RESEARCH ARTICLE

Clinico-Haemato-Biochemical Alterations and Therapeutic Management of Bovine Theileriosis

Krishna D. Prajapati[1]*, Sunant K. Raval[1], Ghanashyam C. Mandali[1], Neha Rao[2], Shailesh K. Bhavsar[3], Munja Bharai[1]

Abstract

Theileriosis is an economically important haemoprotozoan disease of cattle caused by *Theileria* spp. It causes production losses and mortality in dairy industry. A total of 135 cattle suspected of theileriosis were screened based on clinical signs and blood smear examination (Giemsa's stain). Out of them, 64 animals were diagnosed with theileriosis. Twenty-four cattle out of them were selected and divided into four equal groups, *viz.,* B, C, D, and E, each comprised of six animals for four different treatment protocols to evaluate their therapeutic efficacy, while group A of six healthy cattle served as control. The most common clinical findings of theileriosis infected cattle (n = 24) in descending order were anorexia (100%), dullness and depression, decreased milk production, weakness, salivation, enlarged pre-scapular lymph nodes, pale conjunctival mucous membrane, presence of ticks over the body, emaciation, nasal discharge, cessation of rumination, lacrimation, diarrhea and sternal recumbency (8.33%). The mean rectal temperature, heart rate, and respiratory rate were 104.5 ± 0.33° F, 79.5 ± 2.85/min and 42.83 ± 2.67/min, respectively. The haematological findings revealed decreased values of haemoglobin, packed cell volume, total erythrocytes count (TEC), lymphocytes, and mean corpuscular hemoglobin concentration (MCHC), and increased values of neutrophils, eosinophils, Mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCH) in theileriosis infected cattle as compared to healthy cattle. Biochemical findings revealed decreased values of total protein and albumin while increased total bilirubin, Aspartate aminotransferase (AST), Alanine aminotransferase (ALT), and Gamma-glutamyl transferase (GGT) in theileriosis-infected cattle. These altered haemato-biochemical profiles were found to be normalized by the 14th day in different treatment groups. The therapeutic efficacy of Buparvaquone 2 dose (Group B) and Buparvaquone plus Oxytetracycline LA (Group D) was better (100.00%) than the Arteether (Group C, 66.66%) and Arteether plus Oxytetracycline LA (Group E, 83.33%) in theileriosis infected cattle, hence may be advocated to the field veterinarians for effective treatment of theileriosis in cattle.

Keywords: Buparvaquone, Cattle, Clinical signs, Giemsa staining, Haemato-biochemical assay, Theileriosis, Therapeutic trials.

Ind J Vet Sci and Biotech (2022): 10.21887/ijvsbt.18.1.16

Introduction

Bovine theileriosis is one of the most prevalent and economically significant diseases of cattle (Forsyth *et al.,* 1997). Exotic and crossbred cattle are more susceptible than the indigenous breeds of cattle. Out of six identified *Theileria* species, *Theileria annulata* and *Theileria parva* are the most important and pathogenic species which cause theileriosis in bovine (Kohli *et al.,* 2014). *Theileria* spp. is an obligate intracellular protozoan parasite. The vector responsible for transmission is biting tick *Hyalomma anatolicum*. The hot and humid climate favours the development and survival of ticks (Kohli *et al.,* 2014). *Theileria* sporozoites are transmitted to susceptible animals via the saliva of feeding ticks. *Theileria* sporozoites undergo a complex life cycle involving the replication of schizonts in the leukocytes and piroplasms in the erythrocytes (Gachohi *et al.,* 2012). The clinical signs of theileriosis in cattle are elevated body temperature 105°F, anorexia, swelling of superficial lymph nodes, weight loss, drop in milk yield, nasal discharge, lacrimation, dyspnoea, anaemia, and in later stage some time diarrhea and dysentery, with the presence of ticks on the body (Radostitis *et al*., 2008). Infected cattle remain a carrier for a lifetime since organisms localize in the macrophages and lymphoid tissues.

Theileriosis in cattle is treated worldwide with different allopathic medicines like parvaquone, buparvaquone, halofuginone lactate, oxytetracycline, and diminazene aceturate (Ngumi *et al.,* 1992). Arteether is a synthetic derivative of artemisinin, a natural product of the Chinese plant *Artemisia annua,* popularly known as sweet wormwood. It is currently used as a second-line drug in severe malaria

[1]Department of Veterinary Medicine, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand-388001, India.

[2]Department of Veterinary Clinical Complex, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand-388001, India.

[3]Department of Veterinary Pharmacology and Toxicology, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand-388001, India.

Corresponding Author: Krishna D. Prajapati, Department of Veterinary Medicine, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand-388001, India, e-mail: krishnaprajapati9697@gmail.com

How to cite this article: Prajapati, K.D., Raval, S.K., Mandali, G.C., Rao, N., Bhavsar, S.K., Bharai, M. (2022). Clinico-Haemato-Biochemical Alterations and Therapeutic Management of Bovine Theileriosis. Ind J Vet Sci and Biotech. 18(1), 81-86.

Source of support: Nil

Conflict of interest: None.

Submitted: 15/07/2021 **Accepted:** 29/11/2021 **Published:** 10/01/2022

cases as schizonticide specifically indicated for the treatment of chloroquine-resistant *Plasmodium falciparum* malaria and cerebral malarial cases. It has also been used in bovine theileriosis (Khawale *et al.,* 2019). Suppose the infected animals are not treated properly and efficiently. In that case, it may have a huge economic impact on the livestock sector due to heavy morbidity and mortality, affecting around 80% world population (Kasozi *et al.,* 2014). Therefore, this study was planned to diagnose tropical theileriosis in cattle using clinical signs and Giemsa staining of blood smears and to evaluate the therapeutic efficacy of different regimens through clinico-haemato-biochemical observations and recovery rates after treatment.

Materials and Methods

The present study was undertaken from January to June 2021 on 135 cattle suspected of having theileriosis and presented at the Veterinary Clinical Complex of the College, Anand, and nearby villages of the Anand district. Blood smear examination of all these animals was done initially, which revealed the presence of *Theileria* spp. piroplasms in 64 cattle (Figure 1). Of these, 24 cattle selected for therapeutic trial were divided into four equal groups, *viz.,* B, C, D, and E, having six animals in each. Group A included six healthy animals from the same area as the control. Blood samples were collected from the jugular vein in sterile plastic K_3-Ethylenediamine tetraacetic acid (K_3EDTA) vials and serum clot activators from all healthy and affected animals before the initiation of treatment and on the 14th day of treatment for haemato-biochemical analysis.

Animals of Group B were treated with Buparvaquone @2.5 mg/kg b.wt., IM, repeated after 48 hours; Group C treated with Arteether @5 mg/kg b.wt., IM for 3 consecutive days; Group D treated with buparvaquone @ 2.5 mg/kg b.wt., IM, and 24 hrs later Inj. Oxytetracycline (long-acting) @20 mg/kg b.wt., IM, and Group E cattle were treated with Arteether @5 mg/kg for three consecutive days followed by Inj. Oxytetracycline (long-acting) @20 mg/kg b.wt., IM.

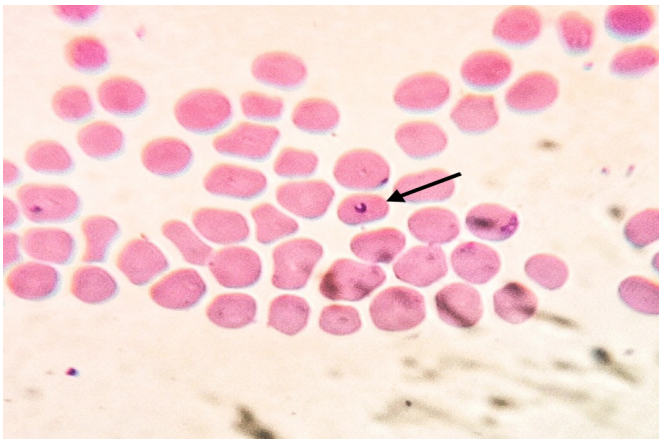

Figure 1: Blood smear of cattle shows *theileria* piroplasm like a signet ring or half-moon shape

Apart from these, all groups received supportive therapy, *viz.*, haematinic preparation-Feritas (Iron + folic acid + vitamin B_{12}) orally, Meloxicam @ 0.2 mg/kg b.wt., IM, Chlorpheniramine maleate @ 30 to 50 mg/kg b.wt., IM, and vitamin B complex along with appropriate fluid therapy. The infected cattle were monitored from pre-treatment to 14 days post-treatment. The therapeutic efficacy of different treatment regimens was evaluated based on clinical signs, blood smear examinations, and haemato-biochemical assay before and after treatment.

The haematological analysis of whole blood was done using an Automatic Whole Blood Analyzer (Abacus Junior Vet-5). The serum biochemical parameters studied using standard assay kits with the help of Clinical Biochemistry Auto-analyser (CKK 300) included glucose, total protein, albumin, total bilirubin, AST, ALT, GGT, serum creatinine, and BUN. The clinical signs and therapeutic efficacy data were analyzed using descriptive statistics and those on haemato-biochemical assays by using one-way ANOVA and paired 't' test (Snedecor and Cochran, 1994).

Results and Discussion

Clinical Findings

The clinical findings of 24 theilerioses affected cattle recorded in decreasing frequency were anorexia (100%), followed by dullness and depression (95.83%), reduced milk production (87.50%), weakness (58.33%), salivation (58.33%), enlarged pre-scapular lymph nodes (54.16%), pale conjunctival mucous membrane (54.16%), presence of ticks over the body (54.16%), emaciation (41.66%), nasal discharge (37.5%), cessation of rumination (33.33%), lacrimation (28.83%), diarrhea (12.50%) and sternal recumbency (8.33%). The mean values of rectal temperature, heart rate, and respiratory rate observed were 104.5 ± 0.33° F, 79.5 ± 2.85 per min and 42.83 ± 2.67 per min, respectively. Similar findings were also reported earlier by Naik *et al.* (2016), Kumar *et al.* (2018), and Nagar *et al.* (2019). The clinical parameters in treatment groups B, C, D, and E, treated with Buparvaquone, Buparvaquone plus oxytetracycline LA, arteether, and arteether plus oxytetracycline LA were more or less similar to the overall findings as the animals were randomly and equally allotted to four treatment groups.

haematological Findings

The results of haematological findings in all five groups of animals before and after treatment are shown in Table 1. The mean (± SE) values of haemoglobin, packed cell volume, total erythrocytes count, and lymphocytes were significantly decreased ($p < 0.05$) in theileriosis infected cattle as compared to healthy cattle group A. The total leucocytes count, monocytes and eosinophils were non-significantly increased, while neutrophils increased significantly ($p < 0.05$) in theileriosis infected cattle as compared to healthy cattle. However, there was a significant ($p < 0.05$) increase in MCH and a non-significant increase in MCV, while MCHC

was non-significantly decreased in theileriosis infected cattle compared to healthy cattle. On 14th day of different treatments, the values of most of these haematological parameters were improved as compared to '0' day values and were found to be normal or nearer to normal, except few parameters in certain groups which were still statistically different from the day '0' values and also of a healthy control group (Table 1). These observations suggested the beneficial effect of specific and supportive therapies used in theileriosis-infected cattle.

These findings concurred well with the earlier reports of Tuli *et al.* (2015), Saravanan *et al.* (2017), Brahambhatt *et al.* (2019), and Goud *et al.* (2021). The lower haemoglobin, PCV, and TEC values observed in theileriosis-infected animals might be due to the toxic metabolites of *Theileria* spp. (Radostits *et al.,* 2008), which destruct the erythrocytes. Persistent loss of blood caused by blood-sucking ticks is also an important factor. The higher value of total leucocyte counts might be due to leukocytosis (Pandey *et al.,* 2017). Lymphocytopenia might be due to the destruction of lymphocytes in lymphoid organs and the infiltration of these cells into various organs (Goyal, 2018). Neutrophilia observed in theileriosis-infected cattle may be due to the release of endogenous corticosteroid in acute disease or stress or inflammation (Ugalmugle *et al.,* 2010). The higher value of MCV, MCH, and the lower value of MCHC observed may be due to macrocytic hypochromic anaemia in theileriosis-infected cattle (Durrani and Kamal 2008).

Biochemical Findings

The results of biochemical findings observed in different groups of animals before and after treatment are presented in Table 2. The mean (± SE) values of total protein and albumin were decreased non-significantly, while glucose was decreased significantly ($p < 0.05$) in theileriosis-infected cattle as compared to the healthy group. Similar findings were reported by Khan *et al.* (2011) and Kachhawa *et al.* (2016). The lower value of total protein and albumin might be due to

Table 1: Haematological findings of healthy (Gr A) and theileriosis infected cattle under different treatment regimens (Gr. B, C, D, E) (mean ± SE, n = 6 each)

Haematology	*Stage of treatment*	*Haematological profile in Groups*				
		A	*B*	*C*	*D*	*E*
Hb (gm/dl)	0 day	$10.73^{b} \pm 0.39$	$5.95^{a} \pm 0.64$	$6.54^{a} \pm 0.98$	$5.93^{a} \pm 0.57$	$6.28^{a} \pm 0.82$
	14th day	$10.80^{b} \pm 0.44$	$7.72^{a} \pm 0.69^{**}$	$7.19^{a} \pm 1.08^{*}$	$7.45^{a} \pm 0.28$	$7.53^{a} \pm 0.74^{*}$
PCV (%)	0 day	$32.34^{b} \pm 0.69$	$20.19^{a} \pm 2.39$	$20.87^{a} \pm 3.29$	$20.23^{a} \pm 2.19$	$24.87^{ab} \pm 4.05$
	14th day	$32.73^{b} \pm 0.89$	$25.97^{ab} \pm 2.60^{**}$	$23.71^{a} \pm 3.15$	$25.58^{ab} \pm 0.74$	$25.81^{ab} \pm 3.48$
TEC ($x\ 10^6/\mu L$)	0 day	$7.21^{b} \pm 0.09$	$4.59^{a} \pm 0.66$	$4.09^{a} \pm 0.68$	$4.05^{a} \pm 0.36$	$4.98^{a} \pm 1.95$
	14th day	$7.44^{c} \pm 0.46$	$6.29^{b} \pm 0.12^{*}$	$5.00^{a} \pm 0.48^{*}$	$5.53^{ab} \pm 0.28^{*}$	$5.38^{ab} \pm 0.30$
TLC ($x\ 10^3/\mu L$)	0 day	7.20 ± 1.01	9.79 ± 1.44	9.64 ± 2.08	9.81 ± 0.39	8.60 ± 1.52
	14th day	7.37 ± 0.46	8.12 ± 0.62	9.43 ± 1.40	7.51 ± 1.07	8.19 ± 0.76
Lymphocytes (%)	0 day	$60.10^{b} \pm 2.50$	$46.98^{a} \pm 4.57$	$47.66^{a} \pm 8.82$	$44.73^{a} \pm 6.62$	$45.78^{a} \pm 1.55$
	14th day	$61.73^{b} \pm 1.39$	$60.57^{b} \pm 3.29$	$51.69^{a} \pm 2.42$	$59.73^{b} \pm 2.08$	$58.56^{ab} \pm 2.49^{**}$
Monocytes (%)	0 day	1.95 ± 0.35	3.22 ± 0.65	2.75 ± 0.72	4.82 ± 2.03	3.62 ± 0.67
	14th day	1.93 ± 0.34	2.40 ± 0.70	2.24 ± 0.63	2.40 ± 0.61	2.90 ± 0.79
Neutrophils (%)	0 day	$35.08^{a} \pm 01.82$	$46.67^{b} \pm 5.08$	$47.36^{b} \pm 9.37$	$48.05^{b} \pm 6.98$	$48.20^{b} \pm 1.99$
	14th day	$34.68^{a} \pm 1.25$	$35.65^{ab} \pm 3.61$	$44.09^{b} \pm 2.72$	$36.40^{ab} \pm 2.29$	$37.07^{ab} \pm 3.09^{*}$
Eosinophils (%)	0 day	1.15 ± 0.37	3.08 ± 0.82	2.21 ± 0.45	2.27 ± 0.32	2.37 ± 0.30
	14th day	1.52 ± 0.78	1.32 ± 0.23	1.89 ± 0.39	1.43 ± 0.18	1.40 ± 0.51
Basophils (%)	0 day	0.05 ± 0.03	0.05 ± 0.05	0.03 ± 0.03	0.13 ± 0.13	0.03 ± 0.21
	14th day	0.13 ± 0.07	0.07 ± 0.03	0.08 ± 0.03	0.03 ± 0.03	0.07 ± 0.03
MCV (fl)	0 day	47.83 ± 0.48	52.00 ± 1.03	51.37 ± 3.49	51.06 ± 1.35	50.15 ± 1.68
	14th day	47.17 ± 1.66	$48.21 \pm 1.13^{**}$	49.71 ± 2.26	49.52 ± 1.56	49.77 ± 2.06
MCH (pg)	0 day	$14.87^{a} \pm 0.44$	$18.30^{b} \pm 0.69$	$16.72^{b} \pm 0.50$	$17.25^{b} \pm 0.49$	$17.06^{b} \pm 0.72$
	14th day	15.11 ± 0.31	$14.36 \pm 1.00^{**}$	15.41 ± 0.74	$14.72 \pm 0.35^{**}$	$14.87 \pm 0.62^{**}$
MCHC (g/dL)	0 day	33.28 ± 1.52	29.53 ± 0.55	28.26 ± 1.48	29.58 ± 0.71	29.49 ± 3.85
	14th day	34.75 ± 1.57	31.75 ± 2.00	30.93 ± 1.64	31.09 ± 1.21	30.87 ± 2.58

Means bearing different superscripts (a,b) within the row differ significantly between groups ($p < 0.05$). *$p < 0.05$, **$p < 0.01$ between 0 and 14th day for a particular parameter.

Table 2: Biochemical findings in healthy (Gr A) and theileriosis infected cattle under different treatment regimens (Gr. B, C, D, E) (mean ± SE, n = 6 each)

Biochemical findings	*Stage of treatment*	*Biochemical profile in Groups*				
		A	*B*	*C*	*D*	*E*
Total protein (gm/dL)	0 day	7.05 ± 0.38	5.48 ± 0.44	5.69 ± 0.31	6.27 ± 0.54	6.25 ± 0.65
	14th day	7.33 ± 0.22	7.10 ± 0.45*	5.71 ± 0.46	6.51 ± 0.54	6.26 ± 0.64
Albumin (gm/dL)	0 day	3.63 ± 0.28	2.81 ± 0.31	2.88 ± 0.39	3.08 ± 0.16	2.97 ± 0.19
	14th day	3.62 ± 0.20	3.31 ± 0.13	3.13 ± 0.22	3.32 ± 0.09*	3.18 ± 0.23
Total bilirubin (mg/dL)	0 day	0.34 ± 0.07	0.97 ± 0.12	0.87 ± 0.16	0.86 ± 0.14	0.81 ± 0.31
	14th day	0.27 ± 0.04	0.31 ± 0.12**	0.56 ± 0.12*	0.33 ± 0.07**	0.39 ± 0.15
Glucose (mg/dL)	0 day	54.17^{b} ± 2.09	39.83^{a} ± 3.06	40.17^{a} ± 2.77	38.33^{a} ± 3.03	39.67^{a} ± 2.73
	14th day	55.83^{c} ± 1.30	51.00^{bc} ± 2.34**	44.17^{a} ± 2.21	50.17^{b} ± 1.33*	45.67^{ab} ± 1.49
AST (U/L)	0 day	85.14^{a} ± 2.48	122.02^{b} ± 8.73	108.81^{b} ± 6.95	128.85^{b} ± 7.51	113.71^{b} ± 6.09
	14th day	85.81^{a} ± 2.13	90.75^{ab} ± 3.71*	98.46^{b} ± 3.43	92.15^{ab} ± 2.63**	95.73^{b} ± 3.21**
ALT (U/L)	0 day	28.54 ± 2.07	38.39 ± 4.58	38.82 ± 4.07	40.42 ± 3.02	38.46 ± 1.68
	14th day	27.99 ± 2.52	29.72 ± 2.39*	34.53 ± 3.80*	30.67 ± 1.85*	32.68 ± 2.67**
GGT (U/L)	0 day	22.28^{a} ± 1.91	53.80^{b} ± 3.76	52.58^{b} ± 3.36	46.34^{b} ± 5.19	46.66^{b} ± 3.72
	14th day	23.08^{a} ± 2.32	36.02^{b} ± 1.59**	49.92^{c} ± 4.20	38.97^{b} ± 2.44	39.93^{b} ± 3.93**
Creatinine (mg/dL)	0 day	1.15 ± 0.14	1.13 ± 0.16	1.00 ± 0.13	1.14 ± 0.07	1.03 ± 0.15
	14th day	0.74 ± 0.10	1.05 ± 0.13	0.87 ± 0.11	1.05 ± 0.18	0.85 ± 0.10
BUN (mg/dL)	0 day	12.11 ± 0.52	11.76 ± 0.49	11.19 ± 0.34	11.06 ± 0.38	11.88 ± 1.19
	14th day	10.99 ± 0.15	10.85 ± 0.61*	10.78 ± 0.24	10.97 ± 0.41	10.45 ± 0.40

Means bearing different superscripts (a,b) within the row differ significantly between groups ($p < 0.05$). *$p < 0.05$, **$p < 0.01$ between 0 and 14th day for a particular parameter.

the harmful effect of toxic metabolites of *Theileria* spp. and due to liver failure (Aulakh and Singla, 2006). Hypoglycemia observed may be due to the utilization of glucose by *Theileria* spp. present in the blood (Sandhu *et al.,* 1998). In the present study, gamma-glutamyl transferase (GGT) and aspartate aminotransferase (AST) were increased significantly ($p < 0.05$), but total bilirubin and alanine aminotransferase (ALT) were increased non-significantly in theileriosis infected cattle as compared to healthy cattle. The higher values of serum enzyme activity found in theileriosis-infected cattle might be due to muscular trauma resulting from prolonged recumbency and hepatic dysfunction (Abubakar *et al.,* 2019). These findings concurred well with reports of Acharya *et al.* (2017) and Abubakar *et al.* (2019).

Serum creatinine and blood urea nitrogen showed non-significant differences in theileriosis infected and healthy cattle. On day 14th of treatment in theileriosis infected cattle with four different regimens, the values of these biochemical parameters had reverted to normal or near-normal levels, except a few parameters like glucose and GGT, which still differed significantly from the day '0' values, and from the healthy group in some specific treatment protocols (Table 2).

Therapeutic Management

The therapeutic efficacy of different treatment regimens in 4 groups of theileriosis-infected cattle (6 in each) was evaluated based on blood smear examinations for parasitemia before and after treatment. Out of 24 cattle treated, 21 cases (87.5%) were cured successfully. In Group B (Inj. Buparvaquone 2 dose 48 hr apart) and Group D (Inj. Buparvaquone plus Inj. Oxy LA next day) cattle, the clinical and parasitological recovery was recorded in all animals on 14th day with 100% cure rate. The recovery was also noted by elimination of parasites in the blood smear examination on the 14th day of treatment in Group C (Inj. Arteether daily for 3 days) and Group E (Inj. Arteether for 3 days plus Inj. Oxy LA 4th day), but at the lower rate of 66.66% (4/6) and 83.33% (5/6), respectively, as two and one animal in these groups did not recover completely by the respective treatment protocol (Table 3).

Overall, the efficacy of treatment regimens recorded in this study was 100.00, 66.66, 100, and 83.33% in Group B, C, D, and E, respectively. Many earlier workers have also reported similar efficacy of Buparvaquone and Arteether in theileriosis-infected cattle (Kohli *et al.,* 2014; Kumar *et al.,* 2016; Khan *et al.,* 2017; Siddiqui *et al.,* 2017; Nagar *et al.,* 2019; Khawale *et al.,* 2019).

Conclusion

From the study, it is concluded that the parenteral administration of Buparvaquone (2.5 mg/kg b.wt. twice 48 hrs apart) and Buparvaquone plus Oxytetracycline LA (20 mg/kg b.wt. 24 hr later) are therapeutically better regimens than the Arteether (5 mg/kg b.wt. for 3 days) and Arteether plus

Table 3: Post-treatment detection of parasitemia and therapeutic efficacy of different regimens in theileriosis infected cattle

Groups / Drugs	*Case no.*	*Parasitemia*		*Treatment result*	*Cure rate (%)*
		0 day	*14th day*		
Group B Inj. Buparvaquone two dose 48 hours apart	1	+++	-	Cured	6/6 (100.0%)
	2	++	-	Cured	
	3	++++	-	Cured	
	4	+	-	Cured	
	5	+++	-	Cured	
	6	+++	-	Cured	
Group C Inj. Arteether daily for 3 days	1	++	+	Not cured	4/6 (66.66%)
	2	++	-	Cured	
	3	+++	++	Not cured	
	4	++	-	Cured	
	5	++	-	Cured	
	6	+++	-	Cured	
Group D Inj. Buparvaquone plus Inj. Oxy (LA) next day	1	++	-	Cured	6/6 (100.0%)
	2	+++	-	Cured	
	3	++	-	Cured	
	4	+++	-	Cured	
	5	+++	-	Cured	
	6	+++	-	Cured	
Group E Inj. Arteether for 3 days plus Inj. Oxy (LA) 4th day	1	++	-	Cured	5/6 (83.33%)
	2	+++	-	Cured	
	3	++++	+	Not cured	
	4	+	-	Cured	
	5	++	-	Cured	
	6	+++	-	Cured	

Oxytetracycline LA (20 mg/kg b.wt. on 4th day) at the given dose rates in the treatment of theileriosis infected cattle.

Acknowledgement

The authors are grateful to the Dean of Veterinary College and authorities of AAU, Anand for the facilities and encouragement provided for this work.

References

Abubakar, A.S., Hussein, A.M., Abdelsalam, M.A., Salih, D.A., Samia, H.A., HalaElrayah., & Sara, A.M. (2019). Alterations of hematological and biochemical profile of calves infected naturally with tropical theileriosis. *American Journal of Biomedical Science Research*, *5*(3), 218-223

Acharya, A.P., Panda, S.K. & Prusty, B.K. (2017). Diagnosis and confirmation of *Theileria annulata* infection in cattle in Odisha, *Indian Journal of Entomology and Zoology Studies*, *5*(4), 1543-1546.

Aulakh, G.S., & Singla, L.D. (2006). Clinico-haemato-biochemical observations on bovines naturally infected with *Theileria annulata*. *Journal of Veterinary Parasitology*, *20*(1), 49-52.

Brahmbhatt, N.N., Kumar, B., Thakre, B.J., Parmar, V.L., Choravada, D.R., & Patel, J.A. (2019). Clinico-hematological study of theileriosis in Gir and Jaffrabadi calves. *The Indian Journal of Veterinary Sciences and Biotechnology*, *14*(04), 36-39.

Durrani, A.Z., & Kamal, N. (2008). Identification of ticks and detection of blood protozoa in Friesian cattle by polmerase chain reaction test and estimation of blood parameters in district Kasur, Pakistan. *Tropical Animal Health and Production*, *40*(6), 441-447.

Forsyth, L.M.G., Jackson, L.A., Wilkie, G., Sanderson, A., Brown, C.G.D., & Preston, P.M. (1997). Bovine cells infected *in vivo* with *Theileria annulata* express CD11b, the C3bi complement receptor. *Veterinary Research Communications*, *21*(4), 249-263.

Gachohi, J., Skilton, R., Hansen, F., Ngumi, P., & Kitala, P. (2012). Epidemiology of East Coast fever (*Theileria parva* infection) in Kenya: Past, present and the future. *Parasites Vectors*, *5,* 194.

Goyal, P. (2018). Sex related hospital prevalence of *Theileria annulata* infection confirmed by nested polymerase chain reaction in cattle-calves in Bikaner District of Rajasthan. *International Journal of Livestock Research*, *8*(5), 150-153.

Goud, K., Vijayakumar, K., & Davis, K.J. (2021). Haemato-biochemical studies of *Theileria orientalis* infection in cross bred dairy cattle. *Journal Veterinary Animal Science*, *52*(1), 42-47.

Kachhawa, J.P., Kumar, S., Sharma, A., Singh, A.P., & Ahuja, A. (2016). Studies on alterations of clinical and hemato-biochemical parameters before and after treatment in calves naturally infected with theileriosis. *Veterinary World*, *9*(12), 1381.

Kasozi, K.I., Matovu, E., Tayebwa, D.S., Natuhwera, J., Mugezi, I., & Mahero, M. (2014). Epidemiology of increasing hemo-parasite burden in Ugandan cattle. *Open Journal of Veterinary Medicine*, *4*(10), 220.

Khan, A., Ashfaq, K., Ud Din, I., ulHaq, R., Jamil, M., Ullah, B., ... & Ullah, F. (2017). Bovine theileriosis: Prevalence, estimation of hematological profile and chemotherapy in cattle in Dera Ismail Khan, Khyber Pakhtunkhwa Province, Pakistan. *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)*, *32*(1), 8-17.

Khan, I.A., Khan, A., Hussain, A., Riaz, A., & Aziz, A. (2011). Hemato-biochemical alterations in crossbred cattle affected with bovine theileriosis in semi-arid zone. *Pakistan Veterinary Journal*, *31*(2), 137-140.

Khawale, T.S., Siddiqui, M.F., Borikar, S.T., Sakhare, M.P., & Shafi, T. (2019). Efficacy of arteether against theileriosis in cattle. *Journal of Animal Research*, *9*(6), 883-888.

Kohli, S., Atheya, U.K., Srivastava, S.K., Banerjee, P.S., & Garg, R. (2014). Outbreak of theileriosis and anaplasmosis in herd of Holstein crossbred cows of Dehradun district of Uttranchal, India: A Himalyan region. *International Journal of Livestock Production*, *5*(1), 6-9.

Kumar, A., Singh, M.K., Singh, G.D., Kumari, N., & Kala, S. (2018). Bovine theileriosis and its therapeutic management in crossroad cows- A clinical study in 3 cases. *Journal of Agricultural Search*, *6*(1), 119-121.

Kumar, B., Mondal, D.B., Jithin, M.V., & Raguvaran, R. (2016). Therapeutic management of theileriosis - A clinical study of 5 bovine calves. *Intas Polivet*, *17*(1), 92-93.

Nagar, J.K., Gurjar, T., Mali, M.M., Bargujar, J., Meena, O., & Kumar, A. (2019). Therapeutic management of theileriosis in bovines. *Journal of Veterinary Parasitology, 4*(1), 12-14.

Naik, B. S., Maiti, S. K., &Raghuvanshi, P. D. S. (2016). Prevalence of tropical theileriosis in cattle in Chhattisgarh State. *Journal of Animal Research*, *6*(6), 1043-1045.

Ngumi, P.N., Young, A.S., Lampard, D., Mining, S.K., Ndungu, S.G., Lesan, A.C., & Kariuki, D.P. (1992). Further evaluation of the use of buparvaquone in the infection and treatment method of immunizing cattle against *Theileria parva* derived from African buffalo (*Syncerus caffer*). *Veterinary Parasitology*, *43*(1-2), 15-24.

Pandey, V., Nigam Rajesh, Bachan, R., Sudan, Vikrant., Jaiswal, A.K., Shanker, D., & Yadav, Brijesh. (2017). Oxidative and haemato-biochemical alterations in theileriosis affected cattle from semi arid endemic areas of India. *Indian Journal of Animal Sciences*, *87*(7), 846-850.

Radostits, O. M., Gay, C. C., Hinchcliff, K. W., & Constable, P. D. (2008). Anaplasmosis. In: *Veterinary Medicine: A textbook of the diseases of cattle, horses, sheep, pigs, and goats*. 10th edn., Saunders, Elsevier, pp. 1455-1459.

Sandhu, G.S., Grewal, A.S., Singh, A., Kondal, J.K., Singh, J., & Brar, R.S. (1998). Haematological and biochemical studies on experimental *Theileria annulata* infection in crossbred calves. *Veterinary Research Communications*, *22*(5), 347-354.

Saravanan, M., Ranjithkumar, M., Bapu Prasanth, N., Yogeshpriya, S., Jayalakshmi, K., & Kannan, K. (2017). Clinical, hematological changes and therapeutic efficacy of buparvaquone with oxytetracycline against the natural infection of *Theileria annulata* in cattle. *International Journal of Livestock Research*, *7*(10), 128-133.

Siddiqui, M.F., Waghmare, S.P., Mode, S.G., Rekhate, D.H., Kolte, S.W., Hajare, S.W., & Ali, S.S. (2017). Phyto-pharmacological study and therapeutic efficacy of *Calotropisprocera* (flower) against theileriosis in cattle. *Journal of Animal Research*, *7*(4), 757-762.

Snedecor, G.W., & Cochran, W.G. (1994). *Statistical Methods*. 8th edn. Iowa State University Press, Ames, Iowa, USA.

Tuli, A., Singla, L.D., Sharma, A., Bal, M.S., Filia, G., & Kaur, P. (2015). Molecular epidemiology, risk factors and haematochemical alterations induced by *Theileria annulata* in bovines of Punjab (India). *Acta Parasitologica*, *60*(3), 378-390.

Ugalmugle, S.S., Jayraw, A.K., & Gatne, M.L. (2010). Prevalence and clinical pathology of bovine tropical theileriosis in crossbred population of Ahmednagar district of Maharashtra. *Journal of Veterinary Parasitology*, *24*(2), 141-145.