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Review on Bovine Babesiosis

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Abstract: The objectives of this paper are to review the epidemiology, economic significance, prevention and control of bovine babesiosis" since it is the most common tick- borne disease problem in tropic and sub topical regions of the world, It is caused by protozoan parasite of the genus *Babesia*, which affects a wide range of domestic and wild animals and occasionally humans. *Babesia bigemina* and *B bovis* are the most prevalent species which affect cattle. They are widespread in tropical and subtropical areas including Ethiopia and are vectored by one host tick *Rhipicephalus* (formerly *Boophilus*) species and transmission is manly transovarial. Availability of host, presence of ticks that act as vector for transmission of infections, presence of parasites within vectors, as well as hosts and environmental conditions are the most important factor for occurrences of bovine babesiosis. Intravascular haemolysis, coagulation disorders and release of pharmacologically active substances resulting in vascular malfunction and hypotensive shock which is major pathogenesis of this disease. High fever, depression, anorexia, haemoglobinaemia and haemoglobinuria arethe predominant signs. Since blood smears are not reliable for detection of carrier animals; in these cases molecular detection methods or serological diagnostic methods are the most important to demonstrate specific antibodies that are needed, the successful treatment of this disease depend on early diagnosis, followed by prompt administration of antiprotozoal agents, the integration of immunization, chemoprophylaxis and vector control methods are the main methods which prevent and control of bovine babesiosis. Since it has major impact in cattle industry because it causes huge economic losses due to loss of meat and beef production of infected animals and death and also nowadays to those costs there must be added the high cost of tick control, disease detection, prevention and treatment. A surveillance system should be developed and implemented to prevent bovine babesiosis from spreading; epidemiological study should be conducted on bovine babesiosis to provide the necessary data.

Key words: *Babesia* · Bovine Babesiosis · Epidemiology · Erythrocytelysis · Vector

INTRODUCTION

Bovine babesiosis is the most important arthropod-borne disease of cattle in the worldwide that causes significant morbidity and mortality. It is the second most common blood-borne parasitic disease of mammals after the trypanosome [1]. It is a disease caused by intra erythrocytic protozoal parasite of the order Piroplasmida, phylum Apicomplexa, of the genus *Babesia*, widely found in tropical and subtropical areas [2]. Now a day it is a disease with a world-wide distribution affecting many species of mammals with a major impact on cattle and man [3, 4]. It is a tick-borne intra-erythrocytic apicomplexan parasites found in a variety of domestic and wild animals and in humans. Mixed infections are responsible for widespread morbidity and mortality in livestock of tropical and subtropical regions of the world. However, the major impact occurs in the cattle industry and the species affecting bovines are the most studied, including Babesia bovis, B. bigemina and B. divergens [5].

Two species are economically important in tropical and subtropical regions of the world, including southern Africa: *Babesia bovis*, which causes Asiatic red water, and *Babesia bigemina*, which causes

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African red water. *Babesia divergens* causes an economically important disease in the British Isles and northern Europe [6]. They also have a considerable impact on cattle health and productivity in tropical and subtropical countries [7].

Bovine babesiosis is communicated by the bite of ticks and is the most important disease to attack bovine populations in humid areas. In hot and warm areas there is great financial loss due to bovine death by bovine babesiosis, with decrease of bovine products and by products. Besides, the environment conditions in those regions favor the survival and reproduction of ticks, so bovines have an en during interaction with these vectors [8]. The endemic condition of bovine babesiosis in a specific geographic region is related with presence of a vector capable to transmit the infection and the enzootic stability condition depends of the interaction established between tick, parasite and bovine [9].

There is age related immunity to primary infection of cattle. Young calves possess strong innate immunity against infection that lasts for approximately 6 months after birth and is abrogated with the removal of the spleen [10]. Infected animals develop a lifelong immunity against reinfection with the same species. There is also evidence of a degree of cross-protection in *B.bigemina*-immune animals against subsequent *B.bovis* infections [11].

Therefore, the objectives of this seminar paper are:

- To overview the epidemiology of bovine babesiosis.
- To review the economic significances of bovine babesiosis.
- To review prevention and control options of bovine babesiosis.

Review on Bovine Babesiosis: Bovine babesiosis is a tick-borne disease of cattle caused by the protozoan parasites of the genus *Babesia*, order Piroplasmida, phylum Apicomplexa. Babesiosis has been dubbed piroplasmosis, tick fever, Texas fever, redwater. Babesial parasites are some of the most ubiquitous and widespread blood parasites in the world, second only to the trypanosome*s* and consequently have considerable worldwide economic, medical and veterinary impact [12]. Nowadays, it is a disease with a world-wide distribution affecting many species of mammals with a major impact on cattle and man. It has increasingly been recognized throughout the world as public health problems [3,4]. It was Victor Babes who at the end of the 19th century ?rst discovered microorganisms in erythrocytes of cattle in Romania and associated them with bovine hemoglobinuria or red water fever [13]. To date, more than 100 species have been identi?ed, infecting many mammalian and some avian species [14].

Etiology: Bovine babesiosis is caused by multiple species but the principal species of *Babesia* that cause are *Babesia bovis*, *Babesia bigemina* and *Babesia divergens* [15]. Additional species that can infect cattle include *Babesia major*, *Babesia ovata*, *Babesia occultans* and *Babesia jakimovi* [16]. Babesia is an apicomplexan parasite that infects red blood cells causing a disease known as babesiosis. *Babesia* are classified as apicomplexan parasites of the suborder Piroplasmidea, family Babesiidae and genus *Babesia* on the basis of their exclusive invasion erythrocytes, multiplication by budding rather than schizogony and lack of hemozoin [17].

Morphology: The intra-erythrocytic structure of these organisms is pyriform in shape and is surrounded by two peripheral membranes within the host cytoplasm [18, 19]. Babesia species enter red blood cells (Erythrocytes) at the sporozoite stage then within the red blood cell, the protozoa become cyclical and develop into a trophozoite ring. The trophozoites moult into merozoites, which have a tetrad structure coined a Maltese-cross form. The tetrad morphology, which can be observed under microscope with Giemsa staining of a thin blood smear, is unique to *Babesia* and serves as a distinguishing feature [20]. Anterior and posterior ends, termed polar rings, delimit the shape of the parasite. Three major organelles (Microtubules, rhoptries and micronemes) concentrate in the anterior polar ring and are collectively known as the apical complex [18, 19]. *Babesia bovis* is smaller than *B.bigemina*, measuring up to 2 ìm in length. Under light microscopy, this organism is often found in pairs at an obtuse angle. Conversely, *B. bigemina* can measure 2 to 5 ìm in length and extend the full diameter of an erythrocyte. Under light microscopy, *B. bigemina* is also found in pairs but unlike *B. bovis*, the angle is acute. Although both organisms are often found in pairs, single forms of the organism are often found within infected erythrocytes [21].

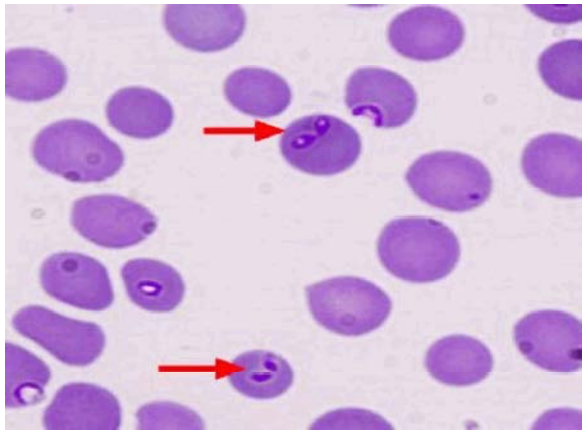

Fig. 1: Morphology of bovine babesiosis picture
Source: Radostits e*t al*.[22]

Table 1: Recognized *Babesia* species of bovines

Babesia Species	Size and Morphology of organism	Principal Tick vectors	Distribution
B. bigemina	4.5 by 2.5 µm (Large, round and pryiform, acute angle)	*Boophilus microplus, Bo annulatus, Bo geig Bo decoloratus*	Africa, Egypt, Asia, America, Australia and Southern Europe
B. bovis	2.4 by 1.5 µm (small, more rounded obtuse angle)	The same as *bigemina* and Ixodes species	The same as *Babesia bigemina*
B. major	2.6 by1.5 µm (large round & pyriform)	*Haemaphysalis punctate*	Europe, North Africa
B. *divergens*	1.5 by 0.4 µm (small, narrow and obtuse angle)	*Ixodes ricinus*	Northern Europe
B. jakimovi (Cattle and wild ruminants)	Similar to *B. major*	*Ixodes ricinus*	Northern USSAR
B. ovate	Similar to *B.bigemina*	*H. longicornis*	Japan
B. occultans	Large	*H. marginatum rufipes*	Southern Africa

Source: El Sawalhy [23].

Epidemiology: All *Babesia* spp. are transmitted by ticks with a limited host range. The principal vectors of *B. bovis* and *B. bigemina* are *Rhipicephalus* (formerly *Boophilus* spp.) ticks and these are widespread in tropical and subtropical countries. Bovine babesiosis is principally maintained by sub clinically infected cattle that have recovered from disease. Morbidity and mortality vary greatly and are influenced by prevailing treatments employed in an area, previous exposure to a species/strain of parasite and vaccination status. In endemic areas, cattle become infected at a young age and develop a long-term immunity. However, outbreaks can occur in these endemic areas if exposure to ticks by young animals is interrupted or immuno naive cattle are introduced. The introduction of *Babesia* infected ticks into previously tick free areas may also lead to outbreaks of disease [24].

The epidemiology of babesiosis in general depended on several parameters such as availability of host, presence of ticks that act as vector of transmission of infections, presence of parasites within vectors, as well as hosts and environmental condition. These parameters are responsible for spread of infections. Absence of any one parameter will discontinue the spread of infections. As regarding epidemiology of babesiosis, a state of "endemic stability" where the relationship between host, parasite, vector and environment remained in such a way that clinical disease occur rarely or not at all [25].

Geographic Distribution: Bovine babesiosis can be found wherever the tick vectors exist, but it is most common in tropical and subtropical areas. *Babesia* spp. are widely distributed throughout the world, with the geographic distribution only limited by the distribution of suitable tick vectors. *Babesia 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 [26].

Table 1: Geographical distribution of *Babesia* parasite, the hosts and tick vectors involved

Babesia species	Animals affected	Geographical distribution	Tick vectors
Babesia bigemina	Cattle Zebu, Water buffalo, Deer, Wild ruminants	Central and South America, Australia, Africa Southern Europe, China	*Boophilus annulatus, B. microplus, B. australis, B. calcaratus, B. decoloratus, Rhipicephalus everts, Rh. bursa, Rh. appendiculatus Haemaphysalis punctate*
Babesia bovis	Cattle, deer, Water buffalo, wild ruminants	Southern Europe, Asia Africa, America, Australia	*Ixodes ricinus, I. persulcatus, B. calcaratus, Rh. Bursa*
Babesia diverged	Cattle	Northern Europe	*I. ricinus*
Babesia major	Cattle	West and South Europe, UKNW, Africa, China	*H. punctate*
Babesia argentina	Cattle	Central and South America, Australia	*B. microplus*

Source: AU-IBAR [27].

Host Range: *Babesia 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*). *Babesia 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 [28]. Susceptibility to infection with *Babesisa* spp. decreases with age, but the severity of clinical disease increases. After 6 months of age, the number of infected animals in enzootic areas increases. The greatest infection rate is in animals in the 6-12 month age group. Immunocompromised and stressed cattle (Pregnancy - poor conditioned) are most susceptible to infection. Cross breeds are more susceptible than native breeds and there is a high incidence during the summer months, the period of high tick activity [23]. Generally in Africa local breeds are hardier and less susceptible to *Babesia,* because they are better adaptation to the local climatic and feeding conditions. Another reason is their genetic diversity due to the large number of allelemorphic genes. Breeds developed for higher productivity, with special climatic or feeding requirements are susceptible because of their poor adaptability due to the limited number of alleles present [29].

Risk Factor: Host factor: host factors associated with disease include age, breed and immune status [30]. *Bos indicus* breeds of cattle are more resistance to Babesiosis than *Bos taurus.* This is a result of evolutionary relationship between *Bos indicus* cattle, *Rhipicephalus* (formerly *Boophilus*) species and *Babesia* [22]. Pathogen factor: strains vary considerably in pathogenicity; however, *B. bovis* is usually more virulent than *B. bigemina* or *B. divergens* [28].

Environmental factor: there is a seasonal variation in the prevalence of clinical Babesiosis, the greatest incidence occurring soon after the peak of the tick population. Of the climatic factors, air temperature is the most important because of its effect on tick activity; higher temperatures increase its occurrence. Heaviest losses occur in marginal areas where the tick population is highly variable depending on the environmental conditions [22]. Climatic data such as environmental temperature, humidity and rainfall of a particular area are responsible for transmission of bovine babesiosis [31].

Life Cycle: The life cycle of all Babesia species is approximately similar but slight difference exists because in some species transovarial transmission occur (*Babesia spp.sensu stricto*) while not in other species, *Babesia microti,* Uilenberg [32]. Babesia species generally complete their life cycle in 3-stages: gamogony (In the tick gut gametes fusion and formation), sporogony (In salivary glands asexual reproduction occur), merogony in vertebrate asexual reproduction occur [33]. Cattle are infected by feeding ticks which inoculates sporozoites that invade erythrocytes where they transform into trophozoites that divide by binary fission (Merogony). The erythrocyte membrane breaks down and the released merozoites invade new cells resulting in an intra-erythrocytic cycle. Following a tick blood meal, gametocytes develop in the tick gut, which fuse to form diploid zygotes. Zygotes invade the digestive cells and probably basophilic cells where they undergo successive round of multiplication before emerging as haploid kinetes. The kinetes migrate to many other organs including the ovaries where further division occurs. After egg hatching, the kinetes migrate to the salivary gland where they transform into multi-nucleated stages (Sporogony) which later forms porozoite [34].

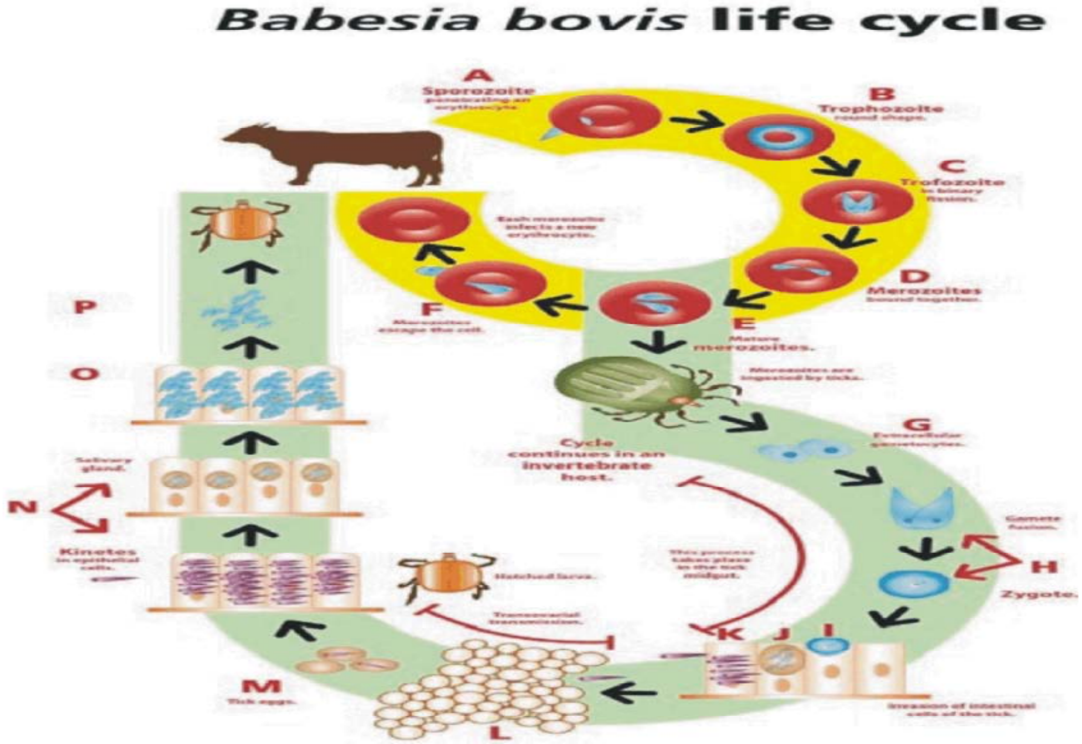

Fig. 2: *Babesia bovis* life cycle. *B.bovis* sporozoite invades an erythrocyte and transforms into a trofozoite. **B.** The trofozoite in a ring shape. **C.** Two merozoites are generated from each trofozoite by binary fission. **D.** Merozoites are initially bound together resembling two pears in an acute angle. **E.** The mature merozoites separate before escaping the erythrocyte. **F.** Merozoites are liberated from the erythrocyte. Some of them will invade new erythrocytes and develop into trofozoites, while others will be picked up by adult ticks to continue their cycle in the invertebrate host. **G.** Sexual stages are freed from the red blood cells in the intestinal tick lumen and develop to gametocytes. **H.** The gametocytes transform into male and female gametes that form a zygote after fusion. **I.** The zygote develops into an infecting stage and penetrates the tick intestinal cells. **J.** Fission bodies form and from them motile kinetes develop. **K.** Kinetes destroy the intestinal cells, escape into the haemolymph and distribute into the different cell types and tissues, including the ovaries. **L.** In the ovary, embryo cells are infected by kinetes (Transovarial transmission). **M.** When the female tick lays her eggs, the embryos are already infected. **N.** Hatched infected larvae attach to a bovine and the kinetes migrate to the salivary glands of the tick, where they form a sporoblast. **O.** Thousands of sporozoites develop from each sporoblast. **P.** Tick larvae feed from the bovine blood and the sporozoites are liberated with saliva into the animal's circulatory system [35].

Transmission: All babesial parasites described today are transmitted by ixodid ticks to their vertebrate hosts. All species of *Babesia* are naturally transmitted from animal to animal through the bites of ticks and within ticks 'Transovarial transmission' (Transmission of infection through eggs from mother ticks) and transsadial (Transmission of infection from egg to larvae to nymph to adult) occurs [36]. Ticks of the genera *Boophilus*, *Haemaphysalis*, *Hyalomma* and *Ixodes* acts as vector for transmission of *B. bigemina* and ticks of the genera *Boophilus* and *Ixodes* are responsible for transmission of *B. bovis*. The presence of *B. microplus* ticks in *B. bigemina* infected animals reported earlier [37].

In cattle, the prevalence of *Hyalomma* tick was highest followed by *Boophilus*, *Hemaphysalis* and *Boophilus* [38]. *B. bovis* and *B. bigemina* are transmitted transovarially (From one generation to the next via the egg) by *B. microplus*, a one-host tick, with transmission after final development in the salivary glands of the larval stage (*B. bovis*) or the nymphal and adult stages of the tick (*B. bigemina*). *B. bovis* infection does not persist in *B. microplus* beyond the larval stage while *B. bigemina* can pass from one generation to the next even when the ticks feed on non-susceptible hosts [39].

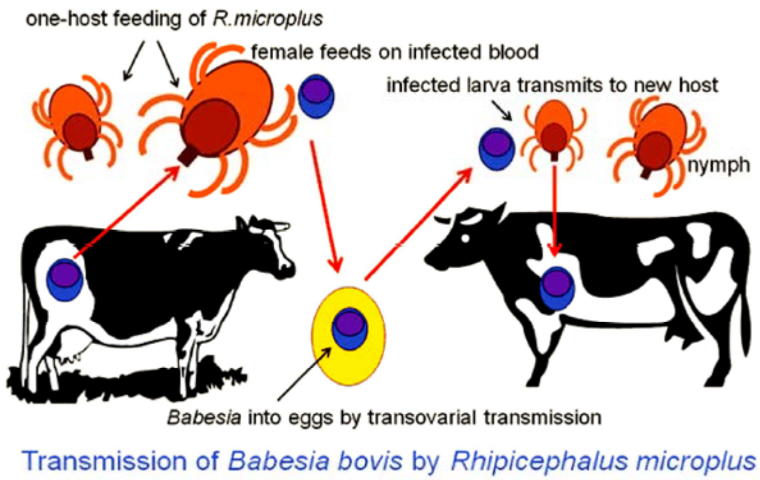

Fig. 3: Transmission of *Babesia bovis* by *Rhipicicephalus microplus*
Source: Joan Kleynhans [40].

Pathogenesis: The primary mechanismis intravascular haemolysis (Leading to haemoglobinaemia and haemoglobinuria), resulting in anaemia, hypoxia and secondary inflammatory lesions in various organs, especially liver and kidneys. The secondary mechanism is electrolyte imbalances, complement activation, coagulation disorders and release of pharmacologically active substances resulting in vascular malfunction and hypotensive shock.The main sequelae of the disease are: anaemia due to haemolysis; haemoglobinaemia and haemoglobinuria, Icterus. Pharmacologically active substances such as kinins and catecholamines lead to increased vascular permeability and dilatation of blood vessels resulting in oedema and hypovolaemic shock. Centrilobular liver degeneration and degeneration of kidney tubule epithelium are caused by hypoxia and possibly by immune pathologic reactions. Damage to kidney tubule epithelium impairs ion exchange, resulting in hydrogen ion retention leading to acidosis [5].

In *B.bovis* infections, the disease pathology can be both due to over-production of pro inflammatory cytokines and the direct effect of red blood cell destruction by the parasite. During an acute infection, macrophages activated by the parasite produce pro inflammatory cytokines and parasitocidal molecules [41]. In general infections with *B. bovis* are considered more pathogenic than *B. bigemina* and cause higher morbidity and mortality among susceptible cattle [42]. 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* [26].

Clinical Findings: Clinical signs depend on virulence and pathogenic effects of a particular Babesia species and host factors associated with disease include age, breed and immune status. Fever, lethargy, diarrhoea, haemolytic anaemia, tachycardia, haemoglobinuria and icterus are common features of acute infections while chronic infections often without apparent haemoglobinuria. Acute *B.bovis* often develops in fatal cerebral babesiosis with hyperaesthesia, convulsions and paralysis due to aggregation of red blood cells in the cerebral capillaries and extravascular, following endothelial damage.Recovered animals become carriers, without apparent clinicalsymptoms, but with possibility to relapse under stress conditions. They also remain infective[43]. Cessation of rumination, various degrees of jaundice (Icterus) from paleness in mild cases to severe yellow discoloration, breathing is laboured and rapid and the heartbeat is fast and loud [44]. Nervous signs are characterized by hyper excitability and the animal may charge moving objects. The vision becomes impaired. Urine may have a red-tinged colour (Because of haemoglobinuria), hence the name 'red water' [45]. In milking cows there is a fall in yield. Other manifestations include salivation, lachrymation, diarrhoea or constipation, delirium and incoordination of gait [46].

Lesions: The main pathological change after *B bovis* infection is the development of a hypotensive shock syndrome with intravascular stasis and sequestration of parasitized red blood cells in the peripheral circulation. Anaemia is progressive. Dead animals are usually anaemic, with jaundice, haemoglobinuria, excess thick granular bile, ecchymotic haemorrhages of the epicardium and endocardium and congestion of the brain and visceral organs. A cherry pink discolouration of the cerebral cortex is characteristic of acute *B bovis* infections. The urinary bladder is frequently distended, with dark, reddish-brown urine, the kidneys and brain moderately congested or even pale, the spleen and liver only slightly enlarged, Thick, granular bile is a constant finding. The pathogenesis of *B. bigemina* infection is almost entirely related to parasite induced intravascular haemolysis. Anaemia, jaundice, haemoglobinuria and excess thick granular bile are commonly seen in fatal cases but not congestion of the brain and visceral organs. Cardiac haemorrhages and splenic enlargement are not as marked as after *B. bovis* infection, but pulmonary oedema is a more regular feature [47].

Diagnosis: The diagnosis of bovine babesiosis is an important tool to control and prevent the dissemination of the disease. During the acute stage of the disease the number of parasites inside the erythrocytes increases in such a way that they can be detected microscopically, however, in chronically infected animals where a subclinical form of the disease occurs, this method is useless and other, more sophisticated methods must be employed [35]. Direct diagnostic method: this include blood films examination such as thin and thick blood smears, brain smears and tick haemolymph smears [35].

Clinically, babesiosis can be confused with other conditions that cause fever, anemia, hemolysis, jaundice, or red urine. Therefore, confirmation of diagnosis by microscopic examination of Giemsa-stained blood or organ smears is essential. From the live animal, thick and thin blood smears should be prepared, preferably from capillaries in the ear or tail tip. Smears of heart muscle, kidney, liver, lung, brain and from a blood vessel in an extremity (eg, lower leg) should be taken at necropsy. Microscopically, the species of *Babesia* involved can be determined morphologically [48].

Indirect diagnostic methods: blood smears are not reliable for detection of carrier animals; in these cases molecular detection methods or serological diagnostic procedures to demonstrate specific antibodies are required [49]. This includes immunological /serological methods such as indirect fluorescent antibody test which is based on the recognition of parasite antigens by serum antibodies in the blood of the tested animal. Bound antibodies are detected by a fluorochrome- labelled antibody anti-Ig (Secondary antibody), Enzyme-linked Immunosorbent Assay, complement fixation test [50] and molecular methods such DNA probes, Polymerase chain reaction, Reverse line blot hybridization and Real time PCR [35]. But the most sensitive and specific methods for detection are molecular. The most common method used to detect *Babesia* in both the tick and the vertebrate host involves simple or multiplex PCR-amplification of the 18S rRNA gene fragment [51].

Biochemical findings: Babesiosis infected cattle showed significant increase in AST, GGT hypoproteinemia, hypoalbuminemia and decreased A/G ratio. This may indicate the harmful effect of toxic metabolites of *Babesia* sp. on liver cells. These results were supported by Stockham *et al.* [52]. The significant increase in serum globulins in babesiosis could be attributed to the immune response against *Babesia* [53].

Differential Diagnosis: Babesiosis resembles other conditions that cause fever and hemolytic anemia. The differential diagnosis includes: Anaplasmosis: haemoglobinuria is not seen in uncomplicated *A. marginale* infections and the color of urine is often brown due to the presence of bile pigments, respiratory distress particularly after exercise and rapid deterioration of the physical condition.Trypanosomiasis: erection of hair, adenopathy. Theileriosis: superficial lymph node greatly swollen, painful and hot during palpation and urine is straw yellow color. The others are bacillary hemoglobinuria, leptospirosis, rapeseed poisoning, chronic copper poisoning [28].

Treatment Prevention and Control: Treatment: successful treatment of *B. bovis* relies on early diagnosis, followed by prompt administration of chemotherapeutic drugs. Currently, antiprotozoal agents, diminazene aceturate and imidocarb dipropionate, are the only available treatments for bovine babesiosis, with imidocarb dipropionate being the principle babesiacide for the last two decades [35]. Administered by s.c. injection at 1.2–3 mg/kg, imidocarb dipropionate is the babesiacide of choice for a number of bovine *Babesia* spp.; at the high dose rate it can provide short term protection from clinical disease caused by *B. bovis* (4 weeks protection), *B. bigemina* (8 weeks protection) and *B. divergens* (3–6 weeks protection) [35,54]. Despite this, the concern of drug residues in meat and dairy products following prolonged treatment has led to the withdrawal of its use in many European countries [10, 35]. It is evident that the development of new therapeutics, highly specific against *Babesia* parasites, combined with a low toxicity profile against the host is highly desirable. Novel chemotherapeutic agents currently in development have recently been reviewed [35].

Prevention and control: active prevention and control of bovine babesiosis is achieved by three main methods: immunization, chemoprophylaxis and vector control. Ideally, the three methods should be integrated to make the most cost effective use of each and also to exploit breed resistance and the development and maintenance of enzootic stability [55]. Eradication of bovine babesiosis has been accomplished by elimination of tick vector in areas where eradication of tick is not feasible or desirable; ticks are controlled by repellents and acaricides [56].

Vaccination for *Babesia*: most live vaccines contain specially selected strains of *Babesia* (mainly *B. bovis* and *B. bigemina*) and are produced in calves or in vitro in government-supported production facilities as a service to the livestock industries. Caution should be used in their employment as they may be virulent in adult animals, may be contaminated with other disease agents and could lead to hypersensitivity reactions; usually used in younger animals [57]. Currently available *Babesia* vaccines: Australia is at the forefront in terms of the production and distribution of live attenuated vaccines (Chilled or frozen trivalent live vaccine) worldwide [54]. Internationally available strains are: Attenuated Australian strains of *B. bovis* and *B. bigemina* have been used effectively to immunise cattle in Africa, South America and South East Asia [58]. Tick-transmissible and non-transmissible strains are available. A strain of *B. divergens* with reduced virulence for meriones has also been developed [10].

Economic Significance and Public Health Importance of Bovine Babesiosis

Economic Significance: Bovine babesiosis causes most serious economic loss to the livestock industry, endangering half a billion cattle across the world [53]. Babesiosis, especially in cattle has great economic importance, because unlike many other parasitic diseases it affects adults more severely than young cattle, leading to direct losses through death and the restriction of movement of animals by quarantine laws. The disease is also a barrier to improving productivity of local cattle by cross-breeding due to the high mortality of genetically superior but highly susceptible cattle, especially dairy cattle, imported from *Babesia* free areas. The consequence is that the quality of cattle in endemic areas remains low, therefore impeding the development of the cattle industry and the wellbeing of producers and their families [55].

In general, infections with *B. bovis* are considered more pathogenic than *B. bigemina* and cause higher morbidity and mortality among susceptible cattle [42]. The impact of this disease varies from fever, anorexia, anemia, threatened abortion and death in the acute form of infections [59]. They also impose a great economic burden on the tropical and subtropical developing countries; this economic impacts are includes lowered meat and milk production, lowered fertility in bulls, control measure costs and a general impact on the global cattle trade industry [5].

Public Health Importance: Human babesiosis cases in Europe are very uncommon but require rapid aggressive treatment. In the past most have occurred in splenectomised patients and were caused by *B. divergens*. Parasitaemias may range between 1 and 80% causing severe intravascular haemolysis with haemoglobinuria. The subsequent nonspecific clinical presentation can be easily confused with malaria; jaundice due to severe hemolysis is accompanied by persistent non periodic high fever (40 to 41°C), shaking chills, intense sweats, headaches and myalgia as well as lumbar and abdominal pain, vomiting and diarrhea may be present. Total hemoglobin levels may fall to 70 to 80 g/liter, in the most severe cases; patients develop shock like symptoms, with renal failure induced by intravascular hemolysis and pulmonary edema [60]. Unless treated rapidly, the infection is usually fatal. During the incubation period of 1 to 3 weeks, patients frequently complain of general weakness and discomfort. Acute illness appears suddenly, generally with hemoglobinuria as the presenting symptom [12].

Status of Bovine Babesiosis in Ethiopia: Ticks and Tick borne diseases cause considerable losses to the livestock economy of Ethiopia, ranking third among the major parasitic disasters, after trypanosomes [61]. Major cattle tick-borne diseases in Ethiopia are anaplasmosis, babesiosis, cowdriosis and theileriosis [62]. Bovine babesiosis is one of the most important diseases in Ethiopia because it occurs sometimes in acute forms with serious recognized clinical manifestations yet lowering the productive performance of the affected animals [63]. Different researchers have reported the prevalence of bovine babesiosis from different areas of Ethiopia.

The study from Benishangule Gumuz Regional State,Western Ethiopia,was reported an overall prevalence of 1.5% [63] from which *B.bovis* was found to be 1, 24% and *B. bigemina* was 0.248%. Another study in and around Jimma town, southwest Ethiopia [64] was reported overall prevalence rate of bovine babesiosis as 23% out of which 33.33% was *B.bovis*and*B. bigemina*. A study from Bishoftu, central Ethiopia, was reported a prevalence of 0.6% with an equal prevalence of both*B.bovisand B. bigemina* [65] A recent study from Southern Ethiopia in Teltele District, Borena Zone, indicated the overall prevalence of 16.9% with a relatively similar prevalence of both *B.bovisand B. bigemina* [65].

CONCLUSION AND RECOMMENDATIONS

Bovine babesiosis is the most important tick-borne disease of cattle worldwide that causes significant morbidity and mortality. It iscaused by an apicomplexan haemoprotozoan parasite under the family Babesiidae, order Piroplasmida. The most prevalent species are *B. bovis* and *B. bigemina* found throughout most tropical and subtropical regions including Ethiopia. Bovine babesias are transmitted by ticks with a limited host range. The principal vectors of *B. bovis* and *B. bigemina* are *Rhipicephalus* (formerly *Bophillus*) spp. Ticks and these are widespread in tropical and subtropical countries. Generally it causes most serious economic loss to the livestock industry, endangering half a billion of cattle across the world. It is one of the most important diseases in Ethiopia because it occurs sometimes in acute forms with serious recognized clinical manifestations yet lowering the productive performance of the affected animals. The disease is also a barrier to improving productivity of local cattle by cross-breeding due to the high mortality genetically superior but highly susceptible cattle. Therefore, based on the above conclusion the following recommendation are forwards:

- Different control strategies should be adopted in order to prevent the day to day increasing of livestock industry losses.
- Vaccines should be practiced in order to control and prevention of bovine babesiosis.
- A surveillance system should be developed and implemented to prevent bovine babesiosis from spreading
- Epidemiological study should be conducted on bovine babesiosis to provide the necessary data.
- Awareness must be given for livestock owners in relation to tick control as one of the measure for controlling bovine babesiosis.
- Rotational grazing should be important during season of tick prevalence.

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