CHAPTER II
REVIEW OF LITERATURE

Cattle are economically important livestock species. It is the major source of milk, meat, hides and draught power, and hence be considered as multi-purpose livestock. In addition, since their domestication, they have played a major role in human culture by participating in fight games, racing and religious ceremonies. Because of the animal’s size, the husbandry of cattle requires a more organized management than the keeping of other livestock, which may have made a major contribution to the growing complexity and stratification of early agricultural societies. As with other domestic species, their dispersal over different continents and adaptation to various environments has led to the development of many types of cattle (Felius et al., 2011).

The Gir is a famous milk cattle breed of India. The native tract of the breed is Gir hills and forests of Kathiawar including Junagadh, Bhavnagar, Rajkot and Amreli districts of Gujarat. This breed is also known as Bhodali, Desan, Gujarati, Kathiawari, Sorthi and Surti in different parts of the breeding tract. The Gir animals are famous for their tolerance to stress conditions and resistance to various tropical diseases (Gaur et al., 2003).

Tick-borne pathogens (TBP) are considered to be one of the major hindrances to productivity and health of livestock, globally. The four main pathogens responsible for these losses are the tick borne protozoa Babesia and Theileria, and the tick-borne rickettsial disease pathogens, Anaplasma and Ehrlichia. In developing countries like India, TBP spp. can impose considerable economic loss on large and small holding livestock productivity farming systems. The resulting diseases causing high mortality rates, reduced milk production and loss of body condition (Kolte et al., 2017).

Babesiosis or tick fever is a disease caused by intra erythrocytic protozoan parasites within the genus Babesia. The main pathogenic species is thought to be Babesia bigemina but B. bovis infection has also been reported in Maharashtra state, India. These species are primarily transmitted by Rhipicephalus (Boophilus) microplus. Bovine species under stress from other diseases are potentially susceptible to infection. Babesia infections in India have been reported across indigenous,
crossbred cattle and buffaloes with an associated annual economic loss of more than US$ 57.2 million (Kolte et al., 2017).

The present work on “Clinical studies and Therapeutic management of Babesiosis in Gir animals” covered clinical signs, haematological changes, biochemical changes, diagnosis and therapeutic management of babesiosis in Gir animals.

The available scientific literature pertinent to the topics covered in this study has been briefly reviewed under the following heads and sub-heads.

2.1 Diagnosis:

2.1.1 Based on Clinical signs

Seshadri et al. (1985) and Muraleedharan et al. (2008) expressed that the commonest symptoms observed in B. bovis infection were indistinguishable from those of B. bigemina. The symptoms were pyrexia (106-107°F), haemoglobinuria accompanied by dullness, debility and pale mucus membranes. Sometimes blood shot eyes and lachrymation may be observed.

Ansar Kamran (1991) studied 45 babesiosis positive cases which had haemoglobinuria, rectal temperature ranging from 98°F to 107.6°F, pale visible mucus membrane, anorexia and partial or complete loss of rumination.

Kasaralikar et al. (1993) reported B. bigemina infection in a less than three weeks old calf which was presented for treatment in a moribund condition with sub-normal temperature (99°F), anorexia, recumbency, haemoglobinuria, icteric mucus membranes and deep and shallow respiration. The calf suddenly succumbed to the illness before any treatment could be administered and the result of blood smear examination revealed B. bigemina infection.

Camacho et al. (2005) studied the occurrence of equine piroplasmosis in Galicia, North-West Spain. Clinical examination revealed fever, anorexia, weakness, severe icterus and haemoglobinuria.

Hussein et al. (2007) studied 43 field cases of cattle of both sex, out of which, 20 animals had theileriosis and 8 animals had babesiosis. Clinical examination revealed enlargement of superficial lymph nodes, fever, congested mucous membranes, corneal opacity and emaciation in cases of theileriosis, whereas fever, paleness of mucous membranes and brown coffee coloured urine were common clinical findings in cases of babesiosis.
Ananda et al. (2009) screened 132 clinical cases of cross bred cattle with clinical symptoms such as anorexia, pyrexia, enlarged superficial lymph nodes, trembling, pale conjunctival mucus membrane, haemoglobinuria, nasal discharge, coughing and grinding of teeth in haemoprotezoan parasites infected animals. In addition to the above symptoms, there was sudden drop in the milk yield and abortion during the course of the disease.

Ibrahim et al. (2009) observed clinical findings in cattle with babesiosis such as fever, dark brown to coffee coloured urine, pale mucous membranes with empty episcleral blood vessels.

Mervat et al. (2010) examined 100 animals aged from 1-3 years for bovine babesiosis and 38 calves suffered from fever (41° C) anaroxia, depression, weakness, pale mucous membrane, emaciation, weight loss haemoglobinuria and accelerated heart and respiratory rates.

Patel et al. (2011) observed 10 years old Mehsana buffalo with the symptoms of haemoglobinuria, anorexia, suspended rumination, reduced milk yield, depression, reluctance to move, elevated body temperature 103°F, accelerated heart and respiration rates. The buffalo had icteric mucous membranes alongwith moderate tick infestation.

Abdullah et al. (2013) observed 8 babesiosis affected Friesian-Sahiwal cattle aged between 8 months and 1 ½ years old of both sex. Chief clinical signs found were of pale mucous membrane, jaundice and increased respiratory rate.

Jyothisree et al. (2013) examined babesiosis in 162 H. F. crossbred cattle, of which 13 were infected with babesiosis with typical symptoms like pyrexia (103.5-105°F), haemoglobinuria, anorexia and ruminal atony, pale to yellowish mucous membranes, dyspnoea, anaemia, decreased milk yield and reluctance to move.

Hamoda et al. (2014) observed 40 cattle ageing 1 to 3 years, of which 30 had increased body temperature, off feed and hemoglobinuria from endemic area with Babesia.

Mahmmod (2014) studied cattle infected with B. bovis having high rise in body temperature (40– 41.5° C), pale to yellow discoloration of conjunctival and vaginal mucosa, dark brown to dark red urine- haemoglobinuria, accelerated heart and respiratory rates. Few cases showed nervous manifestations in advanced stage such as incoordination and head pressing. Various degrees of tick infestations were present around groins, horns, Inter-mandibular space, and ears.
Bal et al. (2016) observed a total of 465 cattle at risk (125 Sangrur and 340 Faridkot) of babesiosis, out of which 28 (12 Sangrur and 16 Faridkot) were critically ill and 14 (6 Sangrur and 8 Faridkot) died of disease with morbidity, mortality, and case fatality rates of 6.02%, 3.01%, and 50.00%, respectively. Major clinical symptoms observed in affected animals were pale mucous membranes, jaundice, increased respiratory rate, hemoglobinuria, and fever. Moderate to heavy tick infestation was observed in animals. Ticks collected from both the outbreaks were identified as Rhipicephalus (Boophilus) microplus.

El-Hamed et al. (2016) examined 135 cattle of different ages, sexes and breeds of which 48 animals were anaemic. Out of 48 animals 20 animals were suffering from babesiosis showing symptoms such as thin body condition, pale mucous membrane, body temperature was 40.1°C, the pulse was 84 beats per minute. Ruminal contraction was 3.48±0.32 per 2 minute, respiratory cycle per minute was 41 and urine appeared dark brown to coffee in color with presence of tick on the animal body.

Gungi et al. (2016) studied 4 cross bred cows aged between 4 and 6 years having history of fever, anorexia, passing coffee coloured urine, reduced milk yield, depression and reluctance to move. Clinical examination revealed elevated temperature ranging from 103°F to 104.2°F, accelerated heart and respiration rates, dyspnoea, suspended rumination, presence of icteric mucus membranes with mild to moderate tick infestation and enlarged lymph nodes with haemoglobinuria.

Qadri et al. (2016) observed a cross bred cow of Holstein Friesian affected by babesiosis with history of recent parturition three days back and anorexia. Clinical examination revealed high rise of temperature (104.2°F), passing red color urine and anaemic mucus membrane. On further investigation, presence of several ticks on the body was also reported.

Sharma et al. (2016) screened 542 bovines (cattle 466 and buffaloes 76) out of which (9) clinically babesiosis positive cases exhibited clinical symptoms of high fever (39.4–40.5°C), history of hemoglobinurea, jaundice, icterus, tachycardia, weight loss and decrease in milk yield.

Ganguly et al. (2017) diagnosed B. bigemina in naturally infected crossbred cows showing clinical signs like fever, anaemia, loss of appetite, cessation of rumination, laboured breathing and haemoglobinuria.
Mohanapriya et al. (2017) observed babesiosis infected 5 year old Jersy cow. Clinical examination revealed high fever, haemoglobinuria, jaundice, dullness/depression, rapid deterioration of the physical condition, serosanguineous urine, muscle tremors, pale mucus membrane and labored breathing.

2.1.2 Based on Blood smear examination

Ananda et al. (2009) screened 132 cattle by Giemsa’s stainined blood smear, 57 were found positive for haemoprotezoan parasites. Out of 57 positive cases, 16 were positive for B. bigemina.

Ibrahim et al. (2009) examined 54 cattle for presence of babesiosis, theileriosis by Giemsa stained blood smear examination and PCR. Blood smear stained with Giemsa stain revealed 12 positive cases for Babesia spp. and 7 for Theileria spp. Of the total 54 animals studied, 9 (17 %) were positive for B. bigemina specific PCR, while 5 (9 %) were positive for B. bovis specific PCR. PCR showed a higher efficacy of detection of Babesia spp. and Theileria spp.

Mervat et al. (2010) examined 100 animals aged from 1-3 years for bovine babesiosis by Giemsa stained blood smear examination which revealed intra-erythrocytic double (pear shaped) of B. bigemina in 38 blood samples while the other 62 samples appeared free from developmental stages of B. bigemina in blood smears. The results obtained in the PCR assay showed 11 out of 15 samples positive for B. bigemina of expected molecular weight 409 base pair.

Patel et al. (2011) examined blood smear of 10 year old Mahesana buffalo stained by Leishmans stain, which revealed 4-5 % erythrocytes to be infected with B. bigemina piroplasms.

Fadly (2012) examined 800 animals (300 cattle, 200 buffaloes and 300 sheep) aged from 1-3 years by Giemsa stained blood smear under microscope. It was found that 58 out of 300 (19.33 %) cattle, 18 out of 200 (9 %) buffaloes and 51 out of 300 (17 %) sheep were positive for babesiosis by microscopic examination.

Zulfiqar et al. (2012) examined 144 ruminant blood samples by Giemsa stained blood smears, of which 4 (3 %) samples were positive for babesiosis.

Abdullah et al. (2013) diagnosed babesiosis in Eight Friesian-Sahiwal cattle aged between 8 months and 1 ½ years old of both sex by Giemsa stained blood smear examination.
Jyothisree et al. (2013) carried out blood smear examination in 162 H.F crossbred cattle under the microscope and revealed 13 crossbred cattle were affected with babesiosis.

Abdel Aziz et al. (2014) studied 296 apparently healthy Holstein Friesian cattle by microscopic examination for diagnosis of babesiosis. They reported 33 animals to be infected with Babesia spp. with overall prevalence rate of 12 %.

Amorim et al. (2014) studied 309 blood samples from crossbred dairy cattle for diagnoses of anaplasmosis and babesiosis using blood smears and nested PCR (nPCR) techniques. From diagnostic blood smear slides, the observed parasitic frequencies were 31.1 % for *Anaplasma marginale* and 20.4 % for *Babesia* spp. From nPCR diagnoses, they were 63% for *A. marginale*, 34 % for *B. bigemina* and 20.4 % for *B. bovis*.

Hamoda et al. (2014) observed a total of 40 cattle aged 1 and 3 years by Giemsa stained under the microscope. Of which, 30 were found positive for *B. bigemina*. This was also confirmed by inoculation of heparinized blood from these animals in rats resulting in death of rats on fifth day post inoculation and presence of babesia in piroplasma form in pathological tissue of rat’s liver and kidney on histopathological examination.

Mahmoud et al. (2015) examined blood samples of 253 cattle and 81 buffaloes and found 13.8 % cattle and 7.4 % baffaloes positive for babesiosis on blood smear examination.

Saad et al. (2015) analysed 100 blood samples from tick infested cattles for presence of *B. bovis* and *B. bigemina* by polymerase chain reaction and microscopy. Out of 100 samples 73 were cows and bulls and 27 were Buffaloes. In microscopic examination only 24 positive cases were diagnosed in which 16 were of *B. bigemina* having 3 cows and 13 bulls and 8 of *B. bovis* including 8 buffaloes (6 female and 2 male). By polymerase chain reaction 37 positive cases were diagnosed in which 5 were of mixed type and 11 samples were found positive for *B. bovis* and 21 samples for *B. bigemina*.

Tufani et al. (2015) observed 4.5 years old Holstein-Friesian crossbred cow presented with typical signs of babesiosis. On Giemsa staining of the peripheral blood film, piroplasms of *B. bigemina* were found in 40 % of the erythrocytes.

Bal et al. (2016) observed 465 cattle (125 Sangrur and 340 Faridkot) at risk, 28 (12 Sangrur and 16 Faridkot) were critically ill. Twenty three samples were
collected (15 diseased and 8 healthy animals) for blood smear examination and PCR. Among 15 diseased animals, 7 samples were found positive for piroplasms of *B. bigemina* by blood smear examination and 13 were positive by PCR technique.

El-Hamed *et al.* (2016) examined 135 cattle of different age, sex and breed where in, 48 animals were anaemic. Out of 48 animals, 28 animals were suffering from theileriosis and 20 animals were suffering from babesiosis upon examination of Giemsa stained blood smears.

Lemma *et al.* (2016) screened 400 blood samples from cattle and examined by thin smear using Giemsa stained where in 92 samples were positive for bovine babesiosis.


Sharma *et al.* (2016) screened 542 bovines (cattle 466 and buffaloes 76) by Giemsa stained thin blood smears technique and PCR technique out of which 1.66 % cases were positive for babesiosis by blood smear examination and 16.42 % cases were positive for babesiosis by PCR.

Ganguly *et al.* (2017) screened 150 random blood samples for diagnosis of *B. bigemina* in naturally infected crossbred cows by direct smear, direct blood PCR detection method. Out of 150 random blood samples screened, 18 % (27/150) were found positive under light microscope, whereas direct blood PCR revealed 26 % (39/150) samples to be positive for *B. bigemina*.

Mohanapriya *et al.* (2017) revealed presence of numerous large pear shaped, paired organisms of *B. bigemina* placed centrally in a 5 year old female Jersy cow by microscopic examination of the blood smear.

### 2.2 Haematobiochemical examination:
#### 2.2.1 Haematological examination

Ansar Kamran (1991) studied 45 babesiosis positive cases where in mean haemoglobin levels on the day of presentation of cases (0 day) were 7.27 g% which reached towards normalcy by 45 days to 10.87 g%. Total leucocyte counts (TLC) were also lower on 0 day (7,995/µl) due to relative neutropenia. The count gradually increased thereafter till 30 days (13,406/µl) with relative lymphocytosis and dropped to 13,195/µl on the 45th day.
Kasaralikar et al. (1993) studied blood picture of a babesiosis infected neonatal calf brought to clinics in critical condition which was infected with babesiosis and found a total erythrocytic count (TEC) of 2.39 x10⁶/μl, packed cell volume (PCV) of 14 % and Hb of 5.8 g/dl.

Hussein et al. (2007) studied 43 field cases of cattle of both sexes. Clinical and laboratory investigation revealed that about 20 and 8 animals were found suffering from theileriosis and babesiosis, respectively. Normocytic normochromic anaemia, insignificant changes in total leucocytic count alongwith significant increase in lymphocytes and monocytes associated with significant decrease (P<0.001) in neutrophils were reported in cattle with babesiosis, which was attributed to the breakdown of red blood cells by Babesia which stimulates the phagocytic cells such as lymphocytes and monocytes to clean up the body from the toxic remnants of ruptured red blood cells.

Ananda et al. (2009) screened 132 crossbred cattle of which 16 were positive for Babesia bigemina where haematological values were adversely affected in positive cases. The haemoglobin level was reduced to 8 g/dl. In severely infected cases, it was reduced to 3 g/dl. The TEC and PCV were decreased to 2.3 million/cmm and 9 % respectively.

Ibrahim et al. (2009) carried out haematological investigation in babesiosis infected cattle and found insignificant increase in the number of eosinophils and leucocytic count in cattle with babesiosis, while there was significant increase in lymphocytes and monocytes associated with significant decrease in RBC, Hb, PCV and neutrophils. Babesiosis infected cattle showed a macrocytic hypochromic anaemia.

Lakshmi Rani et al. (2010) carried out haematological studies in 4 babesiosis infected Murrah buffaloes ageing 6-8 year which indicated average 6.78±0.75 g/dl Hb, 20.33±2.32 % PCV, 4.58±0.41 millions/cmm total RBC and 9.2±0.63 thousands/cmm total WBC. Average differential leucocytes count were 45.75±7.81 % neutrophils, 50.25±7.55 % lymphocytes, 2.00±0.41 % monocytes and 2.00±0.82 % eosinophils.

Patel et al. (2011) carried out haematological investigation in babesiosis infected Mehsana buffalo which revealed 6.5 g% Hb, 19 % PCV, 3.2 million/cmm RBC and 7700/cmm total WBC. Differential leucocytes count exhibited 58 % neutrophils, 40 % lymphocytes and 2 % eosinophils.
Zulfiqar *et al.* (2012) observed haematological parameters in 144 clinically healthy large ruminants (105 cattle and 39 buffaloes) from randomly selected herds and concluded that haemoglobin and blood glucose values were reduced in babesiosis affected calves and cattle as compared with the parasite free ones.

Abdullah *et al.* (2013) carried out haematological investigation in 8 Friesian-Sahiwal cattle affected with babesiosis. Haematological examination revealed all animals consistently showed lymphocytosis and monocytosis which were suggestive of the infection.

Jyothisree *et al.* (2013) carried out haematological studies in 13 *Babesia* infected Holstein friesian crossbred cattle which revealed reduced Hb, PCV and TEC with significant neutrophilia and lymphopaenia.

Mahmmod (2014) reported significant decrease in the RBCs, WBCs counts, Hb concentrations and PCV % in the *B. bovis* infected cattle. He stated that the immune response to the babesial antigen causes a significant lymphocytosis.

Mahmoud *et al.* (2015) studied 253 cattle and 81 buffaloes of which 13.8 % cattle and 7.4 % buffalo were suffering from babesiosis. They observed significant decrease in the mean levels of RBCs, HCT %, Hb and MCHC along with increased MCV value in infected cattle. The result suggested that *Babesia* caused macrocytic hypochromic anemia in the persistently infected animals. In addition, the *Babesia* infected animals had significant reduced platelet counts. However total leukocyte count and granulocytic counts (neutrophils, eosinophils and basophils) were markedly increased.

Bal *et al.* (2016) studied 465 cattle at risk of babesiosis out of which 23 blood samples were collected for haematological examination. The haematological parameters showed a significant (p<0.05) decrease in Hb (3.5±0.19 g/dl) in parasitologically positive animals as compared to parasitologically negative animals (7.79±0.25 g/dl) and healthy animals (9.89±0.23 g/dl). Non significant leukocytosis was observed in parasitologically positive animals as compared to healthy animals.

El-Hamed *et al.* (2016) examined haematological parameters in 135 cattle of different age, sex and breed where in 20 animals were suffering from babesiosis. Hematological picture revealed a significant decrease in RBC, Hb and PCV with non-significant changes in MCV, MCH and MCHC (normocytic normochromic anaemia). Cattle infected with theileriosis and babesiosis exhibited leukopenia and neutropenia accompanied by lymphocytosis as compared to healthy animals.
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Sharma et al. (2016) studied haematological parameters in 89 (83 cattle, 6 buffalo) babesiosis infected animals. Haematological parameters showed significant (P<0.05) decrease in the TEC, Hb, PCV, MCV, Plt and WBC while significant increase (P<0.05) in MCH and MCHC in clinically and subclinically infected animals as compared to non-infected healthy animals.

Ganguly et al. (2017) studied haematological investigation in B. bigemina infected crossbred cows. The infected group showed significantly (p<0.001) decreased levels of TEC (3.04±0.19 millions/cmm), Hb (4.78±0.27 g/dl) and PCV (14.53±0.87 %) than healthy control animals. However, differences in the red blood cell indices (MCV, MCH and MCHC) were non-significant (p>0.05) between the groups indicating normocytic hypochromic anaemia in affected crossbred cattle.

Mohanapriya et al. (2017) studied haematological examination of babesiosis infected a 5 year old Jersy cow. Haematological examination revealed that haemoglobin (Hb), packed cell volume (PCV), red blood cell count (RBC), and platelet count were reduced indicating anaemia and thrombocytopenia. The white blood cell count (WBC) was well within the normal range with neutrophilia.

2.2.2 Biochemical examination

Hussein et al. (2007) studied 43 field cases of cattle of both the sexes. Clinical and laboratory investigation revealed 20 and 8 animals were suffering from theileriosis and babesiosis, respectively. Study revealed that cattle infected with theileriosis and babesiosis showed decreased serum levels of albumin, total proteins and glucose with increased serum globulins. Serum level of aspartate aminotransferase (AST) and gamma glutamyltransferase (GGT) showed significant increase in both theileriosis and babesiosis, while the serum level of alanine aminotransferase (ALT) was significantly increased only in case of babesiosis. Cattle infected with theileriosis showed significant decrease in serum level of iron only, while those suffering from babesiosis showed significant increase in both iron and copper.

Ibrahim et al. (2009) carried out biochemical investigation in babesiosis and theileriosis affected cattle. Biochemical examination revealed that mean values of serum total protein showed a significant increase in the Theileria infected animals with slight reduction in serum albumin and significant hyperglobulinemia while Babesia spp. infected animals showed non significant increase in globulins. Activities of serum enzymes revealed a significant increase in the activity of AST, GGT, total
bilirubin and ALP enzymes in piroplasms infected animals. Blood glucose revealed hypoglycemia which was attributed to persistent feverish condition associated theileriosis and babesiosis resulting in anorexia.

Lakshmi Rani et al. (2010) carried out biochemical studies in 4 babesiosis affected Murrah buffaloes aged between 6 and 8 years which indicated significant increase in values of 98.5±7.85 mg/dl glucose, 4.34±0.97 mg/dl bilirubin, 35.91±2.73 mg/dl blood urea nitrogen and 62.3±5.81 units/ml AST and decrease in value of total protein 5.70±0.41 g/dl. Urine samples of all the affected animals were coffee coloured and were positive for haemoglobin, glucose and bile pigments.

Mervat et al. (2010) carried out biochemical investigation of 38 blood samples from calves confirmed positive for babesiosis. Biochemical examination revealed a significant increase in urea, creatinine, AST, ALT and globulin in clinical cases of B. bigemina but non significant changes in sub clinical cases. Also the result revealed significant increase in serum iron, total iron binding capacity transferrin, total protein; however there are non significant increase in albumin and A/G ratio.

Lotfollahzadeh et al. (2012) studied cattle infected with Theileria annulata and B. bigemina where in biochemical analysis indicated significant increase in serum AST and ALP activities while significant reduction in iron concentration. They concluded that iron deficiency anemia is not an important factor in T. annulata and even in B. bigemina infected cattle with severe intravascular haemolysis. The increased activities of serum enzymes indicated hepatic injuries associated with infection with T. annulata and B. bigemina.

Zulfiqar et al. (2012) examined 144 clinically healthy large ruminants from randomly selected herds and concluded that blood and serum biochemical parameters (cholesterol, ALT, AST, LDH and glucose) varied non-significantly between parasite positive and negative blood samples except ALT.

Abdullah et al. (2013) carried out biochemical investigation in Eight Friesian-Sahiwal cattle aged between 8 months and 1 ½ years old of both sexes affected with babesiosis. Biochemical study revealed hypernatremia, hypoalbunaemia, potassium and creatinine at normal range. Elevated muscle enzyme creatinine phosphokinase (CPK) indicated presence of muscle damage.

El-Hamed et al. (2016) analysed biochemical parameters in 135 cattle of different age, sex and breed in which 28 and 20 animals were suffering from theileriosis and babesiosis respectively. Biochemical analysis showed that cattle
affected with theileriosis and babesiosis revealed significant reduction in total protein, albumin, globulin, glucose and iron levels associated with significant increase in the activities of liver enzymes AST, ALT, total bilirubin, urea and creatinine.

Gungi et al. (2016) studied serum chemistry of 4 cross bred cows infected by Babesia spp. aged between 4 and 6 years and found hyperglycemia, hyperbilirubinemia, BUN, AST and hypoprotienemia. Urine was positive for haemoglobin, glucose and bile pigments.

Sharma et al. (2016) studied biochemical parameters in 89 (83 cattle, 6 buffalo) babesiosis affected animals. Biochemical examination indicated significant increase (P< 0.05) in ALP and AST of clinically infected group while the increase as non-significant in subclinically infected animals as compared to control group. However increase in ALT levels was non-significant (P< 0.05) in clinically and subclinically infected group when compared with the control group. There was no significant difference in the level of creatinine and BUN in clinical and subclinical babesiosis affected animals. There was significant response in terms of decrease in total protein and globulin was seen only in clinically infected animals (P< 0.05), while the alterations in albumin level was non-significant in clinically infected, subclinically infected and control group of animals.

Ganguly et al. (2017) conducted biochemical investigation in B. bigemina infected crossbred cows. Serum samples of infected cows showed significantly increase (p<0.01) in the values of ALT (78.83±8.95 IU/L), AST (146.13±7.62 IU/L), BUN (27.09±1.02 mg/dl), creatinine (1.93±0.1 mg/dl) and total bilirubin (1.42±0.06 IU/L) alongwith significant decrease (p<0.01) of TP (6.12±0.13 g/dl) and albumin (2.39±0.09 g/dl) as compared to healthy control.

Mohanapriya et al. (2017) studied biochemical parameters in a babesiosis affected Jersy cow. There was a reduction in total protein, albumin and potassium alongwith an elevation in alanine transaminase (ALT), alkaline phosphatase (ALP), total bilirubin, direct bilirubin and glucose in the serum.

2.3 Treatment

Setty et al. (1985) treated two cross-bed splenectomised calves experimentally infected with B. bigemina which responded well to a single dose of Berenil (Diminazene aceturate) @ 8mg/kg B.W. IM.

Niazi et al. (2008) conducted chemotherapeutic trials in calves of different group and treated with diminazene aceturate and imidocarb dipropionate @ 3.5 mg/kg
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BW IM and 1ml/100 kg BW IM, separately. The efficacy of diminazene aceturate and imidocarb dipropionate was 90 % and 100 %, respectively.

Ananda et al. (2009) treated 16 crossbred cattle positive for Babesia bigemina with diminazene aceturate @ 1g/100kg BW IM along with the supportive treatment of Imferon-10 ml, Belamyl-12 ml and Stadren-10 ml IM. Animals showed improvement in their condition after one week of the treatment.

Akhter et al. (2010) evaluated therapeutic efficacy of various drugs under field conditions against blood protozoal diseases. Anaplasmosis and babesiosis affected animals were treated with imidocarb dipropionate @ 3-4 mg/kg BW IM. Babesiosis affected buffaloes treated with diminazene aceturate @ 3.5 mg/kg body weight in infected group of buffaloes recovered completely.

Lakshmi Rani et al. (2010) treated babesiosis affected four Murrah buffaloes with Diminazine aceturate @ 10 mg/kg body weight intramuscularly along with supportive therapy (Inj. Imferon 5-10 ml IM, Inj. B complex 10 ml IM, and Inj. Chlorpheniramine maleate 15 ml IM on the first day). The animals became afebrile by 24 h after therapy. Among these buffaloes, one succumbed to illness despite of treatment.

Patel et al. (2011) treated a Mehsana buffalo suffering from babesiosis with diminazene aceturate @ 5 mg/kg BW intramuscularly along with supportive therapy (analgesic, antihistaminic and B complex administered intramuscularly in prescribed dose). Animal become afebrile in 24 h after therapy.

Abdullah et al. (2013) treated Eight Friesian-Sahiwal calves using Berenil (Diminazene Aceturate) injection @ 1 ml/20 kg BW intramuscularly and topical application of Ivermectin pour on. Supportive treatment included intramuscular injection of Fercobsang (Iron, Vit-B1, Vit-B12, Vit-B3, cobalt and copper) @ 5 ml as a supplement for iron and vitamin to hasten the formation of RBC. Calves showed improvement in the condition after one week of treatment.

Jyothisree et al. (2013) treated cattle positive for babesiosis with single dose of Berenil @ 3.5 mg/kg body weight. Supportive drugs comprised of Melonex (Meloxicam) @ 0.5 mg/ kg BW on alternate days continuously for one week. DNS was administered 10 ml/kg BW for first 3 days. To alleviate anaemia, 20 % Iron dextran injection @ 10 ml IM on alternate days for one week was administered. To improve appetite, Tefroli syrup @ 10 ml was administered orally daily from the day of appearance of clinical signs continuously for one week. Butox spray @ 2 ml/lit
water was sprayed. Remarkable clinical improvement was observed with single dose of Berenil and supportive treatment after 72 h of treatment.

Hamoda et al. (2014) carried out therapeutic study in 30 cattle infected with *B. bigemina*. The infected animals were divided into three groups, each of 10 animals. Untreated group was used as positive control and treatment groups were divided into two groups, first group being treated with imidocarb only and the second with the combination of imidocarb and lincomycin. Therapeutic efficacy was evaluated on the basis of improvement in liver and kidney functions. Combination therapy of imidocarb and lincomycin proved to be best in terms of recovery.

Bal et al. (2016) treated 15 babesiosis affected cattle using Inj. Berenil (diminazene aceturate), haematinics, and antipyretics. However, despite treatment, one animal died of disease due to advanced stage of disease.

Gungi et al. (2016) treated 4 cross bred cows having babesiosis with a single dose of diminazine accurate @ 3 mg/kg BW IM at two different sites in neck muscles, long acting oxytetracycline @ 20 mg/kg BW IM at 48 hours intervals on two occasions, haematinic 10 ml IM thrice weekly for one week, rumenotoric 40 ml daily orally for 10 days and injection Rintose 500 ml IV daily for 3 days. After 3 days, temperature reduced drastically to 102°F in three animals. Hb and PCV levels improved after 3 wks. Treatment was successful with diminazene aceturate (Berenil) at 3 mg/kg body weight, together with supportive therapy in three cows. Whereas, one cow that was presented at delayed stage died due to severe anemia and delay in initiation of therapy.

Qadri et al. (2016) treated a cross bred cow suffering from babesiosis with diminazine aceturate, paracetamol, iron preparation, liver tonics and calcium therapy. The cow successfully recovered after five days of treatment.

Mohanpriya et al. (2017) treated a babesiosis affected Jersy cow with Inj. Berenil (Diminazene diacetuarate) @ 3-5 mg/kg IM. Inj. Oxytetracycline @ 20 mg/kg, Inj. Phosphorous @ 15 ml, Inj. Neurokind @ 15 ml, Inj. Iron dextran @ 6 ml alongwith Inj. Dextrose normal saline @ 1000 ml and Inj. Intalyte @ 1000 ml which were given intravenously. Bolus ferritas @ 2 boli twice a day and syrup Aystimin @ 20 ml twice a day were prescribed for oral use. Treatment was continued for 5 days and advised the owner to continue the prescribed oral therapy for the 14 days. The animal showed improvement slowly in the physical condition and became normal after the treatment.