1. INTRODUCTION

Goats play a major role in the rural economy of India. It is a versatile animal and known as the 'poor man’s cow’. It was probably the first animal to be domesticated around 9000 to 7000 BC. In the developing countries, goats make a very valuable contribution, especially to the poor in the rural areas. The importance of this valuable genetic resource is underestimated and its extent of contribution to the livelihood of the poor is inadequately understood. They are often neglected in comparison with cattle and sheep. Part of this attitude towards them can probably be due to recognition of their capability, rather than prejudice against them, as it is believed that goats are intelligent, independent, agile and tolerant to many diseases and parasites and can look after themselves much better than other livestock species (Aziz, 2010). The goat is an animal that adapts itself readily to almost any climate. It can be cheaply reared through browsing on the wasteland and agricultural by products. The diseases of goats cause considerable economic losses in terms of low productivity and mortality.

In India, caprine haemoprotozoan infections are common due to favourable climate for parasites and vectors. Among various haemoprotozoan of goats Babesia motasi, B. ovis, B. taylori (Soulsby, 1986), Theileria ovis, T. hirci (Radostitis et al., 2009) and Trypanosoma evansi (Manjrekar, 1950) have been described in India.

Babesiosis is caused by intraerythrocytic protozoan parasites of the genus Babesia, which is transmitted by hard ticks of family Ixodidae. In those areas where caprine babesiosis occurs, the economic losses associated with it may be significant, particularly around the Mediterranean, Middle East and India.

The known major vector of B. motasi and B. ovis in India is Rhipicephalus bursa (Radostitis et al., 2009). B. motasi is also transmitted by Haemaphysalis punctata and Dermacentor silvarum (Soulsby, 1986). Transovarian and transtadial transmission has been reported in babesiosis. Babesiosis in goats is clinically characterized by high fever, marked anaemia,
jaundice and haemoglobinuria in the final stages (Soulsby, 1986). Anaemia is very common in infected animals, while haemoglobinuria may not be observed in goats infected with \textit{B. ovis} (Popa, 1998).

The diagnosis is made by demonstrating \textit{Babesia} organisms within infected erythrocytes in the blood smear stained with a Romanowsky-type stain. Large (2.5-4 µ) pyriform organism usually present in single or pair is indicative of \textit{B. motasi} (Soulsby 1986). \textit{B. ovis} is much smaller than \textit{B. motasi}, being 1-2.5 µ in length. The majority of the organisms are round, occurring at the margin of red blood cell. Pyriform organisms are rare and when occur in pairs the angle between them is obtuse. The length of \textit{B. taylori} is 1-2.5 µ but usually it is ovoid to round. They undergo several fission to produce eight or even sixteen parasites per erythrocyte.

The most commonly used compounds for the treatment of babesiosis in goats are imidocarb (Hashemi-Fesharki, 1991) and trypan blue for \textit{B. motasi} and quinapyramine sulphate for \textit{B. ovis} (Soulsby, 1986). In cattle Oxytetracycline LA @ 20 mg/kg b.wt., I/M at 96 hours intervals for 3 weeks has been reported to be effective against babesiosis (Davis and Gookin, 2009).

The situation regarding haemoproteozoon infection in goat in India is still not clear. Studies on haemoproteozoon infection in goats at Maharasthra revealed the prevalence of babesiosis and theileriosis were 4.08 and 0.40%, respectively (Jadhao et al., 2007).

Furthermore, a meagre work has been done on caprine haemoproteozoon in India. Hence, keeping these facts in view the present study was planned with the following objectives:

1. To study the prevalence of caprine haemoproteozoon infection in and around Jabalpur city.
2. To study the various clinical and haemato-biochemical alterations in caprine babesiosis.
3. To evaluate the comparative therapeautic efficacy of drugs against caprine babesiosis.
2. REVIEW OF LITERATURE

2.1 Prevalence

Banerji et al. (1990) demonstrated *Theileria hirci* in a 3-year-old female Jamunapari goat at a Veterinary Clinic at Calcutta, India in Giemsa-stained blood smears and lymphatic fluid.

Luo and Yin (1997) reported theileriosis as an important disease of sheep and goats in West China. They stated that the epidemic period of the disease was from late March to July with April to May being the peak months. They found sickness rates of lambs, exotic and native adult animals were 78-85%, 41% and 9% respectively.

Al-Amery and Hasso (2002) examined 615 blood samples of goats by laboratory examination of blood smears in Iraq and reported 33.82% samples to be positive for *Theileria hirci*.

Razmi et al. (2003) studied the prevalence of *Babesia* infection in goats in Mashhad area from 1998-2000 by blood smear examination. A total of 385 blood samples of goats were examined for the presence of *Babesia* organisms. This study revealed prevalence of *Babesia* in goats to be 14.8%. Mixed infections occurred in 1 goat and the prevalence between male and female and different age groups of goats were statistically non-significant.

Aktas et al. (2005) investigated the presence of *Theileria ovis* in small ruminants in the Elazig region between April to October, 2004. A total of 164 whole blood and thin blood smears (from 103 sheep and 61 goats) were collected. Thin blood smears were examined by microscopic examination in which *Theileria* were observed in 40 out of 103 sheep but not seen in goats.

Bhikane et al. (2005) found *Babesia motasi* infection in blood smear of a 5 year old Osmanabadi goat brought to Veterinary Teaching Complex, College of Veterinary Science and Animal Science, Udgir with a history of red-coloured urine, anorexia, dullness and depression. Clinical examination revealed fever, increased respiration and heart rate and pale conjunctive. Nervous signs like trembling, staggering gait and frequent mild convulsions were also observed.
Dargantes et al. (2005) induced *Trypanosoma evansi* isolated from an equine in Mindanao, Philippines to infect intravenously in two groups (A and B) of 5 male goats aged 8–10 months. Animals of groups A and B received 5000 and 50,000 trypanosomes, respectively whereas, 5 animals (group C) served as uninfected controls. Out of 10 infected goats 4 died between 8-78 days after inoculation.

Noaman et al. (2005) carried parasitological survey to find out prevalence of *Babesia* in immigrant sheep and goats of Isfahan area in Iran. A total of 715 blood smears from immigrant sheep and goats originating from 3 area and 57 flocks were investigated for the presence of *Babesia*. They reported the prevalence of *B. motasi* and *B. ovis* to be 22.50% and 77.55% respectively. The study revealed that the infection rate for *B. ovis* and *B. motasi* were 21.26 % and 6.15 % respectively.

Shahabuddin et al. (2006) reported the prevalence of *Babesia* infection in goats in the Province of Balochistan, Pakistan during 1998-2000. A total of 700 goats in various slaughter houses, butchers shops, veterinary farms and many flocks in the six divisions of the province were clinically examined and investigated for the presence of *Babesia* in blood smears. The study revealed that the incidence of infection for *Babesia* in goats was 10.86%.

Theodoropoulos et al. (2006) collected 32 blood samples from goats in Greece. A total of 3 samples produced the DNA fragment specific *Babesia*. Sero-prevalence for *B. ovis* in goats was 4.14%.

Aktas et al. (2007) conducted a prevalence study on 300 sheep and 100 goats from 37 randomly selected herds located in eight locations of eastern Turkey. These animals were examined for the presence of *Babesia* infection and any tick on the body of the animals. Of 400 blood samples examined, 1.50% was found to be positive for *Babesia* piroplasms on microscopic examination. The frequency of *B. ovis* infection was higher in herds with tick burden than no tick burden.
Altay et al. (2007) reported prevalence of *Theileria ovis* in goats in the East and Southeast Anatolia. Whole blood samples of 142 goats and thin blood smears of 139 goats were collected from Malatya, Mus, Erzincan, Erzurum, Iğdır, Diyarbakır and Mardin region. Pirolasms of *Theileria* were detected in 2.88% of goats by microscopic examination.

Jadhao et al. (2007) studied the epidemiological pattern of caprine haemoprotezoan infection in the eastern zone of Vidarbha region of Maharashtra. Blood smears were prepared from 1250 goats in which 14.72% harboured haemoprotezoan infection. The infection rate was 5.95%, 13.07%, 16.75% and 17.53% in animals aged <1 year, 1-3 years, 3-5 years and >5 years respectively. The incidence of infection in male and female was 13.70% and 14.90% respectively. The prevalence of babesiosis, ehrlichiosis and theileriosis recorded was 4.08%, 10.24% and 0.40% respectively.

Lako et al. (2007) conducted a survey on babesiosis of domestic ruminants in 3 regions of West Cameroon. Blood samples were collected from 85 goats. The parasitological examination revealed prevalence of babesiosis was 33.33% in goats.

Sayin et al. (2009) studied the prevalence of *Theileria* infection in goats in different geographical regions of Turkey. A total of 89 goats, suspected to have *Theileria* infection, were examined. They found prevalence of infection with *T. ovis* was 12.36% in goats. Microscopical examination revealed the percentage of parasite carriers as 5.62% in goats.

Inci et al. (2010) conducted study between January 2006 to September 2008 to identify *Babesia* and *Theileria* in goats of Central Anatolia. A total of 152 goats were randomly selected from herds located in Kayseri, Yozgat and Sivas provinces. Among the goats *T. ovis, B. ovis* and *B. ovis* with *T. ovis* were observed in 9.90%, 0.70% and 1.30% respectively.

Irshad et al. (2010) reported the prevalence of theileriosis in goats maintained at National Agricultural Research Centre (NARC) Islamabad and Barani Livestock Production Research Institute (BLPRI) Kherimurat district Attock, Pakistan. A total of 443 goats were screened and found that 41.53% goats were infested with tick. The blood samples were collected from
tick infested goats, stained with Giemsa stain and examined under microscope for presence of *Theileria* organism. The study revealed that prevalence of the theileriosis in goats was 3.80%.

Sulaiman *et al.* (2010) examined 175 goats in Mosul. The results showed that 15.43% goats were infected with *Babesia ovis*, *B. motasi*, *B. foliata* and *B. taylori*.

Iqbal *et al.* (2011) have reported *Babesia* in small ruminant population in Southern Punjab 67 goats in seven districts of Southern Punjab from randomly selected herds. The result showed that 23.88% goats were positive for *Babesia*. It has been also observed that male animals and young animals under one year of age were more prone to the parasitic burden.

Taha *et al.* (2011) confirmed and documented outbreak of malignant ovine theileriosis among goats in Atbara Town, Northern Sudan, 16 out of 22 goats were died from *Theileria*. The infection was detected microscopically and confirmed by polymerase chain reaction technique.

Vidhya *et al.* (2011) reported *Babesia ovis* infection in adult buck brought to Veterinary College Hospital, Bidar with the history of weakness, haemoglobinuria, pale mucous membrane and fever (104°F) the Giemsa stained blood smear revealed *B. ovis* organism.

Zangana and Naqid (2011) reported the prevalence of *Theileria hirci* and *Babesia motasi* in goats in the Duhok area of Iraq from April to September 2010. A total of 500 local black breed goats were clinically and then examined in laboratory for the presence of piroplasmosis in blood smears. The study revealed that 20.8% of the goats infected with *T. hirci* and 4% infected with *B. motasi*. Prevalence of piroplasms infection between male and female and between different age groups of goats was statistically significant. They found age wise prevalence for *Theileria* was 1.40%, 5.80% and 13.60% in age groups <1 year, 1-3 years and >3 years respectively and for *Babesia* was 0.40%, 1.40% and 2.20% in age groups age groups <1 year, 1-3 years and >3 years respectively. According to sex wise prevalence they found 1.40% and 19.40% prevalence for *Theileria* and 0.40% and 3.60% for *Babesia* in male and female respectively.
Ziapour et al. (2011) reported the prevalence of babesiosis in goat in Mazandaran Province, North of Iran from middle of March to December 2008. A total of 292 blood samples of goats were stained with Giemsa stain and examined under microscope using 100x lens. They found the mean contamination rate in goats was 22.27%.

Adamu and Musa (2012) collected blood samples from 100 goats slaughtered at the abattoir. The results showed that *Anaplasma ovis* is the most prevalent haemoparasite in goat with relatively very low prevalence of *Babesia ovis*.

Alessandra and Santo (2012) conducted survey on small ruminants for anaplasmosis and piroplasmosis in, Italy and found the prevalence of *Theileria ovis* as 1.60% in goats.

Altay et al. (2012) reported the frequency of *Theileria* and *Babesia* by blood smear-based diagnostic methods in small ruminants. A total of 201 apparently healthy animals from 26 randomly selected herds located in 4 locations of East Black Sea Region of Turkey were investigated for the blood protozoans. *Theileria* piroplasms were identified in 4.47% blood samples by microscopic examination however, no *Babesia* was detected.

Biu et al. (2012) reported the prevalence of babesiosis in goats of Maiduguri between January and November 2002 in Nigeria. A total of 130 blood samples were collected form goats, stained with Giemsa stain and examined under microscope. The results showed that the prevalence of *Babesia ovis* was 4.60%. The prevalence among 77 males and 53 females was reported as 3.90% and 5.70% respectively. The prevalence related to age was 2.20% and 5.90% in ≤6 months and >6 months old goats respectively.

Durrani et al. (2012) reported the presence of *Theileria ovis* in goats from 5 sampling sites in Punjab and Khyber Pukhtoon Khwa provinces, in Pakistan, from randomly selected herds. A total 111 blood samples from goats was collected. They found prevalence of *T. ovis* in goats was 1.00% by blood smear examination.
Esmaeilnejad et al. (2012) studied on Babesia ovis infection in goats of Iran. A total 402 blood samples were collected from sheep and goats. The result showed that total 67 animals were positive for B. ovis. Among 67 positive samples 52 sheep and 15 goats were found to be positive for B. ovis.

Naz et al. (2012) determined the prevalence of theileriosis in goat of Lahore, Pakistan on the basis of microscopic examination. The prevalence of Theileria was found to be 8.20% goats. The prevalence among males and females were 7.88% and 8.79% respectively.

Rodriguez et al. (2012) conducted a cross sectional study on prevalence of Trypanosoma evansi infection in domestic ruminants in an endemic area of the Canary Islands (Spain). A total 1228 blood samples collected from ruminants. Total 5.00% ruminants were serologically positive (7 cattle, 21 goats, 33 sheep) but T. evansi could be demonstrated in none of them.

Aydin et al. (2013) collected a total of 259 blood sample from goats by active surveillance in Black Sea region of Turkey in different provinces of various cities in the region in years 2010 and 2011. Blood smears were prepared, stained with Giemsa stain and examined under the light microscope in which a total 4 out of 259 goats were found to be positive for Theileria piroplasms. The Infection rate for T. ovis was 10.04 % and for B. ovis was 0.44 % in goats.

Ijaz et al. (2013) studied the prevalence of babesiosis in goat in Lahore and its peri-urban areas. A total of 377 blood samples from goats were collected and examined microscopically. Apart from them Babesia infection was found in 13.53% goats.

Iqbal et al. (2013) reported the prevalence of haemoproteozoan in goats and sheep to be 16.00%. Their study revealed that infected animals comprised of 19.00% goats and 81.00% sheep.

Mohammed and Idoko (2013) examined the goats in Nigeria and reported that 24.70% of the goats samples were positive for haemoproteozoan.
The study revealed the prevalence of *T. ovis* and *B. ovis* to be 3.00% and 1.00% respectively.

### 2.2 Haemato-biochemical alterations

Akinboade *et al.* (1984) reported increase in serum alkaline phosphatase in splenectomized 4 white Fulani calves experimentally infected with *Babesia bigemina*.

Yeruham *et al.* (1998a) estimated the biochemical alteration in experimentally infected sheep with *Babesia ovis* and found a decrease in serum alkaline phosphatase.

Bhikane *et al.* (2005) found *Babesia* infection in a 5-year-old Osmanabadi goat in Udgir. The haematological examination revealed low Hb and PCV values.

Lako *et al.* (2007) studied the effect of *Babesia* organism on haematological parameters of ruminants in three regions of West Cameroon and found that *Babesia* infection did not significantly affect PCV and blood cell counts.

Ibrahim *et al.* (2009) estimated the alteration in biochemical parameters in cattle infected with *Babesia* in Egypt. The study revealed that a significant increase in the activity of serum ALP activity in *Babesia* infected cattle.

Rani *et al.* (2010) estimated hyperglycaemia in four graded Murrah she buffaloes aged between 6-8 years infected with *Babesia* organism.

Sulaiman *et al.* (2010) studied on haemato-biochemical alteration in *Babesia* infected goats in Mosul. The results showed that a statistically significant decrease was recorded in RBC, Hb and PCV and significant increase in TLC was recorded due to significant increase in lymphocyte and neutrophile count. Results of the biochemical tests indicated an increase in activity of AST, ALT, BIT and BUN with a significant decrease in total serum protein.
Vidhya et al. (2011) estimated the haemato-biochemical parameters of a adult buck infested with Babesia ovis at Veterinary College Hospital, Bidar. The haematological and biochemical findings revealed Hb, PCV, glucose, TP, ALT and AST 8.80 g/100ml, 32.00%, 61.00 mg/dl, 3.30 g/dl, 49 U/L and 35 U/L respectively.

Zangana and Naqid (2011) estimated the effect of Babesia motasi on haematological parameters of goats in Duhok area of Iraq. The results showed that decrease in mean values of TEC, PCV and Hb concentration.

Biu et al. (2012) estimated haematological parameters of goats affected with Babesia ovis in Maiduguri between January and November 2002 and found anaemia due to low PCV.

Esmaeilnejad et al. (2012) carried a haematological study in goat affected with Babesia ovis in Iran. They reported that increase in parasitemia rates was associated with B. ovis, significant decrease in Hb, PCV and RBCs while TLC, number of lymphocyte, monocyte, neutrophil, eosinophil, BUN and CRE showed a significant increase.

Mohammed and Idoko (2013) estimated the haematological parameters in goats affected with Babesia in Nigeria. Estimation revealed that non-significant changes occurred in mean PCV, Hb concentration, TP and TLC counts in the goats infected with any of the haemoparasites than those of goats negative for any haemoparasites.

Zulfiqar et al. (2012) estimated the effect of Babesia bovis blood glucose level which is measured by ACCU-CHEK® Active blood glucose meter. The result showed a decrease in blood glucose concentration.

Ijaz et al. (2013) studied the haematological changes in babesiosis in goat in Lahore and its peri-urban areas. Hb, PCV and erythrocytes were found to be significantly decreased while, there was no effect on other blood parameters.

2.3 Treatment

Taylor et al. (1986) observed the inhibitory effects of continuous administration of oxytetracycline (@ 20 mg/kg b.wt., every 4 days intervals) in
the development of parasitemia of *Babesia divergens* in cattle during natural and experimental infections. The result showed no parasite was present in treated animals.

Dolan (1988) reported that buparvaquone @ 2.5 mg/kg as single dose has spectrum of activity against *B. ovis* infection.

Dolan (1991) studied growth inhibitory activity of buparvaquone in vitro cell culture of *B. divergens* and also reported its activity against babesiosis in both gerbils and cattle.

Bhikane *et al.* (2005) found *Babesia motasi* infection in blood smear of a 5 year old Osmanabadi goat in Udgir. The case was treated with a single dose of diminazene aceturate (@ 2 ml, I/M). Supportive treatment included 5% dextrose (250 ml, I/V), multivitamins and oral haematinics. The animal recovered in 24 hours with restoration of other clinical parameters after 3 days of treatment.

Vidhya *et al.* (2011) treated a case of *Babesia ovis* in an adult buck at Veterinary College Hospital, Bidar with diminazene aceturate @ 2.5 mg/kg b.wt., I/M single dose with supportive therapy.

Ijaz *et al.* (2013) estimated the efficacy of various drugs in goat against babesiosis in Lahore and its peri-urban areas. The result showed that the efficacy of imidocarb dipropionate along with oxytetracycline, imidocarb dipropionate alone, diminazene aceturate along with oxytetracycline and diminazene aceturate alone in goats was 100%, 80%, 90% and 70% against *Babesia* respectively.
3. MATERIAL AND METHODS

3.1 Location and place of work

Proposed work was conducted in the Department of Veterinary Medicine, College of Veterinary Science & Animal Husbandry, Nanaji Deshmukh Veterinary Science University (NDVSU), Jabalpur (M.P.).

3.2 Technical programme of work

3.2.1 Animals

The study was conducted in the goats at Amanala goat unit, Livestock farm, Adhartal, Jabalpur, goats brought to the Teaching Veterinary Clinical Complex (TVCC), Government Veterinary Hospital, Omti (Jabalpur), private clinics and area in and around Jabalpur city.

The goats showing signs of haemoprotozoan infection were included in the study. After confirmation of haemoprotozoan infection by examination of Romanowsky-type (Leishman’s stain) stained blood smear goats were selected for the study (Benjamin, 2001).

3.2.2 Clinical study

(i) Anamnesis and signalment –

Apart from clinical signs exhibited age, breed and sex of the goat were also recorded.

(ii) Clinical examination –

All the goats were examined clinically for the rectal temperature, pulse rate, respiration rate, colour of mucous membranes and any other abnormality noticed.

3.2.3 Study of haemato-biochemical alterations in caprine babesiosis

Collection of samples –

Five ml blood was collected aseptically with anticoagulant for haematological and biochemical tests on day ‘0’ (pre-treatment) and day 15 and 30 (post-treatment).
Haematological studies –

Haematological parameters viz total erythrocyte count (TEC, millions/µl), haemoglobin concentration (Hb, g/dl), packed cell volume (PCV, %) and differential leukocyte count (%) were evaluated following standard procedures (Benjamin, 2001).

Biochemical studies –

The following biochemical parameters were estimated by analysis of plasma on Blood Chemistry Semi Auto Analyzer (CHEM-5 PLUS).

(i) Alanine amino transferase (ALT)

ALT was analysed by the Erba Diagnostic kit using International federation of Clinical Chemistry Kinetic Method and activity was expressed as U/L.

(ii) Aspartate amino transferase (AST)

AST was analysed by the Erba Diagnostic kit using International federation of Clinical Chemistry Kinetic Method and activity was expressed as U/L.

(iii) Alkaline phosphatase (ALP)

ALP was analysed by Erba Diagnostic kit using Tris Carbonate Buffer Kinetic Method and activity was expressed as U/L.

(iv) Blood urea nitrogen (BUN)

BUN was analysed by Erba Diagnostic kit using GLDH-Urease method and values were expressed as mg/dl.

(v) Creatinine (CRE)

Creatinine was analysed by Erba Diagnostic kit using Modified Jaffe’s reaction and values were expressed as mg/dl.

(vi) Total bilirubin (BIT)

BIT was analysed by Erba Diagnostic kit using Diazoo method and values were expressed in terms of mg/dl.
(vii) **Total plasma protein (TPP)**

TPP was analysed by Erba Diagnostic kit using Biuret method and values were expressed in terms of g/dl.

(viii) **Blood glucose**

Blood glucose estimation was done with the help of glucometer (Chauhan, 2003) immediately after collection of blood sample and values were expressed in terms of mg/dl.

### 3.2.4 Experimental design

A total of eighteen goats, positive for babesiosis were placed into three groups of 6 animals each. Six apparently healthy goats were also include as control group. The animals were treated with following drugs:

**Table 1. Drugs and dosage in various groups**

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of animals</th>
<th>Drugs and dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (Healthy)</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>( T_1 )</td>
<td>6</td>
<td>Oxytetracycline LA @ 20 mg/kg b.wt, I/M, 2 doses at 96 hrs. intervals (Sandhu and Rampal, 2006)</td>
</tr>
<tr>
<td>( T_2 )</td>
<td>6</td>
<td>Diminazene aceturate @ 3.5 mg/kg b.wt., I/M, 2 doses at 24 hrs. intervals (Radostitis et al. 2009)</td>
</tr>
<tr>
<td>( T_3 )</td>
<td>6</td>
<td>Buparvaquone @ 2.5 mg/kg b.wt., I/M, 2 doses at 96 hrs. intervals (Dolan, 1988)</td>
</tr>
</tbody>
</table>

Supportive therapy with antipyretic drugs (Inj. Paracetamol @10 mg/kg b.wt., I/M, SOS), haematinics (Bolus Feritas \( \frac{1}{2} \) bolus, OD, PO for 15 days), hepato protective drug (Inj. Belamy 0.5-2 ml, I/M) along with fluid therapy (Inj. D\(_5\) or Inj. DNS 5% or Inj. NS, I/V) was given to all the animals under study.
3.3 Statistical analysis

Comparison of the haemato-biochemical parameters of diseased goats with healthy goats was done by analysing the data statistically for mean and standard error and compared using student’s $t$-test. The data of haemato-biochemical parameters at different treatment intervals among different groups were analysed using factorial design and means were compared by Duncan’s multiple range test (Snedecor and Cochran, 1994).
4. RESULTS

Present study was conducted on 800 goats of different age, breed and sex obtained from Amanala goat unit and Livestock farm, Adhartal, goats brought to TVCC, Government Veterinary Hospital, Omti, private clinics and area in and around Jabalpur city.

4.1 Prevalence of caprine haemoproteozoan infection in and around Jabalpur city

The overall prevalence of caprine haemoproteozoan infection during August 2012 to may 2013 was 3.90% (31 out of 800 goats). The prevalence of Babesia and Theileria were 3.50% (28 out of 800 goats) and 0.40% (3 out of 800 goats) respectively (Table 2).

Table 2. Prevalence of caprine haemoproteozoan infection in and around Jabalpur city

<table>
<thead>
<tr>
<th>Total No.</th>
<th>Haemoproteozoan infection</th>
<th>Babesia</th>
<th>Theileria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of positive cases</td>
<td>Prevalence (%)</td>
<td>No. of positive cases</td>
</tr>
<tr>
<td>800</td>
<td>31</td>
<td>3.90</td>
<td>28</td>
</tr>
</tbody>
</table>

4.1.1 Age wise prevalence of caprine haemoproteozoan infection

Among caprine haemoproteozoan infection the overall age wise prevalence was 1.71% (3 out of 175 goats) in age group <1 year, 3.55% (8 out of 225 goats) in age group 1-3 years, 4.21% (8 out of 190 goats) in age group 3 to 5 years of age and 5.71% (12 out of 210 goats) in age group >5 years of age. Age wise prevalence study in goats affected with Babesia showed 1.71% (3 out of 175 goats), 2.22% (5 out of 225 goats), 4.21% (8 out of 190 goats) and 5.71% (12 out of 210 goats) prevalence in age groups <1 year of age, 1-3 years of age, 3-5 years of age and >5 years of age respectively. The goats affected with Theileria were between 1 to 3 years of age thus the prevalence of Theileria in age group 1-3 years of age was 1.33% i.e. 3 out of 225 goats (Table 3).
Table 3. Age wise prevalence of caprine haemoprotozoan infection

<table>
<thead>
<tr>
<th>Age Group (Year)</th>
<th>No. of animals examined</th>
<th>Haemoprotozoan infection</th>
<th>Babesia</th>
<th>Theileria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No. of positive cases</td>
<td>Prevalence (%)</td>
<td>No. of positive cases</td>
</tr>
<tr>
<td>&lt; 1</td>
<td>175</td>
<td>03</td>
<td>1.71</td>
<td>03</td>
</tr>
<tr>
<td>1-3</td>
<td>225</td>
<td>08</td>
<td>3.55</td>
<td>05</td>
</tr>
<tr>
<td>3-5</td>
<td>190</td>
<td>08</td>
<td>4.21</td>
<td>08</td>
</tr>
<tr>
<td>&gt;5</td>
<td>210</td>
<td>12</td>
<td>5.71</td>
<td>12</td>
</tr>
</tbody>
</table>

4.1.2 Sex wise prevalence of caprine haemoprotozoan infection

Among 800 goats examined the sex wise prevalence of caprine haemoprotozoan infection in males and females was 3.37% (15 out of 445 goats) and 4.51% (16 out of 355 goats) respectively. The present study revealed prevalence of Babesia in males and females goats were i.e. 2.92% (13 out of 445 goats) and 4.23% (15 out of 355 goats) respectively. The prevalence of Theileria in males and females was 0.45% (2 out of 445 goats) and 0.28% (1 out of 355 goats) respectively (Table 4).

Table 4. Sex wise prevalence of caprine haemoprotozoan infection

<table>
<thead>
<tr>
<th>Sex</th>
<th>Total No.</th>
<th>Haemoprotozoan infection</th>
<th>Babesia</th>
<th>Theileria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No. of positive cases</td>
<td>Prevalence (%)</td>
<td>No. of positive cases</td>
</tr>
<tr>
<td>Male</td>
<td>445</td>
<td>15</td>
<td>3.37</td>
<td>13</td>
</tr>
<tr>
<td>Female</td>
<td>355</td>
<td>16</td>
<td>4.51</td>
<td>15</td>
</tr>
</tbody>
</table>

4.1.3 Breed wise prevalence of caprine haemoprotozoan infection

Breed wise prevalence of caprine haemoprotozoan infection was higher in well defined breeds (Sirohi, Barbari and Jamunapari) i.e. 5.34% (27 out of 505 goats) followed by non-descript goats i.e. 1.36% (4 out of 295 goats). Prevalence of Babesia was higher in well defined breeds (Sirohi, Barbari and Jamunapari) i.e. 4.75% (24 out of 505 goats) as compared to
non-descript goats *i.e.* 1.36% (4 out of 295 goats). The prevalence of *Theileria* was 0.59% (3 out of 505 goats) in well defined breeds viz. Sirohi, Barbari and Jamunapari (Table 5).

**Table 5. Breed wise prevalence of caprine haemoprotozoan infection**

<table>
<thead>
<tr>
<th>Breed</th>
<th>Total No.</th>
<th>Haemoprotozoan infection</th>
<th>Babesia</th>
<th>Theileria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No. of positive cases</td>
<td>Prevalence (%)</td>
<td>No. of positive cases</td>
</tr>
<tr>
<td>Well defined</td>
<td>505</td>
<td>27</td>
<td>5.34</td>
<td>24</td>
</tr>
<tr>
<td>(Sirohi, Barbari, Jamunapari)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non descript</td>
<td>295</td>
<td>04</td>
<td>1.36</td>
<td>04</td>
</tr>
</tbody>
</table>

4.2 **Clinical signs of goats affected with *Babesia***

Clinical signs in goats affected with *Babesia* were pale mucous membranes (85.70%), loss of appetite (75.00%), nasal discharge (35.70%) and coughing (32.10%), followed by diarrhoea (60.10%), emaciation (53.40%) and haemoglobinuria (7.10%) along with presence of ticks on body in 82.10% goats. (Table 6)

**Table 6. Clinical signs of goats affected with *Babesia* (n=28)**

<table>
<thead>
<tr>
<th>Clinical signs</th>
<th>No. of affected goats</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pale mucous membranes</td>
<td>24</td>
<td>85.70</td>
</tr>
<tr>
<td>Loss of appetite</td>
<td>21</td>
<td>75.00</td>
</tr>
<tr>
<td>Nasal discharge</td>
<td>10</td>
<td>35.70</td>
</tr>
<tr>
<td>Coughing</td>
<td>09</td>
<td>32.10</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>17</td>
<td>60.10</td>
</tr>
<tr>
<td>Emaciation</td>
<td>15</td>
<td>53.40</td>
</tr>
<tr>
<td>Haemoglobinuria</td>
<td>02</td>
<td>07.10</td>
</tr>
<tr>
<td>Presence of ticks</td>
<td>23</td>
<td>82.10</td>
</tr>
</tbody>
</table>
4.2.1 Clinical parameters of goats affected with *Babesia* in comparison with the healthy goats on day 0 pre treatment (n=28)

Among various clinical parameters temperature, pulse rate and respiration rate increased significantly \((p \leq 0.01)\) than healthy goats on day 0 pre treatment (Table 7).

**Table 7. Clinical parameters (Mean±SE) of goats affected with *Babesia* on day 0 pre treatment in comparison with healthy goats (n=28)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Healthy goats</th>
<th>Affected goats</th>
<th>(t) values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (^\circ)F</td>
<td>102.98±0.07</td>
<td>105.65±0.23</td>
<td>11.11**</td>
</tr>
<tr>
<td>Pulse rate (/min)</td>
<td>077.00±0.58</td>
<td>108.33±1.41</td>
<td>20.55**</td>
</tr>
<tr>
<td>Respiration rate (/min)</td>
<td>025.00±0.37</td>
<td>049.67±0.88</td>
<td>25.84**</td>
</tr>
</tbody>
</table>

**\(p\leq0.01\)**

4.2 Haematological alterations in goats affected with *Babesia* in comparison with the healthy goats on day 0 pre treatment (n=18)

Among the various haematological parameters TEC (millions/\(\mu\)l), Hb concentration (g/dl), PCV (%) and neutrophil (%) were significantly decreased \((p \leq 0.01)\) while, TLC (thousands/\(\mu\)l) and lymphocyte (%) increased significantly \((p \leq 0.01)\) on day 0 pre treatment than healthy goats. However, non-significant changes occurred in monocyte (%) and eosinophil (%) on day 0 pre treatment between healthy and affected goats (Table 8).
Table 8. Haematological alterations (Mean±SE) in goats affected with *Babesia* on day 0 pre treatment in comparison with the healthy goats (n=18)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Healthy goats</th>
<th>Affected goats</th>
<th>t values</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEC (millions/µl)</td>
<td>11.85±0.28</td>
<td>06.52±0.22</td>
<td>14.97**</td>
</tr>
<tr>
<td>Hb (g/dl)</td>
<td>09.33±0.76</td>
<td>05.50±0.43</td>
<td>04.37**</td>
</tr>
<tr>
<td>PCV (%)</td>
<td>30.17±0.48</td>
<td>25.00±0.58</td>
<td>06.87**</td>
</tr>
<tr>
<td>TLC (thousands/µl)</td>
<td>09.20±0.40</td>
<td>13.25±0.43</td>
<td>06.90**</td>
</tr>
<tr>
<td>Neutrophil (%)</td>
<td>36.33±0.50</td>
<td>31.50±0.72</td>
<td>05.51**</td>
</tr>
<tr>
<td>Lymphocyte (%)</td>
<td>60.50±0.67</td>
<td>65.50±0.50</td>
<td>05.98**</td>
</tr>
<tr>
<td>Monocyte (%)</td>
<td>01.84±0.31</td>
<td>01.50±0.22</td>
<td>00.87</td>
</tr>
<tr>
<td>Eosinophil (%)</td>
<td>01.33±0.21</td>
<td>01.50±0.22</td>
<td>00.56</td>
</tr>
</tbody>
</table>

** p≤0.01

4.4 Biochemical alterations in goats affected with *Babesia* in comparison with the healthy goats on day 0 pre treatment (n=18)

The results of biochemical parameters showed that a statistically significant increase (p≤0.01) in ALT (U/L), AST (U/L), ALP (U/L), BUN (mg/dl), CRE (mg/dl) and BIT (mg/dl), while significant decrease was noticed in TPP (g/dl) and blood glucose (mg/dl) in affected goats as compared with healthy goats on day 0 pre treatment (Table 9).

Table 9. Biochemical alterations (Mean±SE) in goats affected with *Babesia* on day 0 pre treatment in comparison with the healthy goats (n=18)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Healthy goats</th>
<th>Affected goats</th>
<th>t values</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALT (U/L)</td>
<td>030.77±0.56</td>
<td>061.35±0.37</td>
<td>45.57**</td>
</tr>
<tr>
<td>AST (U/L)</td>
<td>154.17±2.39</td>
<td>311.00±0.93</td>
<td>61.15**</td>
</tr>
<tr>
<td>ALP (U/L)</td>
<td>148.83±1.08</td>
<td>210.67±1.96</td>
<td>27.63**</td>
</tr>
<tr>
<td>BUN (mg/dl)</td>
<td>013.17±0.17</td>
<td>023.17±0.31</td>
<td>28.28**</td>
</tr>
<tr>
<td>CRE (mg/dl)</td>
<td>001.12±0.02</td>
<td>002.45±0.04</td>
<td>29.74**</td>
</tr>
<tr>
<td>BIT (mg/dl)</td>
<td>000.16±0.12</td>
<td>002.93±0.08</td>
<td>19.21**</td>
</tr>
<tr>
<td>TPP (g/dl)</td>
<td>006.77±0.03</td>
<td>004.67±0.05</td>
<td>36.01**</td>
</tr>
<tr>
<td>Blood glucose (mg/dl)</td>
<td>053.83±0.40</td>
<td>033.17±0.79</td>
<td>23.33**</td>
</tr>
</tbody>
</table>

** p≤0.01
4.5 Comparison of haematological alterations during different intervals

4.5.1 Total erythrocyte count (millions/µl)

In the control group, the TEC values on day 0, 15 and 30 were 11.77±0.15, 11.68±0.14 and 11.85±0.28 millions/µl respectively, which differed non-significantly between various intervals.

In all the three treatment groups i.e. T₁, T₂ and T₃, the values of TEC on day 0 were 6.58±0.17, 6.67±0.13 and 6.52±0.22 millions/µl, respectively which were significantly lower (p≤0.05) than control group.

In the treatment groups T₁ and T₂, the values of TEC on day 15 (i.e. 8.63±0.19 and 8.90±0.23 millions/µl respectively) and day 30 (i.e. 11.60±0.24 and 11.90±0.20 millions/µl respectively) post treatment increased significantly (p≤0.05) as compared to day 0 of the same group. On day 30 post treatment the values of TEC in the both the groups increased to normal range which differed non-significantly with the control group.

In group T₃ the TEC value (i.e. 6.90±0.07 millions/µl) on day 15 showed no significant difference from day 0 of the same group; however, significant increase (i.e. 8.60±0.12 millions/µl) was observed on day 30 post treatment, but it was significantly lower than the control group (Table 10).

Table 10. Total erythrocyte count (millions/µl) at different intervals in different groups (Mean±SE)

<table>
<thead>
<tr>
<th>Day</th>
<th>Group</th>
<th>Control (Healthy)</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>11.77±0.15</td>
<td>06.58±0.17</td>
<td>06.67±0.13</td>
<td>06.52±0.22</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>11.68±0.14</td>
<td>08.63±0.19</td>
<td>08.90±0.23</td>
<td>06.90±0.07</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>11.85±0.28</td>
<td>11.60±0.24</td>
<td>11.90±0.20</td>
<td>08.60±0.12</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly (p≤0.05)
4.5.2 Haemoglobin concentration (g/dl)

In the control group, the Hb concentration on day 0, 15 and 30 were $9.17\pm0.48$, $9.33\pm0.21$ and $9.33\pm0.76$ g/dl respectively, which differed non-significantly between various intervals.

In all the three treatment groups *i.e.* $T_1$, $T_2$ and $T_3$, the concentration of Hb on day 0 were $5.17\pm0.40$, $5.50\pm0.43$ and $5.50\pm0.43$ g/dl respectively, which were significantly lower ($p\leq0.05$) than control group.

In treatment groups $T_1$ and $T_2$ the concentration of Hb on day 15 (*i.e.* $7.17\pm0.40$ and $7.50\pm0.43$ g/dl respectively) and day 30 (*i.e.* $9.67\pm0.42$ and $9.83\pm0.31$ g/dl respectively) post treatment increased significantly ($p\leq0.05$) as compared to day 0 of the same group. On day 30 post treatment the concentration of Hb in the both the groups increased to normal range which differed non-significantly with the control group.

In group $T_3$ the Hb on day 15 (*i.e.* $5.83\pm0.40$ g/dl) showed no significant difference from day 0 of the same group; however, significant increase in the value of Hb (*i.e.* $7.67\pm0.21$ g/dl) was observed on day 30, but it was significantly lower than the control group (Table 11).

**Table 11. Haemoglobin concentration (g/dl) at different intervals in different groups (Mean±SE)**

<table>
<thead>
<tr>
<th>Day</th>
<th>Group</th>
<th>Control (Healthy)</th>
<th>$T_1$</th>
<th>$T_2$</th>
<th>$T_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>$9.17^a\pm0.48$</td>
<td>$5.17^c\pm0.40$</td>
<td>$5.50^c\pm0.43$</td>
<td>$5.50^c\pm0.43$</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>$9.33^a\pm0.21$</td>
<td>$7.17^b\pm0.40$</td>
<td>$7.50^b\pm0.43$</td>
<td>$5.83^c\pm0.40$</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>$9.33^a\pm0.76$</td>
<td>$9.67^a\pm0.42$</td>
<td>$9.83^a\pm0.31$</td>
<td>$7.67^b\pm0.21$</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly ($p\leq0.05$)

4.5.3 Packed cell volume (%)

In the control group, the PCV values on day 0, 15 and 30 were $30.17\pm0.40$, $30.33\pm0.56$ and $30.17\pm0.48\%$ respectively, which differed non-significantly between various intervals.
In all the treatment groups i.e. T₁, T₂ and T₃, the values of PCV on day 0 were 25.33±0.92, 25.17±1.01 and 25.00±0.58% respectively, which were significantly lower (p≤0.05) than control group.

In the treatment groups T₁ and T₂ the values of PCV on day 15 (i.e. 28.17±1.05 and 28.00±0.77% respectively) and day 30 (i.e. 30.33±0.42 and 30.17±0.65% respectively) increased significantly (p≤0.05) as compared to day 0 of the same group. On day 30 post treatment the values of PCV in the both the groups increased to normal range and differed non-significantly with the control group.

In group T₃ the PCV on day 15 (i.e. 28.33±0.88%) showed no significant difference from day 0 of the same group; however, significant increase in PCV (i.e. 28.50±0.43%) was observed on day 30 post treatment, but it was significantly lower than the control group (Table 12).

**Table 12. Packed cell volume (%) at different intervals indifferent groups (Mean±SE)**

<table>
<thead>
<tr>
<th>Group Day</th>
<th>Control (Healthy)</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>30.17ᵃ±0.40</td>
<td>25.33ᶜ±0.92</td>
<td>25.17ᶜ±1.01</td>
<td>25.00ᶜ±0.58</td>
</tr>
<tr>
<td>15</td>
<td>30.33ᵃ±0.56</td>
<td>28.17ᵇ±1.05</td>
<td>28.00ᵇ±0.77</td>
<td>28.33ᶜ±0.88</td>
</tr>
<tr>
<td>30</td>
<td>30.17ᵃ±0.48</td>
<td>30.33ᵃ±0.42</td>
<td>30.17ᵃ±0.65</td>
<td>28.50ᵇ±0.43</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly (p≤0.05)

**4.5.4 Total leukocyte count (TLC) (thousands/µl)**

In the control group, the TLC values on day 0, 15 and 30 were 9.23 ±0.45, 9.22±0.45 and 9.22±0.40 thousands/µl respectively, which differed non-significantly between various intervals.

In all the three treatment groups i.e. T₁, T₂ and T₃, the values of TLC on day 0 were 12.75±0.17, 12.75±0.14 and 13.25±0.43 thousands/µl respectively, which were significantly higher (p≤0.05) than control group.
In all the three treatment groups i.e. $T_1$, $T_2$ and $T_3$ the values of TLC on day 15 (i.e. 11.47±0.16, 11.28±0.23 and 11.53±0.24 thousands/$\mu$l respectively) and day 30 (i.e. 9.22±0.39, 9.18±0.38 and 9.07±0.43 thousands/$\mu$l respectively) decreased significantly ($p\leq0.05$) as compared to day 0 of the same group.

On day 30 post treatment the values of TLC in all the treatment groups i.e. $T_1$, $T_2$ and $T_3$ decreased to normal range which differed non-significantly with the control group (Table 13).

**Table 13. Total leukocyte count (thousands/$\mu$l) at different intervals in different groups (Mean±SE)**

<table>
<thead>
<tr>
<th>Group Day</th>
<th>Control (Healthy)</th>
<th>$T_1$</th>
<th>$T_2$</th>
<th>$T_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>09.23$^c$±0.45</td>
<td>12.75$^a$±0.17</td>
<td>12.75$^a$±0.14</td>
<td>13.25$^a$±0.43</td>
</tr>
<tr>
<td>15</td>
<td>09.22$^c$±0.45</td>
<td>11.47$^b$±0.16</td>
<td>11.28$^b$±0.23</td>
<td>11.53$^b$±0.24</td>
</tr>
<tr>
<td>30</td>
<td>09.22$^c$±0.40</td>
<td>09.22$^c$±0.39</td>
<td>09.18$^c$±0.38</td>
<td>09.07$^c$±0.43</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly ($p\leq0.05$)

**4.5.5 Neutrophil (%)**

In the control group, the neutrophil values on day 0, 15 and 30 were 36.17±0.40, 36.17±0.48 and 36.33±0.50% respectively, which differed non-significantly between various intervals.

In all the treatment groups i.e. $T_1$, $T_2$ and $T_3$, the values of neutrophil on day 0 were 32.50±1.46, 32.00±0.86 and 31.50±0.72% respectively, which were significantly lower ($p\leq0.05$) than control group.

In all the three treatment groups i.e. $T_1$, $T_2$ and $T_3$ the values of neutrophil on day 15 (i.e. 35.00±0.97, 34.67±0.72 and 35.00±0.45% respectively) and day 30 (i.e. 36.17±0.60, 36.50±0.62 and 36.83±0.48% respectively) increased significantly ($p\leq0.05$) as compared to day 0 of the same group.
On day 30 post treatment the values of neutrophil in all the treatment groups i.e. T₁, T₂ and T₃ increased to normal range which differed non-significantly with the control group (Table 14).

Table 14. Neutrophil (%) at different intervals in different groups (Mean±SE)

<table>
<thead>
<tr>
<th>Day</th>
<th>Group</th>
<th>Control (Healthy)</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>36.17±0.40</td>
<td>32.50c±1.46</td>
<td>32.00c±0.86</td>
<td>31.50c±0.72</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>36.17±0.48</td>
<td>35.00b±0.97</td>
<td>34.67b±0.72</td>
<td>35.00b±0.45</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>36.33±0.50</td>
<td>36.17a±0.60</td>
<td>36.50a±0.62</td>
<td>36.83a±0.48</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly (p≤0.05)

4.5.6 Lymphocyte (%)

In the control group, the lymphocyte values on day 0, 15 and 30 were 60.50±0.67, 60.67±0.72 and 60.50±0.67% respectively, which differed non-significantly between various intervals.

In all the treatment groups i.e. T₁, T₂ and T₃, the values of lymphocyte on day 0 were 64.33±1.20, 64.67±0.42 and 65.50±0.50% respectively, which were significantly higher (p≤0.05) than control group.

In all the three treatment groups i.e. T₁, T₂ and T₃ the values of neutrophil on day 15 (i.e. 62.00±1.32, 62.33±0.61% and 62.17±0.31% respectively) and day 30 (i.e. 60.83±0.48, 60.50±0.62 and 60.33±0.42% respectively) decreased significantly (p≤0.05) as compared to day 0 of the same group.

On day 30 post treatment the values of lymphocyte in all the treatment groups i.e. T₁, T₂ and T₃ decreased to normal range which differed non-significantly with the control group (Table 15).
Table 15. Lymphocyte (%) at different intervals in different groups (Mean±SE)

<table>
<thead>
<tr>
<th>Group (Day)</th>
<th>Control (Healthy)</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>60.50±0.67</td>
<td>64.33±1.20</td>
<td>64.67±0.42</td>
<td>65.50±0.50</td>
</tr>
<tr>
<td>15</td>
<td>60.67±0.72</td>
<td>62.00±1.32</td>
<td>62.33±0.61</td>
<td>62.17±0.31</td>
</tr>
<tr>
<td>30</td>
<td>60.50±0.67</td>
<td>60.83±0.48</td>
<td>60.50±0.62</td>
<td>60.33±0.42</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly (p≤0.05)

4.5.7 Monocyte (%)

The values of monocyte in all the three treatment groups i.e. T1, T2 and T3 did not differ significantly (p≤0.05) between various intervals however, they were within the normal range as they did not differ significantly to control group (Table 16).

Table 16. Monocyte (%) at different intervals in different groups (Mean±SE)

<table>
<thead>
<tr>
<th>Group (Day)</th>
<th>Control (Healthy)</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.67±0.21</td>
<td>1.50±0.22</td>
<td>1.50±0.22</td>
<td>1.50±0.22</td>
</tr>
<tr>
<td>15</td>
<td>1.67±0.21</td>
<td>1.83±0.31</td>
<td>1.67±0.21</td>
<td>1.67±0.21</td>
</tr>
<tr>
<td>30</td>
<td>1.83±0.31</td>
<td>1.67±0.21</td>
<td>1.83±0.31</td>
<td>1.50±0.22</td>
</tr>
</tbody>
</table>

4.5.8 Eosinophil (%)

The values of eosinophil in all the three treatment groups i.e. T1, T2 and T3 did not differ significantly (p≤0.05) between various intervals however, they were within the normal range as they did not differ significantly to control group (Table 17).
Table 17. Eosinophil (%) at different intervals in different groups (Mean±SE)

<table>
<thead>
<tr>
<th>Day</th>
<th>Group</th>
<th>Control (Healthy)</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>1.50±0.22</td>
<td>1.67±0.33</td>
<td>1.83±0.54</td>
<td>1.50±0.22</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>1.50±0.22</td>
<td>1.67±0.17</td>
<td>1.33±0.21</td>
<td>1.17±0.17</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>1.33±0.21</td>
<td>1.33±0.21</td>
<td>1.33±0.21</td>
<td>1.33±0.21</td>
</tr>
</tbody>
</table>

4.6 Comparison of biochemical alterations during different intervals

4.6.1 Alanine amino transferase (U/L)

In the control group, the ALT values on day 0, 15 and 30 were 30.57±0.64, 30.58 ±0.63 and 30.77±0.56 U/L respectively, which differed non-significantly between various intervals.

In all the treatment groups i.e. T₁, T₂ and T₃, the values of ALT on day 0 were 60.72±0.53, 60.93±0.39 and 61.35±0.37 U/L respectively, which were significantly higher (p≤0.05) than control group.

In the treatment groups T₁ and T₂ the values of ALT on day 15 (i.e. 39.02±0.64 and 39.95±0.49 U/L respectively) and day 30 (i.e. 30.62±0.35 U/L and 30.68±0.35 U/L respectively) decreased significantly (p≤0.05) as compared to day 0 of the same group. On day 30 post treatment the values of ALT in both the groups decreased to normal range which differed non-significantly with the control group.

In group T₃ the ALT value (i.e. 58.35±0.22 U/L) on day 15 showed no significant difference from day 0 of the same group; however, significant decrease in the value of ALT (i.e. 39.80±3.30 U/L) was observed on day 30 post treatment, but it was significantly higher than the control group (Table 18).
Table 18. Alanine amino transferase (U/L) at different intervals in different groups (Mean±SE)

<table>
<thead>
<tr>
<th>Group</th>
<th>Control (Healthy)</th>
<th>T&lt;sub&gt;1&lt;/sub&gt;</th>
<th>T&lt;sub&gt;2&lt;/sub&gt;</th>
<th>T&lt;sub&gt;3&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>30.57±0.64</td>
<td>60.72±0.53</td>
<td>60.93±0.39</td>
<td>61.35±0.37</td>
</tr>
<tr>
<td>15</td>
<td>30.58±0.63</td>
<td>39.02±0.64</td>
<td>39.95±0.49</td>
<td>58.35±0.22</td>
</tr>
<tr>
<td>30</td>
<td>30.77±0.56</td>
<td>30.62±0.35</td>
<td>30.68±0.35</td>
<td>39.80±3.30</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly (p≤0.05)

4.6.2 Aspartate amino transferase (U/L)

In the control group, the AST values on day 0, 15 and 30 were 153.83±2.33, 154.33±2.43 and 154.17±2.39 U/L respectively, which differed non-significantly between various intervals.

In all the treatment groups i.e. T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, the values of AST on day 0 were 317.17±6.30, 314.67±5.51 and 311.00±0.93 U/L, respectively, which were significantly higher (p≤0.05) than control group.

In the treatment groups T<sub>1</sub> and T<sub>2</sub> the values of AST on day 15 (i.e. 189.67±2.51 and 188.00±1.77 U/L respectively) and day 30 (i.e. 150.83±1.82 and 153.17±2.36 U/L respectively) decreased significantly (p≤0.05) as compared to day 0 of the same group. On day 30 post treatment the values of AST in the both the groups decreased to normal range which differed non-significantly with the control group.

In group T<sub>3</sub> the AST value (i.e. 308.±1.40 U/L) on day 15 showed no significant difference from day 0 of the same group; however, significant decrease in the value of AST (i.e. 187.67±0.61 U/L) was observed on day 30 post treatment, but it was significantly higher than the control group (Table 19).
Table 19. Aspartate amino transferase (U/L) at different intervals in different groups (Mean±SE)

<table>
<thead>
<tr>
<th>Group</th>
<th>Control (Healthy)</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>153.83±2.33</td>
<td>317.17±6.30</td>
<td>314.67±5.51</td>
<td>311.00±0.93</td>
</tr>
<tr>
<td>15</td>
<td>154.33±2.43</td>
<td>189.67±2.51</td>
<td>188.00±1.77</td>
<td>308.17±1.40</td>
</tr>
<tr>
<td>30</td>
<td>154.17±2.39</td>
<td>150.83±1.82</td>
<td>153.17±2.36</td>
<td>187.67±0.61</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly (p≤0.05)

4.6.3 Alkaline phosphatase (U/L)

In the control group, the ALP values on day 0, 15 and 30 were 148.50±0.92, 148.67±0.99 and 148.83±1.08 U/L respectively, which differed non-significantly between various intervals.

In all the treatment groups i.e. T₁, T₂ and T₃, the values of ALP on day 0 were 209.17±0.60, 210.83±1.92 and 210.67±1.96 U/L, respectively, which were significantly higher (p≤0.05) than control group.

In the treatment groups T₁ and T₂ the values of ALP on day 15 (i.e. 205.17±1.55 and 206.17±1.67 U/L respectively) and day 30 (i.e. 149.33±0.72 and 150.17±0.87 U/L respectively) decreased significantly (p≤0.05) as compared to day 0 of the same group. On day 30 post treatment the values of ALP in the both the groups decreased to normal range which differed non-significantly with the control group.

In group T₃ the ALP value (i.e. 209.83±1.85 U/L) on day 15 showed no significant difference from day 0 of the same group; however, significant decrease in the value of ALP (i.e. 205.00±1.55 U/L) was observed on day 30 post treatment, but it was significantly higher than the control group (Table 20).
Table 20. Alkaline phosphatase (U/L) at different intervals in different groups (Mean±SE)

<table>
<thead>
<tr>
<th>Day</th>
<th>Control (Healthy)</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>148.50c±0.92</td>
<td>209.17a±0.60</td>
<td>210.83a±1.92</td>
<td>210.67a±1.96</td>
</tr>
<tr>
<td>15</td>
<td>148.67c±0.99</td>
<td>205.17b±1.55</td>
<td>206.17b±1.67</td>
<td>209.83a±1.85</td>
</tr>
<tr>
<td>30</td>
<td>148.83c±1.08</td>
<td>149.33c±0.72</td>
<td>150.17c±0.87</td>
<td>205.00b±1.55</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly (p≤0.05)

4.6.4 Blood urea nitrogen (mg/dl)

In the control group, the BUN values on day 0, 15 and 30 were 12.83±0.31, 12.67±0.33 and 13.17±0.17 mg/dl respectively, which differed non-significantly between various intervals.

In all the treatment groups i.e. T₁, T₂ and T₃, the values of BUN on day 0 were 23.17±0.79, 23.00±0.37 and 23.17±0.31 mg/dl respectively, which were significantly higher than control group.

In the treatment groups T₁ and T₂ the values of BUN on day 15 (i.e. 16.83±0.48 and 16.83±0.48 mg/dl respectively) and day 30 (i.e. 13.00±0.37 and 12.67±0.33 mg/dl respectively) decreased significantly (p≤0.05) as compared to day 0 of the same group. On day 30 post treatment the values of BUN in the both the groups decreased to normal range which differed non-significantly with the control group.

In group T₃ the BUN value (i.e. 23.17±0.70 mg/dl) on day 15 showed no significant difference from day 0 of the same group; however, significant decrease in the value of BUN (i.e. 16.33±0.50 mg/dl) was observed on day 30 post treatment, but it was significantly higher than the control group (Table 21).
Table 21. Blood urea nitrogen (mg/dl) at different intervals in different groups (Mean±SE)

<table>
<thead>
<tr>
<th>Day</th>
<th>Group (Healthy)</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12.83⁺⁻0.31</td>
<td>23.17⁺⁻0.79</td>
<td>23.00⁺⁻0.37</td>
<td>23.17⁺⁻0.31</td>
</tr>
<tr>
<td>15</td>
<td>12.67⁺⁻0.33</td>
<td>16.83⁺⁻0.48</td>
<td>16.83⁺⁻0.48</td>
<td>23.17⁺⁻0.70</td>
</tr>
<tr>
<td>30</td>
<td>13.17⁺⁻0.17</td>
<td>13.00⁺⁻0.37</td>
<td>12.67⁺⁻0.33</td>
<td>16.33⁺⁻0.50</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly (p≤0.05)

4.6.5 Creatinine (mg/dl)

In the control group, the CRE values on day 0, 15 and 30 were 1.13⁺⁻0.02, 1.15⁺⁻0.02 and 1.12⁺⁻0.02 mg/dl respectively, which differed non-significantly between various intervals.

In all the treatment groups i.e. T₁, T₂ and T₃, the values of CRE on day 0 were 2.48⁺⁻0.05, 2.47⁺⁻0.05 and 2.45⁺⁻0.04 mg/dl respectively, which were significantly higher than control group.

In the treatment groups T₁ and T₂ the values of CRE on day 15 (i.e. 1.73⁺⁻0.05 and 1.58⁺⁻0.08 mg/dl respectively) and day 30 (i.e. 1.20⁺⁻0.05 and 1.18⁺⁻0.03 mg/dl respectively) decreased significantly (p≤0.05) as compared to day 0 of the same group. On day 30 post treatment the values of CRE in the both the groups decreased to normal range which differed non-significantly with the control group.

In group T₃ the CRE value (i.e. 2.45⁺⁻0.16 mg/dl) on day 15 showed no significant difference from day 0 of the same group; however, significant decrease in the value of CRE (i.e. 1.60⁺⁻0.15 mg/dl) was observed on day 30 post treatment, but it was significantly higher than the control group (Table 22).
Table 22. Creatinine (mg/dl) at different intervals in different groups (Mean±SE)

<table>
<thead>
<tr>
<th>Group (Healthy)</th>
<th>Control (Healthy)</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 0</td>
<td>1.13±0.02</td>
<td>2.48±0.05</td>
<td>2.47±0.05</td>
<td>2.45±0.04</td>
</tr>
<tr>
<td>Day 15</td>
<td>1.15±0.02</td>
<td>1.73±0.05</td>
<td>1.58±0.08</td>
<td>2.45±0.16</td>
</tr>
<tr>
<td>Day 30</td>
<td>1.12±0.02</td>
<td>1.20±0.05</td>
<td>1.18±0.03</td>
<td>1.60±0.15</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly (p≤0.05)

4.6.6 Total bilirubin (mg/dl)

In the control group, the BIT values on day 0, 15 and 30 were 0.16±0.01, 0.16±0.01 and 0.16±0.01 mg/dl respectively, which differed non-significantly between various intervals.

In all the treatment groups i.e. T₁, T₂ and T₃, the values of BIT on day 0 were 2.97±0.07, 2.93±0.08 and 2.93±0.08 mg/dl respectively, which were significantly higher than control group.

In the treatment groups T₁ and T₂ the values of BIT on day 15 (i.e. 1.73±0.05 and 1.70±0.07 mg/dl respectively) and day 30 (i.e. 0.17±0.01 and 0.19±0.04 mg/dl respectively) decreased significantly (p≤0.05) as compared to day 0 of the same group. On day 30 post treatment the values of BIT in the both the groups decreased to normal range which differed non-significantly with the control group.

In group T₃ the BIT value (i.e. 2.80±0.04 mg/dl) on day 15 showed no significant difference from day 0 of the same group; however, significant decrease in the value of BIT (i.e. 1.65±0.07 mg/dl) was observed on day 30 post treatment, but it was significantly higher than the control group (Table 23).
Table 23. Total bilirubin (mg/dl) at different intervals in different groups (Mean±SE)

<table>
<thead>
<tr>
<th>Day</th>
<th>Group</th>
<th>Control (Healthy)</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>0.16c±0.01</td>
<td>2.97a±0.07</td>
<td>2.93a±0.08</td>
<td>2.93a±0.08</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>0.16c±0.01</td>
<td>1.73b±0.05</td>
<td>1.70b±0.07</td>
<td>2.80a±0.04</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>0.16c±0.01</td>
<td>0.17c±0.01</td>
<td>0.19c±0.04</td>
<td>1.65b±0.07</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly (p≤0.05)

4.6.7 Total plasma protein (g/dl)

In the control group, the TPP values on day 0, 15 and 30 were 6.77±0.03, 6.75±0.03 and 6.77±0.03 g/dl, respectively, which differed non-significantly between various intervals.

In all the treatment groups i.e. T₁, T₂ and T₃, the values of TPP on day 0 were 4.67±0.09, 4.62±0.08 and 4.67±0.05 g/dl respectively, which were significantly lower (p≤0.05) than control group.

In the treatment groups T₁ and T₂ the values of TPP on day 15 (i.e. 5.55±0.08 and 5.67±0.08 g/dl respectively) and day 30 (i.e. 6.73±0.07 and 6.75±0.04 g/dl respectively) increased significantly (p≤0.05) as compared to day 0 of the same group. On day 30 post treatment the values of TPP in the both the groups increased to normal range which differed non-significantly with the control group.

In group T₃ the TPP value (i.e. 4.65±0.21 g/dl) on day 15 showed no significant difference from day 0 of the same group; however, significant increase in the value of TPP (i.e. 5.70±0.18 g/dl) was observed on day 30 post treatment, but it was significantly lower than the control group (Table 24).
Table 24. Total plasma protein (g/dl) at different intervals in different groups (Mean±SE)

<table>
<thead>
<tr>
<th>Day</th>
<th>Group</th>
<th>Control (Healthy)</th>
<th>( T_1 )</th>
<th>( T_2 )</th>
<th>( T_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>6.77(^a)±0.03</td>
<td>4.67(^c)±0.09</td>
<td>4.62(^c)±0.08</td>
<td>4.67(^c)±0.05</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>6.75(^a)±0.03</td>
<td>5.55(^b)±0.08</td>
<td>5.67(^b)±0.08</td>
<td>4.65(^c)±0.21</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
<td>6.77(^a)±0.03</td>
<td>6.73(^a)±0.07</td>
<td>6.75(^a)±0.04</td>
<td>5.70(^b)±0.18</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly (p≤0.05)

4.6.8 Blood glucose (mg/dl)

In the control group, the blood glucose values on day 0, 15 and 30 were 53.67±0.49, 53.50±0.50 and 53.83±0.40 mg/dl, respectively, which differed non-significantly between various intervals.

In all the treatment groups i.e. \( T_1 \), \( T_2 \) and \( T_3 \), the values of blood glucose on day 0 were 32.17±0.40, 32.50±0.76 and 33.17±0.79 mg/dl respectively, which were significantly lower than control group.

In all the three treatment groups i.e. \( T_1 \), \( T_2 \) and \( T_3 \) the values of blood glucose on day 15 (i.e. 48.00±0.63, 47.33±0.92 and 48.17±0.31 mg/dl respectively) and day 30 (i.e. 53.33±0.42, 53.50±0.43 and 52.83±0.48 mg/dl respectively) post treatment significantly increase (p≤0.05) as compared to day 0 of the same group.

On day 30 post treatment the values of blood glucose in all the treatment groups i.e. \( T_1 \), \( T_2 \) and \( T_3 \) increased to normal range which differed non-significantly with the control group (Table 25).
Table 25. Blood Glucose (mg/dl) at different intervals in different groups (Mean±SE)

<table>
<thead>
<tr>
<th>Day</th>
<th>Group (Healthy)</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>53.67a±0.49</td>
<td>32.17c±0.40</td>
<td>32.50c±0.76</td>
<td>33.17c±0.79</td>
</tr>
<tr>
<td>15</td>
<td>53.50a±0.50</td>
<td>48.00b±0.63</td>
<td>47.33b±0.92</td>
<td>48.17b±0.31</td>
</tr>
<tr>
<td>30</td>
<td>53.83a±0.40</td>
<td>53.33a±0.42</td>
<td>53.50a±0.43</td>
<td>52.83a±0.48</td>
</tr>
</tbody>
</table>

Means in the rows and columns with the same superscript do not differ significantly (p≤0.05)

4.7 Blood smear examination at different intervals showing the presence of parasites in each group

The results of present study revealed that on day 15 post treatment, in group T₁ (Inj. Oxytetracycline LA) 5 out of 6 goats were recovered, while in group T₂ (Inj. Diminazene aceturate) all the 6 goats recovered completely and were negative for Babesia on blood smear examination.

In group T₃ (Inj. Buparvaquone) the goats showed no significant improvement in clinical signs as evident by the results of the present study that out of 6 goats treated, 5 goats revealed Babesia on blood smear examination on day 15 post treatment. On day 30 post treatment Babesia was present in blood smears of 4 out of 6 goats. However, 2 goats were completely recovered with appreciable health status.

The results showed that group T₂ was superior to groups T₁ and T₃ as all the 6 goats (100%) recovered on day 15 post treatment, as compared to group T₁ and T₃ i.e. 5 out of 6 (83.33%) and 1 out of 6 (16.67%) goats respectively.

The results of present study revealed that the T₂ (Inj. Diminazene aceturate) and T₁ (Inj. Oxytetracycline LA) groups were found to
be superior than T₃ (Inj. Buparvaquone) as indicated by the no. of goats recovered in all the three groups i.e. 6 goats in T₂ and T₁ groups while, only 2 goats were recovered in group T₃ on day 30 post treatment. (Table 26)

Table 26. Blood smear examination at different intervals showing the presence of parasites

<table>
<thead>
<tr>
<th>Day</th>
<th>Animal</th>
<th>T₁</th>
<th>T₂</th>
<th>T₃</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>15</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>30</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
5. DISCUSSION

Tick born diseases are widely distributed throughout the world particularly in tropical and subtropical countries, among them babesiosis and theileriosis are economically important. In India very little research has been done on these aspects especially in goats, so, the data regarding the prevalence and occurrence of such type of disease in goats are scarce. A wide range of clinical signs are reported in caprine babesiosis among them pale mucous membrane, anorexia, fever, diarrhoea and nasal discharge are the common symptoms followed by haemoglobinuria. So, keeping these facts in mind the present work was undertaken to study the prevalence of various caprine haemoproteozoan infection, clinical and haemato-biochemical alterations in caprine babesiosis and evaluate the therapeutic efficacy of various drugs against caprine babesiosis.

A total of 800 blood samples of goats were collected from Amanala goat unit, Livestock farm, Adhartal, goats brought to TVCC, Jabalpur and Government Veterinary Hospital, Omoti, private clinics and areas in and around Jabalpur city from August 2012 to May 2013. Confirmation of haemoproteozoan was done by microscopic examination of blood smears stained with Leishman’s stain.

5.1 Prevalence of caprine haemoproteozoan infection in and around Jabalpur city

The overall prevalence of caprine haemoproteozoan during August 2012 to May 2013 was 3.90% (Table 2). However, Jadhao et al. (2007) reported higher prevalence in Maharashtra i.e. 14.72%.

Among caprine haemoproteozoan the prevalence of Babesia was 3.50% (Table 2). Similar findings were reported by Theodoropoulos et al. (2006) in Greece i.e. 4.14%, Jadhao et al. (2007) in Maharashtra i.e. 4.08%, Zangana and Naqid (2011) in Iraq i.e. 4.00% and Biu et al. (2012) in Nigeria i.e. 4.60%. However, higher prevalence for Babesia was reported by Razmi et al. (2003) in Mashhad area i.e. 14.80%, Shahabuddin et al. (2006) in Pakistan i.e. 10.86%, Lako et al. (2007) in West Cameroon i.e. 33.33%, Sulaiman et al. (2010) in Mosul i.e. 15.43%, Iqbal et al. (2011) in Southern Punjab i.e.
23.88%, Ziapour et al. (2011) in Iran i.e. 22.27%, Esmaeinejad et al. (2012) in Iran i.e. 22.39% and Ijaz et al. (2013) in Lahore i.e. 13.53%. Lower prevalence was reported for Babesia by Inci et al. (2010) in Central Anatolia i.e. 0.70% and Mohammed and Idoko (2013) in Nigeria i.e. 1.00%.

In present study the prevalence of Theileria was found to be 0.40% (Table 2). The finding is in accordance with Jadhao et al. (2007) who reported the prevalence of Theileria was 0.40% in Maharashtra. Higher prevalence for Theileria was reported by Al-Amery and Hasso (2002) in Iraq i.e. 33.82%, Altay et al. (2007) i.e. 2.88%, Sayin et al. (2009) in Turkey i.e. 12.36%, Inci et al. (2010) in Central Anatolia i.e. 9.90%, Irshad et al. (2010) in Pakistan i.e. 3.80%, Taha et al. (2011) in Northern Sudan i.e. 72.72%, Zangana and Naqid (2011) in Iraq i.e. 20.8%, Alessandra and Santo (2012) in Italy i.e. 1.60%, Altay et al. (2012) in Turkey i.e. 4.47%, Durrani et al. (2012) in Pakistan i.e. 1.00%, Naz et al. (2012) Lahore i.e. 8.20%, Aydin et al. (2013) in Turkey i.e. 1.54% and Mohammed and Idoko (2013) in Nigeria i.e. 3.00%.

The variability in the prevalence of caprine haemoproteozoan infection in different area may be due to epidemiology of the parasites, infestation of the host with vector ticks and available population of goats (Inci et al., 2010). According to Zangana and Naqid (2011) the variability in the prevalence caprine haemoproteozoan infection in different area may be due to close relationship between incidence of piroplasmosis with activity period and distribution area of the ticks.

Among the various age groups positive for caprine haemoproteozoan infection the prevalence was 1.71% in 3 year, 3.55% in 1-3 years, 4.21% in 3-5 years and 5.71% in >5 year of age (Table 3). These result suggested higher prevalence in age group >3 years of age which are in agreement with observations of Jadhoa et al. (2007) who reported higher prevalence in age group >3 years of age i.e. 16.75% in age group 3-5 years and 17.53% in age group >5 years.

The prevalence of Babesia was found to be 1.71%, 2.22%, 4.21% and 5.71% in age groups <1 year, 1-3 years, 3-5 years and >5 years of
age groups respectively (Table 3). These findings were in accordance with the Zangana and Naqid (2011) i.e. higher prevalence was found in age group above 3 years of age in comparison to other age groups. According to them the passive immunity induced via colostrum and recovery from acute phase of infection results into pre immunity which prevent challenge infection in younger goats.

The prevalence of *Theileria* was found only in age group of 1-3 years i.e.1.33% (Table 3). The higher prevalence in age group 1-3 years was reported by Zangana and Naqid (2011) i.e. 5.8% where as according to Durrani *et al.* (2011) age has no effect on occurrence of *Theileria* in goat.

In the present study the prevalence of caprine haemoproteozoan in males and females was 3.37% and 4.51% respectively, suggesting that both the sexes were almost equally affected. These observations correlated with Jadhao *et al.* (2007) who have reported 13.70% prevalence of caprine haemoproteozoan in males and 14.90% in females.

The sex wise prevalence of *Babesia* in males and females was found to be 2.92% and 4.51% respectively, suggesting that both the sexes of goats were almost equally affected (Table 4). Similar findings were reported by Biu *et al.* (2012) and Colditz *et al.* (1996).

The sex wise prevalence of *Theilera* in goats was found to be 0.45% in males and 0.28% in females, suggesting that both the sexes were almost equally affected (Table 4). Naz *et al.* (2012) and Durrani *et al.* (2011) reported similar findings.

Well defined breeds (Barbari, Sirohi and Jamunapari) had higher prevalence i.e. 5.35%, 4.75% and 0.59% for caprine haemoproteozoan, *Babesia* and *Theileria* respectively. Although, non-descript goats had lower prevalence i.e. 1.36% and 1.36% for caprine haemoproteozoan and *Babesiosis* respectively. As per available literature work on this aspect is scarce. In the present study the higher prevalence was found in well defined breeds which may be due to higher population of well defined breeds than non-descript breeds.
5.2 Clinical and haemato-biochemical alterations in caprine babesiosis

5.2.1 Clinical alterations

Clinical signs in goats affected with *Babesia* were pale mucous membrane (85.70%), loss of appetite (75.00%), nasal discharge (35.70%) and coughing (32.10%), followed by diarrhoea (60.10%), emaciation (53.40%) and haemoglobinuria (7.10%) along with presence of ticks on body in 82.10% goats (Table 6). These findings were in accordance with Soulsby (1986).

The development of pale mucous membranes was due to anaemia and decrease in TEC and Hb. The haemoglobinuria may be as a result of destruction of erythrocyte, intravascular haemolysis and haemoglobinemia (Lewis *et al.*, 1981). Loss of appetite may be due to fever which causes emaciation. Nasal discharge and coughing may be because of seasonal stress or concurrent viral or bacterial diseases. Diarrhoea may be due to hepatic insufficiency.

Among the various clinical parameters temperature, pulse rate and respiration rate (Table 7) increased significantly (p≤0.01) in affected goats than healthy goats on the day 0 pre treatment. The result of this study showed that the clinical signs observed in affected goats were in agreement with Sulaiman *et al.* (2010). The fever in goats affected with *Babesia* may be associated with exogenous pyrogens which include haemoglobinemia in a haemolytic crisis (Radostitis *et al.*, 2009). The increased respiration rate may be due to inadequate delivery of oxygen to tissues because of anaemia thereby low level of haemoglobin (Radostitis *et al.*, 2009) while increased pulse rate was due to fever.

5.2.2 Haematological alterations

In the affected goats TEC was significantly lower (p≤0.01) than healthy control group (Table 8), indicating anaemia in the affected goats. Similar findings were reported by Sulaiman *et al.* (2010), Zangana and Naqid (2011), Esmaeilnejad *et al.* (2012) and Ijaz *et al.* (2013).

The mean Hb concentration decreased significantly (p≤0.01) in the affected goats (Table 8). These observations were similar with the findings
of Bhikane et al. (2005), Sulaiman et al. (2010), Zangana and Naqid (2011), Esmaeilnejad et al. (2012) and Ijaz et al. (2013).

In the affected goats the PCV was significantly lower (p≤0.01) than the healthy goats (Table 8). These finding was in accordance with that of Biu et al. (2012) and Ijaz et al. (2013).

All the three findings i.e. decreased TEC, PCV and Hb concentration may be associated with the intravascular haemolysis of erythrocyte, increased erythrophagocytosis by reticuloendothelial system and restricted erythropoietic activity of bone marrow (Lewis et al., 1981).

The TLC was significantly increase (p≤0.01) in affected goats as compared with healthy goats which may be due to significant (p≤0.01) increase in lymphocyte count. However, Sulaiman et al. (2010) estimated leukocytosis because of significant increase in lymphocyte and neutrophil counts; although Esmaeilnejad et al. (2012) reported leukocytosis due to significant increase in lymphocyte, neutrophil, monocyte and eosinophil count.

Differential leukocyte count showed statistically significant (p≤0.01) increase in lymphocyte count and decrease in neutrophil count in affected goats as compare with healthy goats. Ibrahim et al. (2009) explained that breakdown of erythrocyte by Babesia organism stimulates the phagocytic cells such as lymphocyte to clean the toxic remnants of ruptured erythrocytes from the body as well as increased tissue demand of neutrophil that reduces its concentration in peripheral circulation. Non significant changes occurred in monocyte and eosinophil count between healthy and affected goats (Table 8) which coincides with the findings of Sulaiman et al. (2010). The deviation in these values might be due to degree of infection, tissue necrosis, haemolysis and other concurrent infections (Benjamin, 2001).

5.2.3 Biochemical alterations

The estimation of biochemical parameters showed that level of ALT and AST were significantly increased (p≤0.01) in the affected goats as compared with the healthy goats. The study correlated with the findings of Sulaiman et al. (2010). The elevation of ALT and AST might be due to indirect
damage of liver, kidney tissue and myocardium. These changes indicated the possible damage of liver and kidney tissues (Yeruham et al., 1998b).

ALP was significantly increased (p≤0.01) in affected goats as compared to healthy goats. As per the perusal of available literature no work has been reported in caprine on this aspect. However, Yeruham et al. (2003) and Ibrahim et al. (2009) reported increase in ALP in cattle affected with Babesia organism whereas, decreased in its activity was reported by Yeruham et al. (1998a) in sheep affected with Babesia. According to Ibrahim et al. (2009) the increase in ALP activities was explained as a result of the harmful effect of toxic metabolites of Babesia on liver cells. These results were supported by in Babesia infected cattle.

Biochemical study revealed significant increase (p≤0.01) in the values of BUN in the affected goats as compared with the healthy goats. The study correlated with the findings of Sulaiman et al. (2010) and Esmaeilnejad et al. (2012). According to Esmaeilnejad et al. (2012) elevation in BUN was due to kidney malfunctions in Babesia infected goats.

The levels of CRE were significantly higher (p≤0.01) in affected than healthy goats. Similarly the elevated level of CRE was reported by Esmaeilnejad et al. (2012). The elevation in CRE level might have resulted from kidney dysfunction in Babesia infected goats.

The value of BIT was significantly increased (p≤0.01) in affected goats as compared with the healthy goats. Similar findings were reported by Sulaiman et al. (2010). This change may be attributed to the damage of liver (Jain, 1986).

The present biochemical study revealed that the concentration of TPP in the affected goats decreased significantly (p≤0.01) as compared to healthy goats. Similar finding was reported by Sulaiman et al. (2010). The decrease in TPP may be associated with decreased production from liver which may be direct or indirect effect of organism, anorexia, high fever and digestive disturbance (Al-Abound et al., 2005).
In the present study, significant decrease (p≤0.01) in the blood glucose level was observed in affected goats as compared with healthy goats. Similar findings were reported by Zulfiqar et al. (2012). However, Rani et al. (2010) estimated hyperglycaemia in she buffalo affected with Babesia organism. The decrease in blood glucose concentration may be due to the utilization of glucose by parasites and damage to the liver (Zulfiqar et al., 2012) in addition starvation may also reduces the blood glucose level.

5.3 Comparative therapeutic efficacy of drugs against caprine babesiosis

In the present study all the goats in groups T₁ (Inj. Oxytetracycline LA @ 20 mg/kg b.wt., I/M, 2 doses at 96 hrs intervals) and T₂ (Inj. Diminazene aceturate @ 2.5 mg/kg b.wt., I/M, 2 doses at 24hrs intervals) recovered completely while in group T₃ (Inj. Buparvaquone @ 2.5 mg/kg b.wt., 2 doses at 96 hrs intervals) only 2 goats were recovered. Among all the three treatment groups T₂ was superior because all the 6 goats were recovered on day 15 post treatment; however, 5 out of 6 and 1 out of 6 goats recovered in group T₁ and group T₃ respectively.

The findings in group T₁ were in accordance with Taylor et al. (1986) who have reported inhibitory effects of continuous administration of oxytetracycline LA on the development of parasitaemia of Babesia divergens in cattle during both natural and experimental infections.

In group T₂, the findings were similar with that of Bhikane et al. (2005), Radostitis et al. (2009) and Vidhya et al. (2011) who have reported diminazene aceturate as an effective therapy for caprine babesiosis. Ijaz et al. (2013) reported diminazene aceturate has 70% efficacy against caprine babesiosis.

The present study revealed efficacy of buparvaquone against caprine babesiosis as reported by Dolan (1988).
6. SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

6.1 Summary

The present experiment was aimed to report the prevalence of caprine haemoprotozoan infection, clinical and haemato-biochemical alterations in caprine babesiosis and to evaluate the comparative therapeutic efficacy of drugs against caprine babesiosis. The study was conducted in 800 goats of Amanala goat unit, Livestock farm, Adhartal, Jabalpur, goats brought to the TVCC, Government Veterinary Hospital, Omti (Jabalpur), private clinics and area in and around Jabalpur city. The goats showing signs of haemoprotozoan infection were examined for the presence of haemoprotozoan infection and confirmation was done by microscopic examination of Romanowsky-type (Leishman’s stain) stained blood smear. The blood smear positive goats for haemoprotozoan infection were included for study.

Out of the 28 positive cases for caprine babesiosis 18 goats were placed in 3 groups having 6 goats each. Group T₁, T₂ and T₃ were treated with Inj. Oxytetracycline LA @ 20 mg/kg b.wt., I/M, 2 doses at 96 hrs. intervals, Inj. Diminazene aceturate @ 3.5 mg/kg b.wt., I/M, 2 doses at 24 hrs. intervals and Inj. Buparvaquone @ 2.5 mg/kg b.wt., I/M, 2 doses at 96 hrs. intervals respectively along with supportive therapy with antipyretic drugs (Inj. Paracetamol @ 10 mg/kg b.wt., I/M, SOS), haematinics (Bolus Feritas ½ bolus, OD, PO for 15 days), hepato protective drug (Inj. Belamyl 0.5-2 ml, I/M) along with fluid therapy (Inj. D₅ or Inj. DNS 5% or Inj. NS, I/V) were given to all the goats under study.

The overall prevalence of caprine haemoprotozoan, Babesia and Theileria were 3.90%, 3.50% and 0.40% respectively.

Among caprine haemoprotozoan infection the overall age wise prevalence was 1.71% in age group <1 year, 3.55% in age group 1-3 years, 4.21% in age group 3 to 5 years of age and 5.71% in age group >5 years of age. Age wise prevalence study in goats affected with Babesia showed 1.71%, 2.22%, 4.21% and 5.71% prevalence in age groups <1 year of age, 1-
3 years of age, 3-5 years of age and >5 years of age respectively. The goats affected with *Theileria* were between 1 to 3 years of age thus the prevalence of *Theileria* in age group 1-3 years of age was 1.33% *i.e.* 3 out of 225 goats.

The sex wise prevalence study revealed that the prevalence of caprine haemoproteozan infection in males and females was 3.37% and 4.51% respectively. The prevalence of *Babesia* in males and females goats was *i.e.* 2.92% and 4.23% respectively. The prevalence of *Theileria* in males and females goats was 0.45% and 0.28% respectively.

Breed wise prevalence of caprine haemoproteozan infection was higher in well defined breeds (Sirohi, Barbari and Jamunapari) *i.e.* 5.34% followed by non-descript goats *i.e.* 1.36%. Prevalence of *Babesia* was higher in well defined breeds (Sirohi, Barbari and Jamunapari) *i.e.* 4.75% as compared to non-descript goats *i.e.* 1.36%. The prevalence of *Theileria* was 0.59% in well defined breeds viz. Sirohi, Barbari and Jamunapari.

Clinical signs in goats affected with *Babesia* were pale mucous membrane (85.70%), loss of appetite (75.00%), nasal discharge (35.70%) and coughing (32.10%), followed by diarrhoea (60.10%), emaciation (53.40%) and haemoglobinuria (7.10%) along with presence of ticks on body in 82.10% caprine. Among the various clinical parameters temperature, pulse rate and respiration rate increased significantly (*p*≤0.01) than healthy goats on the day 0 pre treatment.

Among the various haematological parameters TEC (millions/µl), Hb (g/dl), PCV (%) and neutrophils (%) were significantly decreased (*p*≤0.01) while, TLC (thousands/µl) and lymphocyte (%) increased significantly (*p*≤0.01) on day 0 pre treatment in affected goats as compared to healthy goats. However, non-significant changes occurred in monocyte (%) and eosinophil (%) on the day 0 pre treatment between healthy and affected goats.

The results of biochemical parameters showed a statistically significant increase (*p*≤0.01) occurred in ALT (U/L), AST (U/L), ALP (U/L), BUN (mg/dl), CRE (mg/dl) and BIT (mg/dl), while significant decrease was noticed in TPP (g/dl) and blood glucose (mg/dl) in affected goats as compared to healthy goats on day 0 pre treatment.
The results of present study revealed that on day 15 post treatment, in group T₁ (Inj. Oxytetracycline LA) 5 out of 6 goats were recovered, while in group T₂ (Inj. Diminazene aceturate) all the 6 goats recovered completely and were negative for Babesia on blood smear examination.

In group T₃ (Inj. Buparvaquone) the goats showed no significant improvement in clinical signs as evident by the results of the present study that out of 6 goats treated, 5 goats revealed Babesia on blood smear examination on day 15 post treatment. On day 30 post treatment Babesia was present in blood smears of 4 out of 6 goats. However, 2 goats were completely recovered with appreciable health status.

The results showed that group T₂ was superior to groups T₁ and T₃ as all the 6 goats (100%) recovered on day 15 post treatment, as compared to group T₁ and T₃ i.e. 5 out of 6 (83.33%) and 1 out of 6 (16.67%) goats respectively.

The results of present study revealed that the T₂ and T₁ groups were found to be superior than T₃ as indicated by the no. of goats recovered in all the three groups i.e. 6 goats in T₂ and T₁ groups while, only 2 goats were recovered in group T₃ on day 30 post treatment.

6.2 Conclusion
1. The overall prevalence of caprine haemoprotezoan, *Babesia* and *Theileria* were 3.90%, 3.50% and 0.40% respectively.

2. In the goats affected with *Babesia*, haematological studies revealed significant decrease in total erythrocyte count, haemoglobin concentration, packed cell volume and neutrophil, while total leukocyte count and lymphocyte were significantly increased.

3. Among various biochemical parameters alanine amino transferase, aspartate amino transferase, alkaline phosphatase, total bilirubin, blood urea nitrogen and creatinine were significantly increased with significantly decrease in total plasma protein and blood glucose and in the goat affected with *Babesia*.

4. The results of therapeutic study showed that diminazene aceturate was superior followed by oxytetracycline LA and buparvaquone used under the present study for the treatment of caprine babesiosis.

5. It is concluded on the basis of various haemato-biochemical and therapeutic studies that diminazene aceturate was found to be the best and effective treatment for caprine babesiosis followed by oxytetracycline LA and buparvaquone.

6.3 Suggestions for further work
1. Epidemiological study of haemoproteozoa in caprine may be conducted covering a larger population for entire year to obtain the seasonal variations.

2. Formulation of prognostic index for caprine babesiosis using various haemato-biochemical alterations could be developed.

3. Study on serological and molecular diagnostic techniques for caprine babesiosis could be conducted.

7. REFERENCES


PCR amplification, in small ruminants from Southern Punjab (Pakistan). *Parasite, 18*(3): 229-34.


