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Review on Bovine Babesiosis

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Abstract: Bovine babesiosis is a protozoan disease of cattle with a world-wide distribution and affecting many species of mammals with a major impact on cattle. It is the second most common parasite found in the blood of mammals after trypanosomes. *Babesia* species (spp) are transmitted mainly by ticks and able to infect of a wide variety of domestic and wild animals. It has increasingly been recognized throughout the world as public health problems. Babesiosis can be treated by using diminazeneaceturate (35mg/kg), phenemidinediisethionate (8-13mg/kg), Imidocarbdipropionate (1-3 mg/kg) and amicarbalidediisethionate (5-10 mg /kg. Babesiosis causes direct economic losses, such as mortality, reduction in meat and milk yield and indirectly through control measures of ticks. The most control method of *Babesia* was controlling of the ticks by dipping or spraying animals at risk with recommended acaricides.

Key words: Bovine · Babesiosis · Prevalence · Associated Risk Factors

INTRODUCTION

Babesiosis is a disease with a world-wide distribution affecting many species of mammals with a major impact on cattle and human. It has increasingly been recognized throughout the world as public health problems [1, 2]. *Babesia* species (spp) are protozoan parasites transmitted mainly by ticks and able to infect of a wide variety of domestic and wild animals [3, 4]. Babesia is the second most common parasite found in the blood of mammals after trypanosomes [5]. Babesiosis causes direct economic losses, such as mortality, reduction in meat and milk yield and indirectly through control measures of ticks [6, 7]. This infections are characterized by anemia, icterus, hemoglobinuria and death [8, 9]. Bovine babesiosis is caused by multiple species: Babesia bigemina, Babesia divergens, Babesia bovis and Babesia major. Two species, *B. bigemina* and *B. bovis*, have a considerable impact on cattle health and productivity in tropical and subtropical countries [10].

Subclinical Babesiosis and Theileriosis lead to conversion of the affected livestock to chronic carriers and in turn sources of infection for tick vectors and cause natural transmission of the disease. Early detection of blood parasites is highly beneficial in control. Microscopy using Giemsa stained blood smears has been considered the “gold standard” for detecting Babesia [7, 11].

Host factors associated with disease include breed, age and immune status of the animals [12]. Different breed of animals are not equally affected with bovine babesiosi. Bos indicus breeds of cattle are much more resistant to babesiosis than Bos taurus breeds. This phenomenon is thought to be a result of the evolutionary relationship between Bas indicus cattle, *Boophilus* spp. and Babesia [13]. Previous studies conducted on the distribution, abundance and prevalence of bovine babesiosis affecting cattle in different parts of Ethiopia have showed wide spread existence [14, 15].

Therefore, the objectives of this review paper are:

- To review about bovine babesiosis
- To provide some information about epidemiology, treatment and control of the disease.

The Disease: Babesiosis is an infectious tick- borne disease of livestock that characterised by fever, anemia, haemoglobinuria and weakness. The disease is also known by such names as bovine babesiosis, piroplasmosis, Texas fever, redwater, tick fever and tristeza [1]. Bovine babesiosis caused by an apicomplexan haemoprotozoan parasite under family Babesiidae, order Piroplasmida [4]. It is caused by multiple species but three species found most often in cattle are

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B. bovis, *B. bigemina* and *B. divergens*. Additional species that can infect cattle include *B. major*, *B. ovata*, *B. occultans* and *B. jakimovi* [16]. But two species, *B. bigemina* and *B. bovis*, have a considerable impact on cattle health and productivity in tropical and subtropical countries [17]. The disease agents are transmitted to new hosts by the feeding of ensuing tick larvae, nymphs, or adults [18].

Etiology: Bovine babesiosis (BB) is a hemoparasitic disease of cattle caused by protozoan organisms of the genus Babesia (Phylum Apicomplexa, Order Piroplasmida and Family Babesiidae). Organisms within this genus that affect cattle are *B. bovis*, *B. bigemina, B. divergens, B. major, B. ovate (Japan)* and *B. occultans* (South Africa) [13]. *Babesia* belongs to protozoan parasites of the genus Babesia, order Piroplasmida (Figure 1), phylum Apicomplexa and subclass Piroplamsia and are commonly referred to as 'piroplasmas' due to the pear-like shaped merozoites which live as small parasites inside RBC of mammals [15].

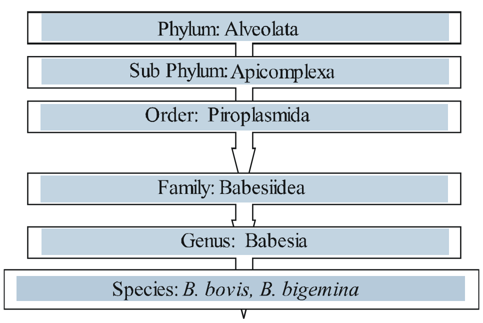

Fig. 1: Taxonomy of the genus *Babesia*. Source: [19]

Only *B. bovis* and *B. bigemina* are considered economically important [9].The list of babesia species is shown in (Table 1).

Babesia bovis is smaller than *B. bigemina*, measuring up to 2 µm in length. Under light microscopy, this organism is often found in pairs at an obtuse angle. Conversely, *B. bigemina* can measure 2 to 5 µm 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 [9].

Babesia bigemina is a large babesia that is pleomorphic but characteristically is seen and identified by the pear-shaped bodies joined at an acute angle within the mature erythrocyte. Round forms measure 2 µm and the pear-shaped, elongated ones are 4-5 µm [20]. *Babesia bovis* is a small pleomorphic babesia typically identified as a single body, as small round bodies, or as paired, pear-shaped bodies joined at an obtuse angle within the mature erythrocyte. The round forms measure 1-1.5 µm and the pear-shaped bodies 1.5 by 2.4 µm in size [21].

The intra-erythrocytic structure of these organisms is pyriform in shape and is surrounded by two peripheral membranes within the host cytoplasm [22]. 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 [22].

Epidemiology

Geographic Distribution: Bovine babesiosis disease is caused by at least six Babesia species (Table 1). But Bovine babesiosis associated with *B. bigemina* and *B. bovis* is the most important disease of tropical and subtropical regions between 40°N and 32°S. Both species are transmitted transovarially by Boophilus ticks, but only tick larvae transmit *B. bovis*, whereas nymphs and adults transmit *B. bigemina* [23]. The distribution of *B. divergens* reflects its triphasictelotropic tick vector, *Ixodes ricinus*, which is widespread across Western Europe and North Africa [24]. *B. major* occurs in Europe, North Africa and South America. *B. major* is transmitted by the three host tick *Haemaphysalis punctata* [25].

Host Range: Babesiosis commonly infect cattle, sheep, goats, horses, pigs, dogs and cats and occasionally man. More than 100 known *Babesia* spp. have been identified which infect many types of mammalian host, out of these, 18 spp. cause disease in domestic animals [15]. *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 [26].

Transmission: Babesia species is transmitted by hard ticks in which Babesia passes transovarially, via the egg, from one tick generation to the next [27]. Ticks become

Table 1: Babesia species (Babesiosis)

Organism	Livestoke affected	Geographical distribution
B. bigemina	Cattle	America, Australia, Africa, Europe
B. bovis (*B. berbera*, *B. Argentina*)	Cattle	America, Australia, Africa, Europa, Rusia, Asia
B. devergens	Cattle	Europe
B. major	Cattle	Europe, Russia, North Africa, Middle East
B. jakimova	Cattle	Asia
B. ovata	Cattle	Japan

infected when they ingest parasites in the blood of infected cattle. Bovine Babesiosis is principally transmitted by means of ticks. Tick vectors of *Babesia bigemina*: *Rhipicephalus microplus* (formerly *Boophilus microplus*) and *Rhipicephalus annulatus* (formerly *Boophilus annulatus*); *Rhipicephalus decoloratus*, *Rhipicephalus geigyi* and *Rhipicephalus evertsi* are also competent vectors. *B. bigemina* transmitted by feeding of adult and nymphal stages of one-host *Rhipicephalus* spp. ticks. Tick vectors of *Babesia bovis*: *Rhipicephalus microplus* and *Rhipicephalus annulatus; Rhipicephalus geigyi* is also a competent vector. *B. bovis* transmitted by feeding of larval stages of one-host *Rhipicephalus* spp. ticks [28]. 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 transovarially though several generations, although this varies with the species of Babesia and the species of tick [29].

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 is 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 [26].

Risk Factors

Host Factors: Host factors associated with disease include breed, age and immune status of the animals [12]. Different breed of animals are not equally affected with bovine babesiosi. Bos indicus breeds of cattle are much more resistant to babesiosis than Bos taurus breeds. This phenomenon is thought to be a result of the evolutionary relationship between Bas indicus cattle, *Boophilus* spp. and *Babesia* [13]. Zebu and Afrikaner cattle have a higher resistance to *B. bovis* than British and European breeds; Santa Gertrudis and cross-bred cattle occupy an intermediate position. Zebu-type cattle also enjoy a relative freedom from the disease because of their resistance to heavy infestations with ticks. In Australia, *B. bigemina* is usually of lower pathogenicity than *B. bovis* and rarely lethal even when fully susceptible adult cattle are introduced to an endemic area. Inoculation studies with *B. bigemina* in Australia have shown that *B. indicus* and *B. indicus* cross cattle are more resistant than the *B. taurus* cattle [30].

Age Resistance: There is a variation in susceptibility to infection according to age in cattle. The severity of clinical babesiosis increases with age. It is frequently stated that there is an inverse age resistance to *Babesia* infection in that young animals are less susceptible to Babesiosis than older animals; the possible reason is passive transfer of maternal antibody via colostrums [27]. The severity of the clinical Babesiosis increases with age so adult is more infected by Babesiosis as compared with calves [6].

Environmental Factors: 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; humidity and rainfall have little effect. Heaviest losses due to babesiosis occur in marginal areas where the tick population is highly variable depending on the environmental conditions [31]. In seasons when the tick population decreases, infection may die out and immunity be lost. Then in favorable seasons when ticks multiply, the infection spreads quickly amongst what has become a susceptible population. Babesiosis infection in cattle mostly reaches peak in summer (33.33%) [6].

Pathogen Factors

Antigenic Variation: Antigenic variation within the vertebrate host is believed to allow variants of *Babesia spp*. populations to continue to adhere to endothelial cells and be sequestered in tissues thus avoiding splenic passage and clearance [32]. Extracellular merozoites (tick derived merozoites) are coated with surface proteins that facilitate attachment to erythrocytes [2]. *Babesia bovis* possess 5 surface proteins known as variable merozoite surface antigens (VMSA) [33]. These are merozoite surface antigen- 1 (MSA-1), MSA-2a1, MSA-2a2, MSA-2b and MSA-2c. These are encoded by two genes MSA- 1 and MSA-2, respectively [2]. These proteins are believed to play a major role in initial erythrocyte attachment.

However, polymorphism in MSA-1 and MSA-2 genes is common among Babesia strains isolated from endemic regions worldwide [34]. The exception is MSA-2c, which is more highly conserved [35, 36]. Another protein extensively studied in *Babesia* spp. is rhoptry-associated protein-1 (RAP-1) [37]. This protein is located in the apical complex of *B. bovis* merozoites and sporozoites and can elicit a humoral response in the host [38]. This protein is highly conserved among geographically diverse isolates and plays an important role in erythrocyte invasion [39].

Babesia bigemina strains also possess similar surface proteins as *B. bovis*. They are designated as Glycoproteins (Gp45/Gp55-proteins) and express a high degree of antigenic polymorphism among different strains of *B. bigemina* [35]. Gp45 is expressed by the Mexican strain of *B. bigemina* but it has not been identified in the 46 strains from St. Croix [40]. These proteins function in the erythrocyte invasion process. Recent studies have identified a novel protein on the surface of erythrocytes infected with mature stages of *B. bovis* [41]. This protein is linked to the process of cytoadhesion of erythrocytes to capillary and post-capillary venous endothelium. Adhesion to capillary endothelium acts to sequester the parasites from the peripheral circulation [42]. This protein consists of 2 subunits and it is termed variant erythrocyte surface antigen 1 (VESA1) [43]. The larger subunit is referred as VESA1a and undergoes rapid antigenic variation.

The smaller unit, VESA1b, has similar characteristics but its antigenic properties have not been determined [41]. The MSA and RAP proteins are highly conserved within an infected individual and within a population whereas VESA1 is constantly changing. The rapid changes in VESA1 proteins may contribute to the development of chronic infection in cattle by prolonging protozoal survival through evasion of the immune system [44]. The above antigenic properties suggest that these surface proteins are good candidates for the development of BB vaccines [2, 35].

Life Cycle: The life cycle of all *Babesia species* is approximately similar but slight difference exists because in some species transovarial transmission occur, while not in other species (*Babesia microti*) [45]. 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 form sporozoites [16]. According to Saad [45] 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) and Merogony (in the vertebrate asexual reproduction occur).

Pathogenesis: Babesia species are a diverse group of tick borne, obligate, intra- erythrocytic Apicomplexan parasites infecting a wide variety of organisms. Infection of a vertebrate host is initiated by inoculation of sporozoite stage parasites into the bloodstream during the taking of a blood meal. Most babesia sporozoites directly invade circulating erythrocytes without a tissue stage of development. Once erythrocyte invasion occurs, a perpetual cycle of asexual reproduction is established despite the rapid development of a strong immune response.

Babesia parasite, likes theleria and malaria parasites invade erythrocytes of infected animals resulting in the destruction of parasitized erythrocytes [47].

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. Subacute syndrome also occurs in young animals, but fever is mild and hemoglobinuria is absent [23].

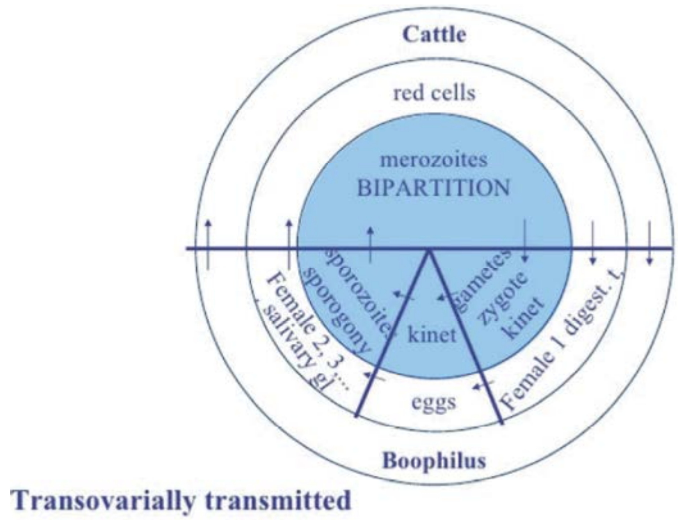

Fig. 2: The life cycle of Babesia speciese.Note: merogony in the vertebrate (top), Gamogony and Sporogony were in the tick gut and salivary glands respectively (bottom). Source: [46]

Strains vary considerably in pathogenicity; however, *B. bovis* is usually more virulent than *B. bigemina* or *B. divergens* [26]. *B. bovis* is the most pathogenic of the bovine Babesia. In animals with acute *B. bigemina* infections are not as virulent as those of *B. bovis*; however the parasites may infect 40% of the red cells [1]. *Babesia bovis* infections are characterised by high fever, ataxia, anorexia, general circulatory shock and sometimes also nervous signs such as cerebral babesiosishyperexcitability, convulsions, opisthotonos, coma and death may be observed in cattle infected with either *B. bigemina* or *B. bovis*, but especially with the *B. bovis*. Central nervous system signs are caused by brain anoxia resulting from severe anemia [18].

Anaemia and haemoglobinuria may appear later in the course of the disease. In *B. bigemina* infections, the major signs include fever, haemoglobinuria and anaemia. Intravascular sequestration of infected erythrocytes does not occur with *B. bigemina* infections. The parasitaemia and clinical appearance of *B. divergens* infections are somewhat similar to *B. bigemina* infections [48].

Diagnosis

Field Diagnosis: Fever, anemia, jaundice and hemoglobinuria are suggestive clinical signs of babesiosis in cattle located in enzootic areas where *Boophilus* ticks occur. If these signs are also associated with erythrocytic destruction, the diagnosis of babesiosis is strengthened. A positive diagnosis requires the identification of the *Babesia* on blood smears.

Laboratory Diagnosis: In acute infection, *B. bigemina* can usually be detected on Giemsa-stained thin blood smears. Microscopy using Giemsa stained blood smears has been considered the “gold standard” for detecting *Babesia* in the blood of infected animals, particularly in acute cases, but not in carriers, where the parasitemia is low with small numbers of the protozoa in the peripheral blood [7].

Diagnoses of babesiosis are made by examination of blood and/or organ smears stained with Giemsa [11, 49]. 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.

Thick smears increase the likelihood of detecting the causative organism, but the characteristic morphology is more difficult to identify with this technique. Thick blood films are 10 times more sensitive and are therefore very useful for the detection of low level *B. bovis* infections [11].

Molecular Diagnois: 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 [50]. Among the various molecur tests, the most important one is polymerase chain reaction assays (PCR).

Polymerase Chain Reaction (PCR): Babesial infections are difficult to detect because of the low number of parasites in peripheral blood. Therefore, DNA-based molecular methods have been developed with great advantages, such as high analytical sensitivity and specificity rates [51]. One of these molecular techniques is PCR, used to amplify, out of a single DNA fragment, millions of copies in vitro. The goal is to detect the presence or absence of a small DNA sequence. Advantages of the PCR assay include: It is more rapid as compared to *in vitro* cultivation of the parasite; it has high analytical and diagnostic sensitivity and specificity rates; Confirmation of the specificity of the assay is accomplished by sequencing the amplicons. However, sometimes PCR is not specific enough, so nested PCR should be carried out to reduce background to non-specific amplification of DNA. The most important disadvantages of the PCR assay are: PCR setting and running requires technical skills; cross contamination risk is possible; PCR is not able to differentiate between living or dead parasites and has a high cost for equipment, consumables and reagents. Different PCR formats have been used, one of the first PCR assays performed was that developed for detection of B. bigemina [52]. The PCR-DNA assay coupled with a nonradioactive DNA probe was sensitive enough to detect cattle persistently infected with *B. bigemina*. Analytical sensitivity assays showed detection of as low as 100 fg of parasite genomic DNA equivalent to 0.0000001% of infected erythrocytes. The analytical specificity was demonstrated by lack of DNA amplification in reactions containing *B. bovis*, *A. marginale*, *S. aureus*, *S. typhimurium*, *E. coli*, *P. hemolytica*, *B. abortus*, *M. bovis* and bovine leukocyte DNA templates [52]. A colorimetric *B. bigemina* DNA probe was utilized in an epidemiological survey, which allowed to detect parasitemias as low as 0.001%. Thus, this assay turned out good to detect asymptomatic carriers in the field [53].

Serological Diagnosis: There are different serological methods that used for the diagnosis of *Babesia*. Among the various serological tests, most important once include, complement fixation test (CFT), indirect fluorescent antibody technique (IFAT) and enzyme-linked immunosorbent assay (ELISA) [54]. Serology 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 [55].

Necropsy Findings: Post–mortem 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 [26].

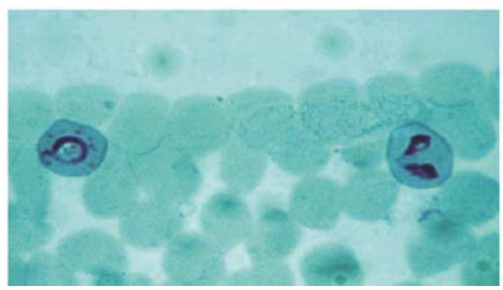

Fig. 3: Morphological characterstics of *B. bigemina.* Blood smear showing *Babesia bigemina*. Note large, round trophozoite (left) and acute angle between two large, pear-shaped merozoites (right). Source: [56].

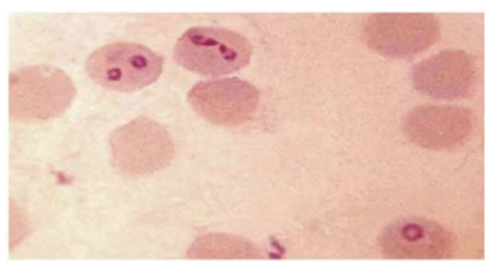

Fig. 4: Morphological characteristics of *B. bovis*. Blood smear showing *Babesia bovis*. Note round trophozoites (bottom right) and 'bow-tie' configuration of merozoites. Source: [56].

Differential Diagnosis: Babesiosis resembles other conditions that cause fever and hemolytic anemia, such as; Anaplasmosis, trypanosomiasis, Theileriosis Bacillaryhemoglobinuria Leptospirosis, Eperythrozoonosis, Rapeseed poisoning and chronic copper poisoning. Rabies and other encephalitides may also be considerations in cattle with CNS signs [26].

Treatment: After the hemoglobinuria or cerebral signs, prognosis is not well. In acute cases that Packed cell volume (PCV) values are above 12%, treatment will be successful. Supportive therapy such as blood transfusions (4 L of whole blood per 250 kg of body weight), fluids, hematinics and prophylactic antibiotics are important [18]. Babesiosis can betreated by using diminazen eaceturate(3-5mg/kg), phenemidine diisethionate (8-13mg/kg), imidocarbdipropionate (1-3mg/kg) and amicarbalidedi isethionate (5-10 mg /kg) [23, 25].

Control and Prevention: The control of the disease depends on effective quarantine to prevent the introduction of the tick. The control of ticks by dipping or spraying animals at risk with recommended acaricides. In routine surgery, Care should be taken to prevent accidental transfer of blood from one animal to another (e.g., castration, dehorning). In addition, in cattle, the selection and breeding of cattle which acquire a high degree of resistance to ticks is practiced. Widespread use of tick vaccines may also have a significant influence on the incidence of infection in cattle [18, 23, 25].

Economic Impact: Bovine Babesiosis causes most serious economic loss to the livestock industry, endangering half a billion cattle across the world [45]. 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 [27].

CONCLUSION AND RECOMENDATIONS

Babesiosis is a disease with a world-wide distribution affecting many species of mammals with a major impact on cattle and human. It has increasingly been recognized throughout the world as public health problems. Bovine Babesiosis causes most serious economic loss to the livestock industry, endangering half a billion cattle across the world. The control of the disease depends on effective quarantine to prevent the introduction of the tick.

Therefore, based on this conclusion the following recommendations are forwarded that might help in preventing losses associated with the occurrence of the parasites in the study area and thereby improving the productivity of the cattle.

- Strategic tick control: Application acaricides aimed at reduction of tick population based on information about their seasonal activity. That is treating animals two to three times at early rainy season and about two treatments later around the end of rain period to reduce of next tick generations, which will help to reduce babesia transmition.

- Awareness creation through Extension work: Educating livestock owners on the problems of tick and the different disease they transmit and their control methods, which can be available in their areas. Successes of ticks control generally associated with good extension work.

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