Bovine Babesiosis

**Importance**

Bovine babesiosis is a tick-borne, parasitic infection that causes significant morbidity and mortality in cattle. It is the most important arthropod-borne disease of cattle worldwide. The most prevalent species, *Babesia bovis* and *B. bigemina*, are found throughout most tropical and subtropical regions. The economic losses from these two organisms can be considerable, particularly in developing countries. Although babesiosis can be controlled with vaccination and treated with antiparasitic drugs, the vaccines are live and have safety concerns, and many effective drugs have been withdrawn from the market due to safety or residue problems. *B. bovis* and *B. bigemina* were once endemic in the southern United States, and caused severe losses to the cattle industry. Although these organisms and their vectors were eradicated from the U.S. by 1943, reintroduction is a significant threat. Another important species, *B. divergens*, causes losses to farmers in parts of Europe and is a serious zoonotic threat to people who are immunocompromised.

**Etiology**

Babesiosis results from infection by protozoa in the genus *Babesia* (family Babesiidae, order Piroplasmida). The three species found most often in cattle are *Babesia bovis*, *B. bigemina* and *B. divergens*. Additional species that can infect cattle include *B. major*, *B. ovata*, *B. occultans* and *B. jakimovi*.

Organisms that are very closely related to *B. divergens*, but do not seem to affect cattle, have recently been discovered in wildlife and humans. Whether these species should be called *B. divergens* is uncertain, but at least in some cases, they appear to be distinct organisms. Some, such as *Babesia venatorum*, have been given individual names.

**Species Affected**

*B. bovis* and *B. bigemina* are found in cattle, which are the main reservoir hosts. They also affect water buffalo (*Bubalus bubalis*) and African buffalo (*Syncerus caffer*). *B. bovis* and *B. bigemina* were recently discovered in white-tailed deer (*Odocoileus virginianus*) in Mexico. The importance of this finding is unknown, but animals other than cattle have generally been considered of little epidemiological significance as reservoir hosts.

*B. divergens* causes clinical signs in cattle and reindeer (*Rangifer tarandus*). Mongolian gerbils (*Meriones unguiculatus*) can be experimentally infected, but mice, hamsters, rats and rabbits are resistant. Splenectomized humans and non-human primates (including chimpanzees and rhesus monkeys) are highly susceptible to *B. divergens* and become severely ill, but non-splenectomized primates are resistant. Experimental infections can also be established in splenectomized ungulates including mouflon (*Ovis musimon*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), and fallow deer (*Dama dama*) but clinical signs are not usually seen. Very low and transient parasitemia has been reported in splenectomized sheep. Intact animals of these species are resistant.

*B. jakimovi* can infect cattle, roe deer, Asian elk (*Alces alces*), and reindeer. *B. major*, *B. ovata* and *B. occultans* infect cattle.

**Geographic Distribution**

Bovine babesiosis can be found wherever the tick vectors exist, but it is most common in tropical and subtropical areas. *B. bovis* and *B. bigemina* are particularly important in Asia, Africa, Central and South America, parts of southern Europe, and Australia. Although *B. bovis* is usually found in the same general geographic area as *B. bigemina*, slightly different groups of ticks spread these two species and some differences in their distribution can be seen. For example, *B. bigemina* is more widely distributed than *B. bovis* in Africa. *B. bigemina* and *B. bovis* and their vectors were formerly enzootic throughout much of the southern United States, but now are found only in a quarantine buffer zone along the Mexican border.
B. divergens is an important parasite in parts of Europe including the United Kingdom, Spain and northern Europe. Surveys have found evidence for this species throughout Europe, and it may also occur in North Africa. Its vector, I. ricinus, can survive from northern Scandinavia to the Mediterranean. However, because this tick requires 80% humidity, it can be found only in some microenvironments such as the base of vegetation in forests, rough hill scrub, and damp low-lying land. B. major can be found in parts of Europe, Northwest Africa and Asia, as well as China. B. ovata has been described in Japan, China and other parts of eastern Asia. B. occultans has been reported in Africa, and B. jakimovi occurs in Siberia.

Transmission

Babesia species are transmitted by ticks, which become infected when they ingest parasites in the blood of infected cattle. The major vectors for B. bigemina are Rhipicephalus microplus (formerly Boophilus microplus) and R. annulatus (formerly Boophilus annulatus). R. decoloratus, R. geigyi, and R. evertsi can also transmit this species. The major vectors for B. bovis are R. microplus and R. annulatus, but R. geigyi can also be a vector. B. divergens is transmitted mainly by Ixodes ricinus. B jakimovi may also be transmitted by an Ixodes species. Haemaphysalis punctata transmits B. major, Haemaphysalis longicornis transmits B. ovata, and Hyalomma marginatum transmits B. occultans.

Inside the tick, Babesia zygotes multiply as ‘vermicules,’ which invade many of the tick’s organs including the ovaries; Babesia species are readily passed to the next generation of ticks in the egg. These parasites can sometimes be passed transovarily though several generations, although this varies with the species of Babesia and the species of tick. B. divergens can survive in tick populations for at least 4 years even if cattle are not present. When an infected tick attaches to a new host, Babesia are stimulated to undergo their final maturation. B. bovis parasites usually become infective within 2-3 days after larval ticks attach, and can be transmitted by larvae. In R. microplus, B. bovis does not persist after the larval stage. In contrast, B. bigemina matures in approximately 9 days after a larval tick attaches, and it is only transmitted by nymphs and adults. All three stages of I. ricinus can transmit B. divergens.

Babesia species can also be transmitted between animals by direct inoculation of blood. Biting flies and fomites contaminated by infected blood might act as mechanical vectors, although this method of transmission is thought to be of minor importance.

Babesia are maintained in cattle populations by asymptomatic carriers that have recovered from acute disease. B. bovis persists in cattle for years, and B bigemina survives for a few months. Recrudescence of parasitemia can occur at irregular intervals. Calves can be infected in utero; however, this appears to require pathological changes in the placenta, and transplacental infection seems to be accidental and rare.

Incubation Period

The symptoms of B. bigemina and B. bovis infections usually appear 2 to 3 weeks after tick infestation. After direct inoculation of blood, the incubation period can be as short as 4 to 5 days for B. bigemina and 10 to 12 days for B. bovis.

Clinical Signs

The clinical signs vary with the age of the animal and the species and strain of the parasite. Most cases of babesiosis are seen in adults; animals younger than 9 months usually remain asymptomatic. Strains vary considerably in pathogenicity; however, B. bovis is usually more virulent than B. bigemina or B. divergens.

Typically, animals infected with B. bigemina develop anorexia and a high fever; fever may be present before other clinical signs appear. The characteristic signs are caused by hemolysis and anemia. Animals become inappetent, may separate from the herd, and are weak, depressed and reluctant to move. The mucous membranes become pale, and respiration and heart rate increase. Anemia often develops rapidly, and is frequently accompanied by hemoglobinuria and hemoglobinemia. Jaundice occurs mainly in subacute cases. Diarrhea or constipation may also be seen, and a respiratory distress syndrome with dyspnea can develop in severely affected animals. Fever may cause abortion in pregnant cows, and bulls sometimes have a temporary decrease in fertility. Central nervous system (CNS) signs are uncommon in B. bigemina infections. Some cattle usually die, but in animals that survive, the anemic crisis generally passes within a week. The survivors may be weak and in reduced condition, although they usually recover fully. Subacute infections, with less apparent clinical signs, are also seen.

B. bovis infections are similar but are often more severe. However, hemoglobinuria and hemoglobinemia are less common than in animals infected with B. bigemina. In addition, infected erythrocytes can be sequestered in brain capillaries, resulting in neurologic signs such as incoordination, teeth grinding and mania. Some cattle may be found on the ground with the involuntary movements of the legs. Most animals with CNS signs die.

B. divergens infections can be mild to severe, depending on the strain and other factors. Subclinical infections, with mild fever, anorexia and an uneventful recovery, are common; more severe cases resembling B. bigemina infections can also be seen. CNS signs are rare in B. divergens infections, but may occur if the anemia causes brain anoxia. B. major is nonpathogenic under most conditions, and B. ovata is mildly pathogenic.

Intrauterine infection with Babesia may result in the birth of a febrile, weak, anemic, icteric and dehydrated calf which may have convulsions or other neurologic signs. In one recent case, an affected calf was born to a dam with no history of clinical babesiosis. Intrauterine infections are very rare.
Post Mortem Lesions

Postmortem lesions are mainly related to intravascular hemolysis, anemia and jaundice. The mucous membranes are usually pale and may be icteric, and the blood can appear thin and watery. Icterus may also be present in the omentum, abdominal fat and subcutaneous tissues. The spleen is markedly enlarged with a dark, pulpy, friable consistency. The liver may be enlarged and darkened or icteric, with a distended gallbladder containing thick, granular bile. The kidneys are usually dark red or black, and the urinary bladder often contains reddish–brown urine; however, in some cases, the urine may be normal. The lungs occasionally show signs of pulmonary edema. Other organs including the heart and brain may have petechiae or ecchymoses or be congested, and the surface of the brain can look pink.

Morbidity and Mortality

The morbidity and mortality rates are highly variable. Treatment and previous exposure/vaccination, as well as the species and strain of parasite, can affect the outcome. Cattle can develop lifelong resistance to a species after infection. Some degree of protection against other Babesia species may also be seen. In endemic areas where tick transmission is high year round, animals tend to become infected when they are young, do not become ill, and become immune. This endemic stability can be upset and outbreaks can occur if climate changes, acaricide treatment or other factors decrease tick numbers and animals do not become infected during the critical early period. Outbreaks are also seen in areas where cold seasons interrupt tickborne transmission for a time, as well as when susceptible animals are introduced to endemic regions or infected ticks enter new areas.

In naive cattle, susceptibility to disease varies with the breed. B. indicus cattle and B. indicus / B. taurus crosses are more resistant than B. taurus. Recently, variable susceptibility to B. bovis was also reported in some Bos taurus cattle: approximately 28% of a population of adult animals was susceptible to infection but resistant to clinical signs. In fully susceptible breeds, up to half or more of untreated adults and up to 10% of treated adults may die. Once hemoglobinuria develops, the prognosis is guarded. Infections with B. bovis are generally more likely to be fatal than infections with B. bigemina or B. divergens, and CNS signs suggest a poor prognosis.

Diagnosis

Clinical

Babesiosis should be suspected in cattle with fever, anemia, jaundice and hemoglobinuria.

Differential diagnosis

Babesiosis resembles other conditions that cause fever, and hemolytic anemia. The differential diagnosis includes anaplasmosis, trypanosomiasis, theileriosis, bacillary hemoglobinuria, leptospirosis, erythro-zoonosis, rapeseed poisoning and chronic copper poisoning. Rabies and other encephalitides may also be considerations in cattle with CNS signs.

Laboratory tests

Babesiosis can be diagnosed by identification of the parasites in blood or tissues, polymerase chain reaction assays (PCR), serology, or transmission experiments.

In blood and tissues, parasites are found most easily during acute infections. They may be difficult to detect in carriers. Treatment can also clear Babesia rapidly from the circulation, although the animal remains ill from their effects. Thick films can be helpful in detecting small numbers of parasites, but species identification is best in thin films. Babesia can be identified under oil immersion (minimum x8 eyepiece and x60 objective lens) in stained blood and tissue smears. Giemsa or acridine orange is often used for staining. Immunofluorescent and immunoperoxidase labeling have also been described. These parasites are found within RBCs, and all divisional stages – ring (annular) stages, pear-shaped (pyriform) trophozoites either singly or in pairs; and filamentous or amorphous shapes – can be found simultaneously. Filamentous or amorphous forms are usually seen in animals with very high levels of parasitemia. B. bovis trophozoites are small (usually 1–1.5 μm x 0.5–1.0 μm), often paired and usually centrally located in RBCs. B. divergens resembles B. bovis, but the pairs are often found at the edge of the RBC. B. bigemina is much longer (3–3.5 μm x 1–1.5 μm) and can fill the RBC. Morphological variability may make precise species identification difficult.

Polymerase chain reaction (PCR) assays can detect and differentiate Babesia species, and are particularly useful in carriers. PCR-enzyme-linked immunosorbent assay (ELISA) has been described. Carriers may also be diagnosed with in vitro culture. These animals may occasionally be identified by transfusing blood into a test calf or, in the case of B. divergens, Mongolian gerbils (Meriones unguiculatus). Animal transmission techniques are cumbersome and seldom used for routine diagnosis.

Serology can detect infected animals; it is most often used for surveillance and export certification. Antibodies to Babesia are usually detected with an indirect fluorescent antibody (IFA) test or enzyme-linked immunosorbent assay (ELISA). Complement fixation has also been used, and agglutination assays (latex and card agglutination tests) have been described. Serological cross-reactions can complicate the differentiation of some species in serological tests.

Samples to collect (check also under lab tests)

Before collecting or sending any samples from animals with a suspected foreign animal disease, the proper authorities should be contacted. Samples should
only be sent under secure conditions and to authorized laboratories to prevent the spread of the disease. B. divergens and possibly B. bovis have been implicated in rare human infections; samples should be collected and handled with all appropriate precautions.

*Babesia* can be found in blood and tissues. Both thin blood films and organ smears should be taken at necropsy. Preferred tissues include brain (cerebral cortex), kidney, liver, spleen and bone marrow. Some sources also suggest heart muscle. Diagnosis is unreliable in animals that have been dead for more than 24 hours; however, parasites can sometimes be found after this time in blood from the lower leg. For good stain definition, blood films should be stained as soon as possible. Slides should be air-dried, fixed in absolute methanol (5 minutes for organ smears, 1 minute for thin blood smears), and stained for 20-30 minutes with 10% Giemsa.

Thick and thin blood films should be taken from live animals. Whenever possible, blood should be taken from the capillaries in the ear or tail; *B. bovis* is much easier to find in capillary blood than in the general circulation. *B. bigemina* and *B. divergens* can be found throughout the vasculature. Thin blood films should be stained as described above. Thick blood films are not fixed before staining, which allows the RBCs to be lysed and the parasites to be concentrated. These films should be air-dried, heat-fixed at 80°C for 5 minutes, and stained with 10% Giemsa for 15-20 minutes. If samples of capillary blood are not available, jugular blood may be collected into an anticoagulant. EDTA can be used; however, heparin can affect staining and is not recommended. Blood samples should be kept cool, preferably at 5°C, and whenever possible should be delivered to the laboratory within a few hours.

Serum can be collected for serology.

**Recommended actions if bovine babesiosis is suspected**

**Notification of authorities**

Bovine babesiosis must be reported immediately to state or federal authorities.

**Federal:** Area Veterinarians in Charge (AVIC):


**State Veterinarians:**


**Control**

Babesiosis can be eradicated by eliminating the host tick(s). In the U.S., this was accomplished by treating all cattle every 2 to 3 weeks with acaricides. In countries where eradication is not feasible, tick control can reduce the incidence of disease. The development of resistance to acaricides can be a concern. Environmental modification can also destroy tick habitats, but in some cases this may be difficult and/or ecologically undesirable.

**Public Health**

Although some species of *Babesia* such as *B. microti* can affect healthy people, cattle parasites seem to cause disease only in people who are immunocompromised. *B. divergens* causes serious disease in humans who have had splenectomies. This infection is rare; in Europe, approximately 30 cases had been reported as of 2003. It is characterized by the acute onset of severe hemolysis, hemoglobinuria, jaundice, persistent high fever, chills and sweats, headache, myalgia, lumbar and abdominal pain, and sometimes vomiting and diarrhea. Shock and renal failure may also be seen. *B. divergens* infections in humans are medical emergencies. They usually progress very rapidly, and most cases in the past ended in death within a week. With modern, antiparasitic drugs and supportive therapy, the case fatality rate is approximately 40%. Mild cases may resolve with drug treatment alone. To prevent infection with *B. divergens*, immunocompromised individuals should be careful when visiting regions where babesiosis is endemic, especially during the tick season. Exposure to ticks should be prevented by wearing appropriate clothing (e.g., long-sleeved shirts and long pants) and tick repellents. Skin and clothing
should be inspected for ticks after being outdoors, and any ticks found should be removed. There is no definitive evidence that B. divergens can infect immunocompetent individuals, or those who are immunosuppressed but not splenectomized. However, antibodies to Babesia were found in two of 190 French blood donors.

B. bovis may also be zoonotic, but this is uncertain. At least some historical cases attributed to B. bovis were probably caused by B. divergens.

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References


Benavides MV, Sacco AM. Differential Bos taurus cattle response to Babesia bovis infection. Vet Parasitol. 2007;150:54-64.


Internet Resources


World Organization for Animal Health (OIE) http://www.oie.int


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