

Babesia and Babesiosis in Livestock of Karnataka State, India- An Overview

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Abstract

The haemoprotozoan disease, babesiosis is caused by six species of *Babesia* in livestock of Karnataka state. They are *B. bigemina* and *B. bovis* in cattle and buffaloes, *B. motasi* in sheep and goats, *B. ovis* in sheep and *B. canis* and *B. gibsoni* in dogs. The morphology of the first three species was elucidated. The incidence of *B. bigemina* varied from 0.60 to 16.0% in cattle and from 0% to 4.7% in buffaloes, higher in calves than in adult cattle. The infection was noticed even in neonatal calf of 20 days. The IgM antibodies played a major role for agglutination of infected erythrocytes which occlude the minute brain capillaries resulting in cerebral babesiosis. ELISA kit developed for *B. bigemina* served to detect carrier status of this infection. Anaemia with jaundice was found common to severe babesial infection, but haemoglobiuria might not be present in all the clinical cases. The other bovine species of *Babesia*, *B. bovis* was very rarely seen and its developmental pattern in cattle was described. Outbreak of *B. motasi* in sheep and goats with heavy mortality was recorded. Berenil (diminazene diacetate) was the common drug used for treating babesiosis and was found to be quite effective.

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1. Introduction

Babesiosis, a haemoparasitic disease of livestock is gaining much attention in recent years. This disease in domestic animals in Karnataka state is caused by six species of *Babesia*. They are *B. bigemina* and *B. bovis* in cattle and buffaloes, *B. motasi* in sheep and goats, *B. ovis* in goats and *B. canis* and *B. gibsoni* in dogs. This review provides a comprehensive picture of the researches done in Karnataka on different species of *Babesia*, observations on their morphology, improved diagnostic methods, pathogenesis noticed, haemato-biochemical estimation, serological details and molecular level studies, knowledge on vectors and treatment adopted. Besides, developmental cycle of *B. bovis* in the final host has been described.

2. *Babesia bigemina*

2.1 Morphology by Dried Smears

Babesia bigemina organisms appeared in Giemsa stained blood smears as larger pear-shaped bodies in pairs joined at their narrow ends, placed centrally in the erythrocytes at acute angle, occupying

at least $\frac{3}{4}$ th of their area. Single pear-shaped, oval and ring forms were also seen. Appearance of two or more parasitized erythrocytes in clumps was not uncommon (Ansar Kamran, 1991).

2.2 Morphology by Wet Mount

Live morphology of *Babesia* was observed using hypotonized erythrocytes in wet mount technique (WMT). The organisms appear as very large, bright, spherical bodies about 3 μ in diameter showing a fine wavy movement of the cytoplasm. The movement of the organism is slow, but some exhibited active amoeboid movement (Setty, 1983a). On vital staining with 0.5% new methylene blue (NMB), *Babesia* organisms are visible as large spherical bodies actually composed of two halves with a fine cleavage line between them. But in routine Giemsa stained smears these two halves got drifted and appeared as two pear-shaped organisms probably by the effect of drying and fixation (Setty, 1983b). NMB stain gives a blue tint to the erythrocytes and the parasites take a basophilic stain (Setty *et al.*, 2003).

2.3 Incidence

Information on the incidence and the epidemiology of haemoparasites including *Babesia* were documented by four veterinary diagnostic laboratories (VDL) established under a joint programme of University of Agricultural Sciences and Karnataka Dairy Development Corporation (UAS-KDDC) project for a period of seven years from 1977 to 1984. VDL, Bengaluru had taken care of the disease diagnosis and surveillance of Bengaluru and Kolar districts, VDL, Mysuru catered the diagnostic needs of Mysuru, Mandya and Kodagu districts, VDL, Hassan extended services to Hassan and Chikkamagaluru districts and VDL, Tumukuru also served Tumukuru district besides two taluks of Mandya district. The analysis of the data of blood smear examinations of cattle conducted at these laboratories for the above period indicated that higher infection (16.0%) was noticed in Kodagu district followed by lower infection in Bengaluru district (3.85%), Mysuru (2.71%), Hassan (1.76%), Tumukuru (1.55%), Chikkamagaluru (1.38%), Kolar (1.05%) and Mandya district (0.6%) (Seshadri *et al.*, 1985). Comparatively very less incidence was recorded from buffaloes. The sporadic nature of babesiosis in different geo-climatic conditions of the state was also projected by Harish *et al.* (2006). Out of the 11,755 blood samples received from various parts of the Karnataka for examination of haemoprotozoan infections during the five-year period (March 1997-April 2002), only 205 samples were positive for babesiosis indicating an incidence rate of 1.74%. The district-wise incidence of *B. bigemina* in bovines for the period 1972 to 2014 based on the works of different scientists has been furnished in Table 1. The overall data indicated that the incidence of *B. bigemina* varied from 0.6 to 16.0% in cattle and from 0% to 4.7% in buffaloes in different districts.

2.3.1 Seasonal Incidence

Based on the analysis of data on blood smear examinations in the study area of 8 southern districts of Karnataka mentioned above, it was observed that *Babesia* infection in bovines was recorded in all the months of the year. In Bengaluru-Kolar districts peak incidence was noted during cold weather season (3.87%), in Hassan-Chikkamagaluru districts during south-west monsoon period (2.68%), and in Mysuru-Mandya-Kodagu districts (2.01%) and in Tumukuru district (4.35%) during north-east monsoon period (Seshadri *et al.*, 1985).

2.3.2 Breed-wise

An analysis on incidence *B. bigemina* in different breeds of cattle recorded at VDL, Mysuru indicated that 3.94% in indigenous (IG; n=813) cattle

had highest infection followed by 2.63% in pure-bred (PB; n=38) and 1.66% in cross-bred (CB; n=3318) cattle. However, a higher infection rate of clinical cases in IG cattle compared to those of CB and PB cattle contradicted the concept that the cattle indigenous to the area were rarely suffered from this disease. Among the PB, the infection was observed only one Red Dane cattle whereas Jersey and Holstein-Friesian (HF) cattle were found free from infection. However, in native breed, Sindhi cattle did not have infection (Seshadri *et al.*, 1985). But on the contrary, Ansar Kamran (1991) reported the infection both in HF and Jersey breeds and HF had higher parasitaemia than Jersey.

2.3.3 Age-wise

From the data of VDL, Mysuru pertaining to five age groups it was deduced that the percentage of incidence of clinical cases was highest in the age group of 6 months to 1 year (3.54%) and followed by 0-6 month age group (3.3%). The infection was detected even in two and half month calf. Age group of 1-4 years had only 1.45% infection. Incidence showed an increasing trend in the age group 4-8 years (2.36%). But no incidence was recorded in cattle of above eight years though 94 blood samples of this age group were screened (Seshadri *et al.*, 1985). As per Ansar Kamran (1991) higher parasitaemia was observed in the age group 4-6 years, next was 2-4 followed by 0-2 and least in above 6 years age group. Kasaraliker *et al.* (1996) reported a case of *B. bigemina* infection from Bidar in a non-descript female calf of 20 days old which appeared to be minimum age at which this infection was noticed in Karnataka state. The findings of VDL, Mysuru indicated that the susceptibility to infection of calves was higher than those of older cattle. But younger stock up to one year of age has been considered to have natural resistance or exhibited no clinical symptoms if infected (Seshadri *et al.*, 1985).

2.4 Experimental Infection in Calves

Report of Setty *et al.* (1985) indicated that two cross-bred *Theileria* carrier calves with less than 1% infection intended for experimental studies on *Theileria* on splenectomy, found positive for *Babesia* organism as well on 5th and 9th day. Ansar Kamran (1991) infected 8-12 months old splenectomized cross-bred calves maintained in tick-proof condition by injecting blood collected from natural case of *B. bigemina* having less than 4% parasitaemia by i/v route. This process was repeated thrice using different calves. To obtain higher parasitaemia, corticosteroid, prednisolone @2-3mg/kg b.w. was administered i/m daily which acted as immune-suppressant.

2.5 Clinical Pathology

Table 1: Incidence of *Babesia bigemina* infection in bovines of Karnataka for the period 1972-2014 based on blood smear examinations

District/locality	No. of samples examined	Per cent positive	Animals/ Breeds	Reference
A. Cattle				
Karnataka	-	300 cases	Cattle	Setty and Krishna Rao (1972)
Bengaluru dt.	*1375	3.85	CB, local	Seshadri <i>et al.</i> (1985)
Kolar dt.	*1234	1.05	CB, local	Seshadri <i>et al.</i> (1985)
Hassan dt.	*2726	1.76	CB, local	Seshadri <i>et al.</i> (1985)
Chikkamagaluru dt.	*145	1.38	CB, local	Seshadri <i>et al.</i> (1985)
Tumukuru dt.	*3154	1.55	CB, local	Seshadri <i>et al.</i> (1985)
Kodagu dt.	125	16.00	CB	Seshadri <i>et al.</i> (1985)
Mysuru dt.	3318	2.71	Exotic, local	CB Seshadri <i>et al.</i> (1985); Muraleedharan <i>et al.</i> (2005)
Mandya dt.	1174	0.60	Exotic, local	CB, Seshadri <i>et al.</i> (1985); Muraleedharan <i>et al.</i> (2005)
Bengaluru	935	4.16	Cattle	Setty <i>et al.</i> (1985)
Bengaluru	-	45cases	HF, JR	Ansar Kamran (1991)
Bidar	-	1 case	Local	Kasaralikal <i>et al.</i> (1996)
Karnataka, different localities	11,755	1.74	-	Harish <i>et al.</i> (2006)
Bengaluru North	132	12.12	CB	Ananda <i>et al.</i> (2009)
Shivamogga, in & around	*566	10.25	JRx, HFx, Hallikar, Amrut Mahal	Ananda <i>et al.</i> (2014)
Shivamogga dt.	215	12.50	-	Krishna Murthy <i>et al.</i> (2014)
B. Buffaloes				
Mysuru dt.	334	0.29	Local	Seshadri <i>et al.</i> (1985); Muraleedharan <i>et al.</i> (2005)
Mandya dt.	177	0.00	Local	Seshadri <i>et al.</i> (1985); Muraleedharan <i>et al.</i> (2005)
Shivamogga dt.	85	4.70	Local	Krishna Murthy <i>et al.</i> (2014)

*Includes a few buffaloes; JRx- Jersey cross; HFx- Holstein-Friesian cross; CB-Cross-breeds

2.5.1 Symptoms

Temperature rise and anaemia were the usual symptoms exhibited in most of the clinical cases of cattle. Analysis of symptoms exhibited in clinical cases, Seshadri *et al.* (1985) recorded that the body temperature of 86.49% of the cases ranged between 103⁰F and 108⁰F, 10.81% with normal temperature and 2.7% with sub-normal temperature. Haemoglobinuria appeared to be not a definite clinical entity of all the cattle positive for babesiosis since it was observed only in 57% of the clinical cases. Other symptoms noticed were anorexia (19%) and enlargement of superficial lymph glands (10%). Reduction in milk yield, dullness, debility, pale conjunctiva, yellow mucus membrane, salivation, diarrhoea, nasal discharge, cough, lachrymation and panting were observed in the affected cattle in one or more combinations. Even young calves below 4-12 months, considered to be resistant to infection, exhibited symptoms as in adult cattle. Four cases of concurrent infections of *B.bigemina* with

Theileria and one with *B. bovis* in cattle were noted. But all the 45 positive cases studied by Ansar Kamran (1991) had haemoglobinuria, rectal temperature ranged from 98⁰F to 107.6⁰F, pale visible mucus membrane, anorexia and partial or complete loss of rumination. Kasaralikal *et al.* (1996) reported *B. bigemina* infection in a less than three weeks old which was presented for treatment in a moribund condition with sub-normal temperature (99⁰F), anorexia, recumbency, haemoglobinuria, icteric mucus membranes and deep and swallow respiration. The calf suddenly succumbed to the illness before any treatment could be administered and the result of blood smear examination revealed that the calf had *B. bigemina* infection. Ziauddeen *et al.* (1987) assigned 3.45% mortality to babesiosis based on the post-mortem examinations of 87 cattle conducted during the period of 1977-1982 in Mysore-Mandya Project area of KDDC.

2.5.2 Haematological Observations

Ansar Kamran (1991) reported that the mean haemoglobin levels on the day of presentation of cases (0 day) were 7.27g% which reached towards normalcy by 45 days to 10.87g%. Total leucocyte counts (TLC) were also lowest on 0 day (7,995/ μ l) indicating leucopenia due to relative neutropenia. The count gradually increased thereafter till 30 days (13,406/ μ l) with relative lymphocytosis and dropped to 13,195/ μ l on the 45th day. *Babesia* organisms or their products would be responsible for such mild cellular changes involving immunosuppressive reaction. The improvement in the counts could be attributed to waning of this immunosuppressive effect following recovery from the acute disease. Plasma fibrinogen estimated in 19 animals was within the normal range of 450-750mg/dl. Osmotic fragility of erythrocytes on day 0 and day 15 was found to be increased and reached normalcy by 30 days. The toxic principles elaborated by the parasites could be responsible for the increased fragility. The blood picture studies of a neonatal calf brought to clinics in critical condition (Kasaralikal *et al.*, 1996) showed a total erythrocytic count (TEC) of 2.39×10^6 / μ l, pack cell volume (PVC) of 14% and Hb of 5.8g/dl. Van den Bergh test conducted on serum was indirect positive and hence suggestive of haemolytic jaundice.

2.6 Serological Studies

B. bigemina antigen for using in ELISA for the estimation of IgM was prepared from blood of splenectomized calves having 10 and 22.1% parasitaemia which was attained by two to four passages of organisms. IgM titers were measured by ELISA and abnormally high values of IgM titers were present in the initial stage of clinical bovine babesiosis and continued during the observation period of 45 days. The titers were found to be significantly constant throughout this period, the OD values of zero day and 45th day being 0.399 and 0.358 respectively. HF cattle showed highest titer, and Jersey and young animals had higher titer compared to animals above four years. The IgM seemed to be responsible for the agglutination of antigen-coated erythrocytes in circulation which occluded the minute brain capillaries causing cerebral babesiosis (Ansar Kamran, 1991; Ansar Kamran *et al.*, 1997). With the help of the ELISA kit developed, Sudha Rani *et al.* (2014) could detect sero-prevalence of carrier status of *B. bigemina* in 25% of cattle of various farms in Bengaluru.

2.7 Clumping of Infected Erythrocytes and Cerebral Babesiosis

Setty *et al.* (2003) experienced that if *Babesia* positive blood samples kept at room temperature for a few hours, the smears made from such samples seldom

revealed the organisms. As per the previous notion, the severe haemolytic behavior of the parasites was attributed for their disappearance in smears made from old samples. But the application of wet mount technique brought out the fact that the parasitized erythrocyte clumps were still evident in old samples of blood suggesting a mechanism other than hemolysis was responsible for not finding the parasites in smears made from aged samples of blood. The reason for absence of parasitized erythrocytes in the smears was explained as the erythrocytic clumps either settled at the bottom of the samples and thereby the parasites did not appear in the smears made or they got washed out during the staining process rendering the smears negative. The parasitized erythrocytes get a coating of parasite-antigen on their surface making them susceptible to the action of immunoglobulin M (IgM) which resulted in the aggregation of infected cells. The erythrocytic clumps formed in general circulation of cattle if carried to vital organs like brain, blockage occurred in minute capillaries leading to ischemia, followed by neurological disturbances and death of the animals by cerebral babesiosis (Setty *et al.*, 2003). It was observed that by treating old blood samples with 0.01 M-2-mercaptoethanol (MCE), the clumping of blood cells would not occur indicating that MCE had prevented the formation of such clumps. The possible role of IgM in the formation of erythrocyte clumps by splitting the IgM molecule into its monomers by mild reduction with MCE. Setty and Gowda (2009) had expressed their view that by widening the scope of research inputs in bovine cerebral babesiosis could also help to unravel the mystery of human cerebral malaria.

3. *Babesia bovis*

3.1 Prevalence

The first Indian report on the occurrence of *B. bovis* infection in an indigenous buffalo of the Military Dairy Farm of Belgavi (Belgavi) of Karnataka was of Indani (1938) and the diagnosis was confirmed at Indian Veterinary Research Institute, Mukteswar by the scientists Ware and Ray who were well-acquainted with *B. bovis* infection of English cattle. Setty and Krishna Rao (1972) recorded interesting forms of *Babesia* organism, not generally encountered in cattle, in a cow at Bengaluru. Blood smears of the cow were sent to Lumsden of the London School of Hygiene and Tropical Medicine who opined that the parasites appeared to be *B. bovis*. *B. bovis* infection was also observed in two buffaloes by Muraleedharan *et al.* (1984; 1991), one each from Devalapura (Mysuru district) and Pandavapura (Mandya district) and the identification of infection was got confirmed by Ian Wright, CSIRO, Queensland, Australia.

3.2 Morphology

The pear-shaped parasite identified from buffalo occurred in pairs widely divergent in their blunt extremities and the parasite had a tendency to lie towards the periphery of erythrocytes. The longest diameter of the parasites ranged from 0.5-2.0 μ , and about 10% of the erythrocytes were found infected (Idnani 1938). According to Setty and Krishna Rao (1972) the *B. bovis* organisms observed inside the erythrocytes of a cow were pyriform or oval-shaped with single or double nucleus. Most of the parasites found solitary in the erythrocytes and some in pairs. Spherical forms with 1-4 chromatin masses in the periphery in a thin layer of cytoplasm and with a central vacuole, and anaplasmod bodies were also observed. Muraleedharan *et al.* (1984) recorded the parasites from buffaloes which measured 1.6-2.4 x 0.8-1.6 μ and they were morphologically similar to *B. bovis*. If in pairs, the organisms were either in divergent angle or side by side (almost parallel), or if single they were either pyriform or vacuolated form, situated in the centre or near to the periphery in the erythrocytes. The infection was also observed in six cattle of Mysuru district. Ansar Kamran (1991) described that *B. bovis* appeared either as single or paired, pyriform, located centrally at an obtuse angle and was much smaller than *B. bigemina*. The pairs occupied less than half the area of erythrocytes.

3.3 Developmental Pattern

After detailed study of about forty blood smears made from a cow positive for *B. bovis*, Setty and Krishna Rao (1972) noted the various developmental forms and schematically arranged them so as to bring out a definite pattern of the asexual developmental cycle of the parasite in the final host. The youngest parasitic stage, merozoite penetrates the erythrocytes as an anaplasmod body of about 1 μ in diameter. This gradually develops a ring of cytoplasm around and later assumes an oval or pyriform shape with nucleus at one end. A central vacuole is then formed and the chromatin is spread over the periphery to become spherical body. The chromatin first divides into two and then into four. After attaining full maturity, this form escapes out of the erythrocytes and is seen as four chromatin masses in thin a layer of cytoplasm. The chromatin masses eventually separate into four anaplasmod bodies which invade other erythrocytes.

3.4 Symptoms

3.4.1 Buffalo

Idnani (1938) reported that the affected she-buffalo exhibited haemoglobinuria, fluctuating temperature of 103.4-106.2°F which continued for 3

days without responding to trypan blue treatment. About 25% of the red cells were found infected by small and slender parasites. Muraleedharan *et al.* (1984) noticed this infection with almost similar symptoms in two she-buffaloes with pyrexia of 105-106°F and haemoglobinuria, blood shot eyes and lachrymation, with low intensity of parasitaemia of 4-5%.

3.4.2 Cattle

Setty and Krishna Rao (1972) recorded *B. bovis* infection in a cow having temperature of 105°F with haemoglobinuria and about 10% of the erythrocytes were infected. 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 and sometimes blood shot eyes and lachrymation. Ansar Kamran (1991) also reported *B. bovis* infection in cattle from Bengaluru with clinical signs and parasitaemia upto 14.73%. His studies indicated that *B. bovis* infected erythrocytes were found to be less fragile. The total serum protein (TSP) levels in young and very old animals had lower values while animals aged 4-6 years showed comparatively higher values. In zero day samples TSP showed reduced concentration of 7.71mg/dl which increased gradually to reach the normal value of 8.77mg/dl on day 45. Four animals suspected to have *B. bovis* infection either had very low or no titer of antibody.

4. *Babesia motasi*

4.1 Morphological Forms

Achar and Sreekantaiah (1934) described *B. motasi* in the erythrocytes of sheep as pear-shaped forms in pair, generally arranged in acute angle with double chromatin mass. Jagannath *et al.* (1974) identified three different parasitic forms of *B. motasi* such as pear, ovoid and irregular shaped ones in an outbreak of this infection. Pear-shaped forms measured 2.7 x 1.7 μ and ovoid form 2.0 x 1.8 μ (average of 25 parasites). The largest pear and ovoid forms measured 3.8 x 2.0 μ and 3.4 x 3.0 μ respectively, while the smallest pear and ovoid forms measured 2.3 x 1.9 μ and 1.5 x 1.4 μ respectively. The percentage of each form was: paired forms-24.5%; pear shaped-40%; ovoid-29% and irregular forms-6.5%.

4.2 Incidence and Pathogenesis

In Karnataka, Achar and Sreekantaiah (1934) were first to report *B. motasi* infection in sheep during

the course of experiments with goat-adapted rinderpest virus as an immunizing vaccine for sheep against rinderpest at Mysore Serum Institute at Bangalore (now Bengaluru). On the 4th day of inoculation, sheep showed rise of temperature and pear-shaped organisms in pairs, united generally at an acute angle resembling *B. bigemina*, but with double chromatin mass, appeared in red cells. The sheep might have been in carrier stage of *B. motasi* infection which flared up by vaccination stress. But no infection was noticed in goats. Jagannath *et al.* (1974) reported an outbreak of babesiosis due to *B. motasi* infection with very heavy mortality in young sheep and goats aged two months to three years in several villages of Gowribidanur taluk of Kolar district exhibiting typical clinical signs. The ailing animals showed high temperature of 106-107⁰F, anorexia, bronchitis, diarrhoea, followed by dysentery in later stages. Few sheep showed swelling of the head around nasal region and some of them were anaemic. Affected sheep died within 48 hours from the onset of symptoms and even heavy infection was observed in a two-month old lamb. Muraleedharan *et al.* (1994) reported that out of the 45 blood samples of sheep examined at VDL, Mysuru, only one (2.2%) had *B. motasi* infection. *Babesia* was recorded from Sheep Breeding Station, Suthatti (Belgavidiistrict) where three sheep were positive for mixed infection of *Babesia* and *Theileria* (Prabhakar, 1976).

5. *Babesia ovis*

Infection of *B. ovis* in goat showing clinical signs was reported from Bidar by Vidya *et al.* (2011). This goat exhibited pyrexia of 104⁰F, reduced Hb of 8.8 g/dl, PCV of 32% and TLC of 11600/ μ l.

6. *Babesia canis* and *Babesia gibsoni*

Two species of *Babesia*, *B. canis* and *B. gibsoni* were observed in blood smear examinations of infected dogs with high pyrexia brought to hospitals at Bengaluru. But their percentage of incidence was not worked out. *Babesia* sp. infection was observed in a Labrador-retriever dog a Shivamogga (Patel *et al.*, 2015).

7. Vector Potentialities

Achar and Sreekantaiah (1934) reported the presence of hard ticks, *Haemaphysalis bispinosa* on sheep positive for *B. motasi*. Jagannath *et al.* (1974) identified the ticks from sheep suffering from *B. motasi* infection were *H. intermedia*, the known vector for this infection. *Babesia* infection was recorded from Sheep Breeding Station, Suthatti (Belgavi dt.) where the *H. intermedia* ticks were found predominant on sheep (Prabhakar, 1976). All the known vector ticks of

Babesia were recorded in the general surveys conducted on tick fauna of domestic animals of Bengaluru, Chitradurga, Dharwad and Kolar districts of Karnataka by different workers and studies were also done on the seasonal proliferation of tick vectors.

8. Treatment and Control

Diminazine diacetate (Berenil) was the common drug used for treating *Babesia* infection in cattle. Two cross-bred calves experimentally developed *B. bigemina* infection on splenectomy responded well to a single dose of Berenil at 8mg/kg b. w. (Setty *et al.*, 1985). Ananda *et al.* (2009), Kumar and Bhat (2011) and Ananda *et al.* (2014) treated babesiosis in cattle with this drug successfully. The treatment with trypan blue (1%) 120 ml i/v for the first day followed by 100 ml on subsequent day found to be ineffective for treating *B. bovis* infection in a buffalo (Idnani,1938). Setty and Krishna Rao (1972) treated a cow having this infection with 2.4 g of Berenil in 15 ml of distilled water and cured. Infections with *B. bovis* in buffaloes were responded to the treatment with Berenil 8 mg/kg b.w. by deep i/m followed by Oxysteclin 50 mg/kg b.w. repeated for two days (Muraleedharan *et al.* 1984).

Information of control measures against *B. motasi* infection in sheep and goats in two villages of Gowribidanur taluk of Kolar district is available. The ailing flocks were treated with Berenil at 0.8 g i/m dissolved in 5 ml distilled water given i/m for an adult and half the dose for a lamb, and ticks were eliminated by spraying 0.5% sumithion and burning the infested pastures (Jagannath *et al.*, 1974). Recently Vidya *et al.* (2011) treated a case of babesiosis in goat in Bidar with Bernil and Patel *et al.* (2015) in a Labrador-retriever dog successfully in Shivamogga.

9. Conclusion and Future Concerns

The role of carrier status of *Babesia* in disseminating infection as well as maintenance of immunity should be investigated to develop control strategies for babesiosis in cattle and buffaloes. The emergence of *B. bovis* after the lapse of five decades in Karnataka State should be viewed with caution. The role of responsible vectors concerned for spreading babesiosis should be explored for further detail. More advanced studies on serological and molecular fronts would facilitate for early detection of infection, especially the carrier stages, as well as for specific identification of species concerned. New drug formulations need to be evolved on priority basis to overcome the probable emergence of resistance due to continuous or repeated use of the same drug against the parasites. The possibility of the use of phyto-therapeutic products as substitute to chemical agents

against parasites as well as their vectors should be explored. A quantitative estimation of immunoglobulins in bovine babesiosis could throw more light on the subject and appeared to be essential in understanding the details on the pathogenesis of erythrocyte agglutination *in vivo* (Setty *et al.*, 2003).

More researches to unravel the mechanisms involved in clogging of minute capillaries of brain in babesiosis will definitely provide clues to solve on similar situation confronted by humans suffering from cerebral malaria.

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