, and they demonstrated Ticks vector takes a significant part in the propagation of disease. This was the initial describe of a vertebrate disease spread by arthropods. Starcovici named these creatures Babesia in 1893 (Uilenberg, 2006). In 1903, Lignieres reported in cattle two types of Babesia in Argentina: *B.bovis* and *B. bigemina*. initially discovered *B. ovis* in sheep in Iran in 1936 (Delpy, 1936). In human, the initial case of babesiosis was reported in 1957 in a splenectomized Yugoslav peasant. Following the original occurrence in Europe, In 1966, a *B. microti*-related case was Identified in person has a splenectomiz from California city, USA. (Hasherni-Fesharki *et al.,* 1981).

Taxonomy and Morphology

The Babesia genus is in the Apicomplexa phylum and the Babesiidae family. Babesia parasite that round, piriform and may be oval in shape, Featuring a polar ring, subpellicular tubules and rhoptries. conoids and Micronemes emerge in at particular stages and species (Levine, 1988). The morphometric approach, which is based on merozoite size and relation to erythrocyte radius, lacks an evident genetic foundation since *Babesia spp*. can alter in red blood cells during the asexual stage or when it infects a host that is not particular (Chauvin *et al.,* 2009) and (Homer *et al.,* 2000) *Babesia* merozoites, like other eukaryotic cells, have membrane organelles such as the nucleus, endoplasmic reticulum (ER), Golgi apparatus, and mitochondria. Furthermore, like other Alveolata members, they have a cellular wrapping known as the pellicle, which is made up of the cell membrane and two inner layers: a primary layer of vesicles or alveoli and a secondary layer of microtubules, both of which are included in host cell invasion and parasite motility (Lew *et al.,* 2002). The anterior apex contains an assembly of invasion-specialized organelles known as the apical complex, which is also found in other Apicomplexans. It consists of a polar ring, micronemes, and rhoptries. Piroplasmids lack another common apical feature, the conoid (Blackman and Bannister, 2001; Klinger *et al.,* 2013). *Babesia spp.* secretory organelles can be found throughout the cytoplasm of parasite, are assumed to similar the thick granules observed in another of apicomplexans parasites, they take part in host-pathogen interactions at every erythrocyte stage, these cells also include an apicoplast, a plastid without photosynthetic function that is considered to have been acquired from algae via secondary endosymbiosis. The apicoplast is responsible for several metabolic functions, including isoprenoid and fatty acid production (Caballero *et al.,* 2012). Because of its critical role in Babesia survival, particular plastid has piqued researchers' interest as a potential target for the creation of parasiticidal drugs (Brayton *et al.,* 2007; Huang *et al.,* 2015).

The morphology of *Babesia spp*. is classified into big and small groups. Small and big Babesia have lengths of 1.0 to 2.5 µm and 2.5 to 5.0 µm, respectively. Small babesias, which comprised *B. bovis*, *B. gibsoni*, *Babesia rodhaini*, *B. microti*, and large babesias, which involved *B. caballi*, *B. bigemina*, *B. Canis*, The orientation of the Babesis in the RBC according to size, since giant pyriform parasites meet at their pointy extremities at an acute angle to one another, whilst microscopic forms make an oblique angle (Ruprah, 1985). Over 100 Babesia species have been found, infecting various mammals and several birds (Hunfeld *et al.,* 2008).

The morphology of distinct Babesia spp. varies depending on the hosts. In bovine and buffaloes, large form of Babesia is *B. bigemina* (4.5 µm x 2.0 µm), the parasites are often pear-shaped. The shape might be round (2-3 µm in diameter), oval, or irregular. *B. bovis* is a tiny form (2.0 µm x 1.5 µm) of Babesia. Vacuolated signet ring forms are notably abundant and somewhat bigger than *B. divergens*. (Soulsby, 1986) *B. divergens* is a small form of Babesia (1.5 µm x 0.4 µm). Typically maintained in paired form, laying superficially on the erythrocytes, however thick, circular or pyriform shaps may be presents, *B. major* is a big form (3.2 µm x 1.5 µm) of Babesia. Pyriform bodies have an angle among the organisms of less than 90°. Round shapes with a diameter of 1.8 µm (Laha *et al.,* 2015).

Babesia motasi, a big form (2.5-4.5 µm) found in ovine and caprine RBC, is pyriform in nature. *B. ovis* is a tiny (1.0-2.5 µm) type of Babesia that is often spherical and found at the RBC periphery. *Babesia foliate* is a smaller type of Babesia. RBC has a leaf-shaped structure and is more centrally positioned. *Babesia taylori* is a tiny (1.5-2.0 µm long) type of Babesia with an ovoid to spherical shape that causes many infections. Up to 16 parasites can be found in an RBC (Laha *et al.,* 2015).

Vector

Tick-borne hemoprotozoan infections such as babesiosis, theileriosis and anaplasmosis pose a serious threat to cattle health state and welfare in tropical and subtropical areas, such as Iraq (Bilgic *et al.,* 2017). Their obligate blood-feeding nature allows them to spread a number of infections that can cause serious illnesses like as theileriosis, babesiosis and anaplasmosis (Kenaw *et al.,* 2023).

Babesiosis is transmitted via infected ticks that feed on host blood, the disease effective is the most commercially significant tick-borne disease in tropical region and subtropical climes (Tavassoli *et al.,* 2013). All Babesia species are naturally transferred from one host to another host through tick bites and Ticks can transmit Babesia via transovarian transmission and among stages transmission (transmission of Babesia from ova to larvae stage to nymph to adult Tick). Ticks are distributed worldwide, especially in tropical and subtropical regions, and 80% of cattle through world's are infected with tick-borne disease (Ghosh *et al.,* 2007). Ticks from the genera Boophilus, Rhipicephalus, Hemaphysalis, Hyalomma, and Ixodes operate as vectors for *B. bigemina* transmission, whereas ticks from the genera Boophilus, Rhipicephalus, and *B. bovis* transmited by Ixodes. *B. bigemina* in B. microplus ticks in infect animal was previously recorded (Wadhwa *et al.,* 2008). The most common ticks were Hyalomma, followed by Hemaphysalis, Boophilus, and Rhipicephalus (Durrani and Kamal, 2008). Experimentally, transovarial and transstadial transmitted done to investigate whether goat infect by *B. ovis* are a source of parasite transmission for *R. bursa* ticks. For the transstadial transmission experiment, goats were infected with 0.1 g of *Babesia spp*. free *R. bursa* larvae (Firat *et al.,* 2024).

Life cycle

Babesia spp. have at least two phases of reproduction: asexual and sexual, These occur in through vertebral animals and the ticks vectors, respectively, the sporozoite stage present in the salivary glands of ticks are normally transmite to the vertebral animals within 2-3 days of insect attach, Sporozoites stages transform into merozoites, which enter erythrocytes and multiply into new merozoites by binary fission. Infect red blood cell gradually break down, allowing organisms to penetrate and divided in another RBC, other merozoites grow into pre-gametocytes and cannot detected by using a light microscope. After 10 hours after ingesting the contaminated blood of the vertebrate host, the merozoites may be detected microscopically in the tick's intestines (Homer *et al.,* 2000).

The pre-gametocytes mature into gametocytes, which produce ray bodies at the front of the piroplasm. The ray bodies generate gametes that unite to form a motile zygote known as an ookinete, which penetrates the intestinal epithelial cells. The ookinete initiates meiotic division, which produces a large number of kinetes.

At this point, the kinetes go via the bloodstream to various tick tissues, including ovarian cells. Infection of eggs results in transovarial transmission. Some kinetes enter cells of salivary gland, where a large multinuclear sporont is finally produced, giving birth to hundreds of microscopic sporozoites stages, inject through feeding and contribute the transmitted transstadial (Melhorn, 2016; Jalovecka *et al.,* 2019).

Clinical signs

Clinical indications vary depending on the animal's age and species, parasite strain, immunological condition, concurrent infection with other infections, and genetic variables in the parasite dosage. The majority of instances have been discovered in animals under the age of nine months, who are typically asymptomatic (Anon, 2008). In cattle Babesiosis, a common tick-borne infection, Infected animals frequently develop symptoms 2-3 weeks following tick infection. However, direct infusion of infected blood can reduce incubation time. With example, *B. bigemina* takes 4-6 days to incubate, but *B. bovis* requires 10-12 days (Schnittger *et al.,* 2022). The intensity of clinical disease indications varies with the age animal, among the older animals frequently sensitive because of reduced the immunological response *B. bovis* is very virulent than *B. bigemina* or *B. divergens*. according to Hayati *et al.,* (2020) and Surjowardojo *et al.,* (2023), Hemoparasites are widely recognized can destroy red blood cells, leading in anemia, anorexia, jaundice, reduced weight growth, loss of production and reproduction, increased morbidity, and even death. (Ademola and Onyiche, 2014; Opara *et al.,* 2016). Emaciation, ataxia, loss of appetite, stop rumination, loss of body weight, progressive hemolytic anemia, jaundice (Icterus), yellowish color of mucous membranes conjunctiva and vagina in sever advanced cases, hemoglobinuria, problems with the heart rate and respiratory rate, and a decrease in milk yield are all clinical signs of babesiosis. In certain circumstances, fever with an infection results in abortion in cattle. Patients have general circulatory shock and, in certain circumstances, neurological symptoms as a result of contaminated RBCs being sequestered in cerebral capillaries (El Moghazy *et al.,* 2014; Bhat *et al.,* 2015; Masih *et al.,* 2021). *Babesia*'s clinical manifestations include dark brown urine (Yadav *et al.,* 2004). Primary clinical signs of *B. bigemina* are fever, hemoglobinuria, and anemia (Zintl *et al.,* 2013).

Epidemiology of *Babesia spp*.

Babesiosis epidemiology was influenced by a variety of parameters, including host availability, tick presence as a vector of infection transmission, parasite prevalence inside vectors, hosts, and environmental conditions. These characteristics contribute to the transmission infection. Any one of this characteristic when absente may lead to stoped the spreads of diseases. In terms of babesiosis epidemiology, "endemic stability" refers to a condition in which the connection between host, parasite, vector, and environment remains such that clinical illness occurs seldom (Laha *et al.,* 2015). Babesia epidemiology is influenced by a variety of factors, including host age. Infection rates are low in young animals due to intrinsic resistance, which is boosted by maternal antibodies transferred to young calve through milk, This resistance progressively declines, leaving the animal very susceptible to disease (Fadly, 2012). Also, the resistance of local breeds resistance to babesiosis higher than imported breeds. Due to long-term expos to tick populations, they evolved either innate resistance or the capacity to produce a powerful immunological response to the tick (Al-Shammari *et al.,* 2024**).** Host immunological state, within endemic locations, when animals young get passive immunity from their dam's colostrum and frequently experience only temporary disease with modest symptoms, tthe active immunity may induced by these infection and establish a long-term carrier status. Active immunity is what makes the carrier survive and immune. These animals maintain a robust immunity while eliminating their disease either naturally or by chemotherapy (Taylor *et al.,* 2007). Bos taurus is categorized into three phenotypes based on *B. bovis* susceptibility to infection, sensitive hosts, who exhibit significant clinical indications that may cause death; animals with intermediate clinical symptoms; and resistant animals, which seldom (Benavides and Sacco, 2007)

Diagnosis

Detecting active cases of babesiosis is mostly dependent on the following diagnostic methods, examine by birect microscopic of giemsa-staine thin blood smear has traditionally considered the most accurate approach for finding the parasite in an infected host, a low-cost, straightforward, generally accessible approach in all labs and, presumably, in fields (Nayel *et al.,* 2012). It is also a useful method for differentiating species. It is efficient in diagnosing acute infections, but less so in low parasitemia and reservoir animals. Immunological examinations, enzyme linked immunosorbent assays (ELISA) and Indirect fluorescent antibody tests (IFAT) can identify Babesia antibodies in subclinical disease and circumvent the limitations of microscopic investigation (El-Fayomy *et al.,* 2013). These tests have limited sensitivity due to the frequency of false-positive and false-negative findings, and cross reactions make species determination problematic. In most cases, they fail to distinguish between chronic and acute infections

(Mahmoud *et al.,* 2016). Nonetheless, these approaches are simple to implement, but they require a high-quality antigen, which is difficult to produce (Mosqueda *et al.,* 2012). Described a complement fixation (CF) assay to identify antibodies against *B. bigemina* and *B. bovis* (Anon, 2008).

Molecular diagnostics is used to identify nucleic acids, which is classified as an indirect identification. However, sensitivity and specificity are quite high (Mosqueda *et al.,* 2012). The most sensitive and specific technology for detecting babesiosis is polymerase chain reaction (PCR) (Vannier and Krause, 2009; AbouLaila *et al.,* 2010), which is beneficial for detecting infection at an early stage. It has been found that PCR is substantially more sensitive than microscopy for detecting babesiosis. It is a crucial test for confirmation, in certain situations for regulatory testing (Sharma *et al.,* 2016; Bal *et al.,* 2016).

Prevalence of Babesia in ruminants

According to a database compiled from several reports, *Babesia spp*. is epidemic in Iraq and infects a wide range of ruminants. (Dakhil, 2021). Prevalence of Babesiosis in cattle, in Iraq, overall prevalence of Babesia infection was 27.27% that investigate in cattle in Erbil (Ameen *et al.,* 2012). In Duhok and Sulaimaniya governorates the prevalence rate of bovine Babesiosis were 11.7%, 56.9% respectively (Ommer *et al.,* 2012). In cattle the infection rate of babesiosis was 0.17% in Mosul city recorded by (Abdullah *et al.,* 2019). Another study about prevalence of Babesiosis in in cattle in Mosul city that reported higher infection was 42.33% (Suleiman & Altaee, 2017). Also infection rate of bovine babesiosis regarded in Mosul city, it was 60% reported by Suleiman & Altaee (2020). In Tikreet provenance the Prevalence of babesiosis in cattle was 8.8%, this study done by Ibrahim *et al.,* (2012). The occurrence of bovine babesiosis was 30% that has been revealed in Diyala provenance (Minnat *et al.,* 2016).

The incidence of Babesia infection in cattle was (3.1%) reported in Diyala governorate (Hassoon, 2018). In Baghdad city the incidence of Babesiosis in cattle was (66.6%) (Saeed *et al.,* 2017). In Babylon Province the prevalence of infection with *Babesia bigemina* was 7.75% reported by (Al-Shammari *et al.,* 2024**)**. The prevalence of bovine Babesiosis in Basrah governorate was (27.1%) investigated by (AL-Mayah & Abdul-Karim, 2020). In Wasit Province the infection rate of babesiosis was 6.78% (Gharban *et al.,* 2022). In Al-Qadisiyah province the occurrence of infection rate was 47.91 % reported by (Khawla *et al.,* 2016). The prevalence of Babesiosis in Basrah province south Iraq are regarded 27.14% (AL-Mayah & Abdul-Karim, 2020).

Prevalence of Babesia in sheep and goat, in Iraq The prevalent of *Babesia* spp. In sheep very low 0.01% in Mosul city was regarded by Abdullah *et al.,* (2019). Also another study indicate the total infection rate of Babesiosis in sheep in Mosul city was 43.07%. reported by Al-lahaibi & Suleiman (2024). In Baghdad provenance the incidence of Babesia infection in sheep was 15.55% recorded by Arwa and Kawan (2022). The prevalence of infection rate in sheep and goat by the Babesia spp. were 20.41% and 17.78% respectively, that indicated in Erbil province (Hassan, 2020). The occurrence of ovine babesiosis was 27.83 that has been revealed in Diyala provenance (Al-Karkhi *et al.,* 2013). The prevalence of Babesia parasites infecting sheep in Sulaimani governorate was 25.78% recorded by Abdullah & Ali (2021). In the Kurdistan region the infection rate of *Babesia ovis* was (1.5%) regarded by Renneker *et al.,* (2013). The prevalence of Babesiosis in small ruminants in Sulaimani city was 56.3% from sheep and 64% of goats (Shadan and Aram, 2014). The study that conduct in Al-najaf provenance that observed the incidence of babesiosis in sheep was 26.9% recorded by Al-mialy *et al.,* (2018). The study in Duhok governorate about Prevalence of Babesiosis among goats it was 4% infected with *Babesia motasi* that observed by (Zangana & Naqid, 2011). In the central part in Iraq the prevalence rate was 2.70% with *Babesia motasi* that regarded by Latif *et al.,* (1987).

Prevalence of Babesia in Buffaloes, in Iraq. Study that conduct in Basrah among Buffaloes indicated infection rate of babesiosis with clinical signs reported 16% (Alautaish *et al.,* 2023). Higher incidence of babesiosis in buffaloes regarded in Al-Najaf city was 45.74% observed by (Ateaa & Alkhaled, 2019). In Wasit governorate Babesia prevalence among buffaloes was 25.7% regarded by (Alkefari *et al.,* 2017).

The occurrence of Babesia infection among Camels in AL-Furat Al-Awsat Governorates was 20% indicated by (Al-Hakak, 2024). The incidence of Babesiosis in camels in desert of Al-najaf provenance was 25% observed by (Al-mialy *et al.,* 2018). The infection rate of babesiosis infect camels with to *B. caballi* was (39.47%) in south of Iraq indicated by (Jasim *et al.,* 2015). In Diwaniyah province the prevalence of Babesia spp in camels was

53% recorded by (Al-Naily & Jasim, 2018). Also another study conduct in Diwaniyah province about Babesia spp. occurrence in camels was 60.8% (Jasim *et al.,* 2022).

In conclusion, the current study indicated that babesiosis highly prevalent in Iraq for many reason such as uncontrolled on Tick vectors and variable environmental conditions. The variation may be due to the species of animal, immunological status of animals and different ages, different breeds and sexes. The high infection rate in middle and south of Iraq belong to presence worm wither, humidity and marshes all these factors lead to improve the environment for increase the population of Tick vector.

Author Contributions

Jihad Talib Obead: Investigation, formal analysis, writing—original draft. Atheer Kareem Kadhim: Validation, methodology, writing—reviewing. Zaid Khalid Alani:—Formal analysis, writing—review and editing.

Data Availability

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

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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How to cite this article:

Jihad Talib Obead, Atheer Kareem Kadhim and Zaid Khalid Alani. 2025. A Review about Prevalence of Babesia spp in Ruminants in Iraq. *Int.J.Curr.Microbiol.App.Sci.* 14(03): 118-127.

doi: https://doi.org/10.20546/ijcmas.2025.1403.016