Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(6): 1420-1425
Received: 01-09-2019
Accepted: 03-10-2019

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Haemato-biohemial alterations and comparative efficacy of different therapeutic regimen against trypanosomosis in buffaloes

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Abstract
The present study was conducted to know the haemato-biochemical alternations and to compare the therapeutic efficacy of different anti-trypanosomal drugs in buffaloes. Total of 118 buffaloes of either sex, age group and parity were screened for trypanosomosis. The haematological alternations in the infected buffaloes showed decreased pre treatment values of Hb, PCV, TEC which got increased on 3rd and 7th day post treatment in all the groups. But Erythrocytic indices remained altered with no significance. The mean value of TLC (10^3/µl) noted markedly decreased on post treatment in all the groups.The biochemical studies revealed no alternation in the mean values of Total protein in all the treated groups on post treatment than the pre treatment mean values 1st day. On the contrary, marked increased mean values of glucose have been obtained on 3rd and 7th days post treatment in the T3 group. The AST values found under study were reported to be significantly reduced in all the groups post treatment, but maximum reduction was obtained in T3 groups on day 3rd day 7th. It was concluded that out of the drugs used isometamidium chloride was found to be most effective as evident by the maximum clinical recovery.

Keywords: Trypanosomiasis, hemoprotozoan, buffaloes, hemato-biochemical

Introduction
Trypanosomosis is a haemoprotozoan disease entity caused by various members of Trypanosoma spp affecting different species of domestic and wild animals like horses, camel, cattle, buffaloes, deer, foxes, tiger and jackals with clinical signs as intermittent fever, anaemia, loss of weight, edema of dependent parts, nervous symptoms and abortion (Jaiswal *et al.*, 2015) [17].

Bovine trypanosomosis (Surra) caused by Trypanosoma evansi is an important haemoprotozoan disease of buffalo which is characterized by high temperature, progressive anaemia and cutaneous eruptions. Infection is mechanically transmitted by blood-sucking insects of the genera Tabanus, Stomoxys etc but in India mostly by tabanid biting files (Vijay *et al.*, 2002) [30].

It is a major killer disease of livestock that leads to major economic losses to the farmers in view of morbidity and mortility, decreased milk yield. Extensive use of trypanocides and by interference with vaccination programme of domestic animals in India. The parasite causes severe anemia, edema, immune suppression and various neurological signs by entering the nervous tissue resulting in death of affected animals. It is repetation in cattle and buffaloes act as carriers most frequently in some of the parts in india.

Trypanosomosis directly affects the productivity of cattle by reducing birth rates, increasing abortion rates and increasing mortality rates (Mersha *et al.*, 2013) [20].

In India, diminazene aceturate, Quinapyramine sulphate and chloride (Antrycide Prosalt) and Quinapyramine sulphate (Antrycide) are currently available drugs for treatment and prophylactic use against trypanosomosis in domestic animals (Ponnudurai *et al.*, 2015) [26].

Material and methods
Location and place of work
The work was conducted in the Department of Veterinary Medicine, College of Veterinary Science and Animal Husbandry, Nanaji Deshmukh Veterinary Science University (NDVSU), Jabalpur and nearby dairy farms in and around Jabalpur.

Animals
A total of 118 animals were screened on the basis of common clinical signs of trypanosomosis viz. Anorexia, temperature, edema of dependent parts, head pressing, excitement, circling, salivation, ocular discharge etc.

Collection of samples for diagnosis
Five ml blood was collected aseptically from jugular vein of each animals with the help of 18 gauge needle and stored in clean, dry, sterilized labelled glass vials containing EDTA @ 1mg/ml of blood. Serum was separated and preserved at 4 degree Celsius in refrigerator and analyzed for biochemical investigations.

Diagnostic study
Diagnosis of trypanosomosis was done on the basis of Parasitological examination. Following techniques were used for the diagnosis of Trypanosomosis.

Blood Smear Method: Giemsa stain
A small drop of blood was placed 20 mm from one end of a clean microscopic slide and a thin film is drawn. The film was air-dried briefly, fixed in absolute methanol for 2 minutes and allowed to dry. The smears were then stained by Giemsa (1 ml Giemsa + 9 ml Distilled Water) for 25 minutes then the slide was washed in tap water and dried. Slides were seen under microscope at 100x using imersion oil (Jain, 1986) [16].

Analysis of haematological parameters
All the haematological parameters were estimated by using semi automated haematology analyzer (MODEL ABACUS) on day 1 (pre-treatment) and day 3rd and 7th (post-treatment).

- Total Erythrocyte Count (millions/µl)
- Haemoglobin concentration (g/dl)
- Packed Cell Volume (%)
- Total Leukocyte Count (thousands/µl)
- Erythrocyte indices

Analysis of biochemical parameters
All the biochemical parameters were estimated by using semi automated biochemical analyzer (MODEL ERBA) at day 1 (pre-treatment) and day 3rd and 7th (post-treatment) following the standard protocol. The parameters included.

- Total protein (g/dl) – by using Total protein kit.
- Glucose (mg/dl) – by using Glucose kit.
- AST (Aspartate Aminotransferase) (U/l) - by using SGOT kit.

Experimental Design
For therapeutic study, a total of 18 positive animals were randomly divided into 3 treatment groups (T_1, T_2 and T_3) whereas 6 normal healthy animals were served as the control group (T_c).

Table 1: Experimental design for therapeutic study

Groups	No. of animals	Treatment
T_c	6	Healthy control
T_1	6	Quinapyramine sulfate (@ 5 mg/kg body weight by S/C SD) and Enrofloxacine (@ 5 mg/kg body weight I/M) for 3 days along with supportive therapy.
T_2	6	Diminazene aceturate (@ 5 mg/kg body weight by deep I/M SD) and Enrofloxacine (@ 5 mg/kg body weight I/M) for 3 days along with supportive therapy.
T_3	6	Isometamidium chloride (@ 0.5 mg/kg body weight deep I/M SD) and Enrofloxacine (@ 5 mg/kg body weight I/M) for 3 days along with supportive therapy.

The supportive therapy included antipyretic, fluid therapy, iron preparation etc. as per clinical observations.

Results and discussion
T. evansi is a major killer disease of livestock, which causes considerable economic losses to the farmers in term of morbidity and mortality, decreased milk yield, extensive use of trypanocides and by interference with vaccination programmes of domestic animals in India.

Clinical symptoms observed in affected buffaloes
The most pertinent clinical signs observed in the buffaloes affected with trypanosomosis were temperature (88.13%), anorexia (82.20%), depression (77.96%), reduced milk yield (73.72%), salivation (63.55%), ocular discharge (58.47%), excitement (34.74%) and head pressing in 33.05%.

Table 2: Clinical Symptoms Observed in infected Buffaloes

S. No.	Clinical Symptoms	No. of Buffaloes	Frequency Distribution (%)
1.	Anorexia	18	100
2.	Temp.	18	100
3.	Depression	14	77.77
4.	Reduced milk yield	15	83.33
5.	Emaciation	05	27.77
6.	Anemia	04	22.22
7.	Oedema	05	27.77
8.	Head pressing	08	44.44
9.	Excitement	09	50
10.	Circling	13	72.22
11.	Exopthalmia	01	5.55
12.	Corneal opacity	02	11.11
13.	L.N. Enlargement	0	0
14.	Salivation	08	44.44
15.	Occular discharge	11	61.11
16.	Generalized paralysis	0	0
17.	Muscular twitching	0	0

Nervous signs i.e., severe convulsions, tremors, circling movement and recumbancy were seen by Nariadkar *et al.* (2006) [23] in buffaloes suffered with trypanosomosis. However, Bhatia *et al.* (2006) [7] and Agrawal (2016) [2] have also found the similar clinical signs viz. anorexia, temperature, anaemia, excitement and reduced milk yield as reported under the present study.

On the contrary, Palanivel *et al.* (2008) [25] reported laboured breathing, lacrymation, ballowing, profuse salivation, icterus and twitching of muscles of slow frequency as the most pertinent signs of trypanosomosis.

Though the disease is mostly asymptomatic but factors like, vaccination, malnutrition, transport etc. often convert's these infection into clinical form and as a result the clinical signs of variable intensity and frequency are developed (Jaiswal *et al.*, 2015) [17].

Nervous signs like incordination of gait, circling movements, head pressing and excitement were seen which may be due to chronic infection resulting in invasion of brain by *T. evansi* (Tuntavusan, 1997) [29].

The presence of oedema in the infected buffalo recorded in the study may probably due to the slight decreased mean values of Total protein which resulted in hypoproteinemia.

Bovine trypanosomosis induces oxidative stress in erythrocyte and also reduces the anti-oxidant capacity of RBC causing tissue damage.

Trypanosome releases sialidase and phospholipase that damages the erythrocyte membrane causing oxidative stress, the affected buffaloes were observed to be indicating exhaustion of immune system.

Hypoglycemia reported in trypanosomosis, may be because of the utilization of glucose from the erythrocyte by the parasites for the growth and multiplication which is compensated by cure with antitrypanocidal which not only kills the parasite and there by prevent the utilization of glucose. Moreover, the intravenous fluid therapy given was also be an aid to decrease the glucose mean value post treatment.

The anaemia reported in infected buffaloes was due to lysis of erythroyte and erythrophagocytosis caused by the trypanosome parasite. Later on, increased erythrocytic mean values reported may probably be due to the action of trypanocidal drug on the parasite and haematinic given under the treatment in the present study.

Haematological alternations

The haematological studies involved estimation of Haemoglobin (Hb), Packed cell volume (PCV), Total erythrocyte count (TEC) and Total leucocyte count (TLC) in the blood samples obtained from the Healthy Control group and buffaloes suffered from trypanosomosis under the present investigation. The findings of the present study indicated decreased mean value of Hb, PCV and TEC on pre-treatment (1st day), than the normal mean values as obtained in healthy buffaloes. Later on a gradual increased mean value of these parameters were reported on day 3rd and 7th post-treatment in all the treatment groups. However, in the buffaloes treated under T3 group the haematological mean values were reported to be increased upto the maximum. Whereas, the mean values of Total leucocyte counts (TLC) were observed to be increased on day 1st (Pre-treatment) from the normal mean values obtained in control group which further got gradually decreased on day 3rd and 7th post-treatment in all the treatment groups but maximum decreased mean value of TLC were observed on day 3rd (11.42 10^3/µl) and day 7th (9.87 10^3/µl) post-treatment in T3 group.

Table 3: Total Erythrocyte count (10^6/µl) in buffaloes in different treatment groups at different intervals

Day	TC	T1	T2	T3
1	$7.55^a \pm 0.21$	$4.12^c \pm 0.16$	$4.39^c \pm 0.05$	$4.41^c \pm 0.15$
3	$7.58^a \pm 0.20$	$4.47^b \pm 0.10$	$5.43^b \pm 0.22$	$5.22^b \pm 0.20$
7	$7.57^a \pm 0.20$	$5.18^a \pm 0.07$	$6.02^a \pm 0.20$	$6.35^a \pm 0.33$

Means of days within a group with the same superscript did not differ significantly

Table 4: Haemoglobin (g/dl) in buffaloes in different treatment groups at different intervals

Day	TC	T1	T2	T3
1	$11.45^a \pm 0.45$	$7.43^b \pm 0.17$	$7.35^b \pm 0.19$	$7.06^c \pm 0.09$
3	$11.47^a \pm 0.45$	$8.05^a \pm 0.17$	$8.31^{ab} \pm 0.19$	$8.22^b \pm 0.20$
7	$11.47^a \pm 0.44$	$8.53^a \pm 0.21$	$9.17^a \pm 0.61$	$8.98^a \pm 0.25$

Means of days within a group with the same superscript did not differ significantly

Table 5: Packed cell volume (%) in buffaloes in different treatment groups at different intervals

Day	TC	T1	T2	T3
1	$33.59^a \pm 0.50$	$25.33^b \pm 0.88$	$22.30^c \pm 0.43$	$24.33^c \pm 0.78$
3	$33.61^a \pm 0.50$	$27.64^b \pm 0.72$	$25.05^b \pm 0.58$	$27.30^b \pm 0.39$
7	$33.60^a \pm 0.49$	$31.47^a \pm 0.76$	$29.32^a \pm 0.70$	$31.42^a \pm 0.46$

Means of days within a group with the same superscript did not differ significantly

Table 6: Total leucocyte count (10^3/µl) in buffaloes in different treatment groups at different intervals

Day	TC	T1	T2	T3
1	$8.16^a \pm 0.18$	$12.72^a \pm 0.20$	$12.99^a \pm 0.13$	$12.93^a \pm 0.19$
3	$8.20^a \pm 0.18$	$11.83^b \pm 0.24$	$11.42^b \pm 0.34$	$11.42^b \pm 0.33$
7	$8.25^a \pm 0.18$	$10.79^c \pm 0.29$	$10.02^c \pm 0.24$	$9.87^c \pm 0.31$

Means of days within a group with the same superscript did not differ significantly

Furthermore, the mean values of erythrocytic indices on pre treatment and post-treatment showed no significant alternations in any of the treatment group.

Table 7: Mean corpuscular volume (fl) in buffaloes in different treatment groups at different intervals

Day	TC	T1	T2	T3
1	$44.55^a \pm 0.65$	$47.46^a \pm 0.66$	$65.29^a \pm 2.94$	$55.60^a \pm 3.29$
3	$44.43^a \pm 0.66$	$46.13^b \pm 1.93$	$65.47^a \pm 1.37$	$52.54^a \pm 3.04$
7	$44.47^a \pm 0.68$	$48.72^b \pm 1.06$	$63.16^a \pm 0.97$	$49.62^a \pm 3.68$

Means of days within a group with the same superscript did not differ significantly

Table 8: Mean corpuscular haemoglobin (pg) in buffaloes in different treatment groups at different intervals

Day	TC	T1	T2	T3
1	$15.15^a \pm 0.40$	$18.07^a \pm 1.11$	$16.07^a \pm 0.52$	$16.95^a \pm 0.47$
3	$15.12^a \pm 0.41$	$18.79^a \pm 0.66$	$15.80^a \pm 0.45$	$14.82^b \pm 0.60$
7	$15.15^a \pm 0.41$	$19.38^a \pm 0.35$	$14.58^a \pm 0.70$	$14.16^b \pm 0.42$

Means of days within a group with the same superscript did not differ significantly

Table 9: Mean corpuscular haemoglobin concentration (g/dl) in buffaloes in different treatment groups at different intervals

Day	TC	T1	T2	T3
1	$34.04^a \pm 0.94$	$29.16^a \pm 0.98$	27.62 ± 0.82	$35.73^a \pm 0.95$
3	$34.07^a \pm 0.96$	$30.41^a \pm 1.32$	28.68 ± 0.63	$32.79^a \pm 1.35$
7	$34.10^a \pm 0.94$	$31.52^a \pm 1.34$	30.44 ± 0.83	$31.18^a \pm 1.66$

Means of days within a group with the same superscript did not differ significantly

The overall mean PCV value was reported to be statistically significant different between aparasitaemic and parasitaemic cattle (Dereje *et al.*, 2018) [9].

Under the present study the decreased mean values of total leucocyte counts (TLC) on pre-treatment with gradual increased on post-treatment in all the groups were obtained.

The reduction in Hb, PCV and TEC was because of the liberation of the toxins or proteolytic enzyme by the trypanosome that results in the severe anemia and death which is considered as an indication of severe disease. The injury of the erythrocyte may be due to lashing action of the parasites. These toxins are responsible for lysis of erythrocyte, inhibition of haemopoietic system and due to erythrophagocytosis (Bal *et al.* 2014) [6]. The findings of the present study are in agreement with the findings of Abeer *et al.* (2011) [1] and Fetehanges *et al.* (2012) [11].

Dargantes *et al.* (2009) [8] mentioned that anaemia is a reliable indicator of trypanosomosis but mild sub clinical infection can have parasitemia without evidence of anaemia, our observations are also in confirmatory with those of Nariadkar *et al.* (2006) [23] who have also reported increased TLC on blood smear examination in the infected buffaloes. Similar observations are reported under the present study revealed decreased mean value of TLC on post-treatment in all the groups where as increased mean values of TLC on pre-treatment.

However, no remarkable alternations in the mean value of erythrocytic indices i.e MCV (fl), MCH (pg), MCHC (g/dl) were observed under study.

Biochemical alternations

Biochemical alternations are the indication of the functional state of the various body organs, which results from infections and depends on the species of the parasite and its virulence (Anosa, 1988) [5].

Total Protein (T.P)

The total protein mean values in the control group were found between 7.16 (g/dl) to 7.17 (g/dl) which were observed to be decreased from the normal value on pre-treatment (day 1). Later on, these mean values were found to be gradually increased in all the treatment groups on post-treatment i.e., on 3rd and 7th day. The overall conclusion revealed no significant alternations in total protein on day 1st in all the groups as compared to the healthy control under the study.

Table 10: Total protein (g/dl) in buffalo in different treatment groups at different intervals

Day	TC	T1	T2	T3
1	$7.16^{a} \pm 0.013$	$6.93^{b} \pm 0.02$	$6.95^{c} \pm 0.02$	$6.92^{b} \pm 0.02$
3	$7.17^{a} \pm 0.01$	$6.98^{ab} \pm 0.02$	$6.99^{b} \pm 0.01$	$6.99^{a} \pm 0.02$
7	$7.17^{a} \pm 0.01$	$7.02^{a} \pm 0.02$	$7.06^{a} \pm 0.01$	$7.04^{a} \pm 0.02$

Means of days within a group with the same superscript did not differ significantly

Moreover no significant change in total protein on days 3rd and 7th post treatment in all the treatment groups were recorded. On the contrary, elimination of mean values of total protein have been obtained by Anosa and Isoun (1976) [4]. Further Anosa (1988) [5] reported that severity of disease influences the total protein levels and may be responsible for variability in the levels of serum protein level.

On the basis of results obtained it can be concluded that changes in total protein are multifactorial in nature, depending on the severity of infection and immunologic power of animal. Similar results have been obtained by Mishra *et al.* (2017) [22].

Glucose

Under the present study the mean values of blood glucose obtained to be lower than the mean values of control groups which got increased on post treatment at different intervals in different groups. However, maximum increase in glucose mean values obtained in T3 group on day 3rd (47.17 mg/dl) and 7th day (55.77 mg/dl) post-treatment. Similar results were obtained by Mishra *et al.* (2017) [22].

Table 11: Glucose (mg/dl) in buffaloes in different treatment groups at different intervals

Day	TC	T1	T2	T3
1	$53.61^{a} \pm 0.52$	$36.42^{c} \pm 0.46$	$35.98^{c} \pm 0.48$	$34.97^{c} \pm 0.36$
3	$53.63^{a} \pm 0.52$	$47.66^{b} \pm 0.50$	$48.21^{b} \pm 0.51$	$47.17^{b} \pm 0.45$
7	$52.38^{a} \pm 1.36$	$55.44^{a} \pm 0.55$	$55.11^{a} \pm 0.62$	$55.77^{a} \pm 0.42$

Means of days within a group with the same superscript did not differ significantly

The blood glucose level is a useful indicator of overall energy balance in buffaloes as decrease in circulatory glucose concentration indicating induction of some degree of negative energy balance in buffaloes (Hagawane *et al.* 2009) [13].

The estimation of glucose is of paramount importance because the parasite utilizes the glucose for their growth and multiplication in the blood resulting in hypoglycemia Juyal *et al.*, 2005 [18] and Bal *et al.*, 2014 [6].

The parasite consumes large amount of blood sugar resulting in disturbance in hepatic function, hypoglycemia with fetal intoxication. Trypanosome also disturb the carbohydrate metabolism resulting in hypoglycemia which may attribute to malnutrition of adrenal, thyroid, pancreas etc. due to consumption of glucose by the parasite (Narladkar, 2006) [23].

Aspartate Aminotransferase (AST)

The trypanosome may lead to hepatic dysfunction there by increased AST values were obtained in infected buffaloes on pre-treatment day which got decreased on post-treatment days in all the groups. However, the highest increased mean values of AST were recorded in the buffalo treated under T3 group on post-treatment i.e., day 3rd (125.69 U/L) and day 7th (119.99 U/L).

Table 12: Aspartate aminotransferase (U/L) in buffaloes in different treatment groups at different intervals

Day	TC	T1	T2	T3
1	$92.93^{a} \pm 3.44$	$131.65^{b} \pm 1.75$	$133.16^{a} \pm 1.38$	$132.38^{a} \pm 1.07$
3	$92.95^{a} \pm 3.44$	$127.45^{b} \pm 0.78$	$126.77^{b} \pm 1.7$	$125.69^{b} \pm 1.37$
7	$92.94^{a} \pm 3.44$	$123.80^{a} \pm 1.31$	$121.56^{c} \pm 1.9$	$119.99^{c} \pm 1.41$

Means of days within a group with the same superscript did not differ significantly

In the present study the higher mean values of AST in the infected buffaloes were found which are in agreement with the findings of Anene *et al.* (2011) [3] and Omejea *et al.* (2012) [24].

Further the decreased mean values of AST obtained could be due to the hepato-protective drug given to correct the hepatic damage in the infected buffaloes caused by trypanosomes.

Diagnostic Procedure

Though various diagnostic tests from traditional to molecular are available, but microscopic examination of blood smears is best diagnostic recommended test for Surra.

In the present study in fresh Giemsa stained smears *T. evansi* was seen peculiar with slender shape and having thin posterior extremity and free flagellum on 1st day. But on 3rd and 7th day post-treatment the blood smear was found to be negative. Sometimes intermediate farms of parasite with shorted free flagellum are also observed also in some cases small stumpy forms of parasites are also reported but with an in consistent feature (Hoare, 1972) [15].

These results were in agreement with Herbart and Lumsden (1976) [14] who found that when parasites number less than 2500,000 per ml present in blood samples microscopic detection is not feasible.

Getachew *et al*. (2014) [12] reported 24% PCV in parasitaemic and 26% in non parasitimic animals whereas, Migri *et al.* (2016) [21] decided the level of parasitimia as 82.2% mild 11.29% moderate and 6.45% high correlation of parasitaemia with those of clinical status of the diseases.

Therapeutic study

Under the present study the Diminazine Aceturate (@ 5mg/kg B.Wt. deep I/M SD) was used for the treatment of infected buffaloes whereas, Desquesnes *et al.* (2013) [10] advocated the dose of the drug @ 7mg/kg b.wt. by I/M route in ruminants as a chemoprophylaxis as they not only kill the parasite but also prevent the new infection.

However, Desquesnes *et al.* (2013) [10] also recommended the dose rate of Isometamidium chloride @ 0.5mg/kg b.wt. deep I/M in the case which have developed the resistance against Diminizine Aceturate.

Jaiswal *et al.* (2015) [17] have emphasized the use of quinapyramine (@ 4.4mg/kg b.wt.) and Isometamidium (@ 0.5mg/kg b.wt.) to have good therapeutic activity while quinapyramine was found better than Isometamidium for prophylaxis in buffaloes naturally infected with *T. evansi*.

Malik and Dewidi (1981) [19] recommended diminizine Aceturate @ 10-15mg/kg b.wt. was quite effective for treatment of clinical bovine Surra where as Singh and Joshi (1991) [27] recommended that single dose of Diminizine @ 10mg/kg b.wt. was not effective as a prophylactic drugs because persistent of *T. evani* was in treated buffalo 48 and 38 days after treatment. On the contrary, low dose of diminazine aceturate under the trial was used.

Juyal *et al*. (2005) [18] recommended the dose of 3 anti trypanosomal drugs for bovine trypanosomosis as Antrycide methyl sulphate @ 3mg/kg b.wt. S/C as 10% solution, Diminazene Aceturate @ 3.5mg/kg b.wt. I/M & isometamedium chloride @ 1mg/kg b.wt. I/M.

Curative drugs aim to eliminate all the parasites from a sick animal in a specific dose as Diminezene aceturate is most widely used as curative trypanocide against surra. The withdrawal period of drug is 3 days for milk. The dose is 7 mg/kg body weight by Intramuscular injection in ruminants.

These drugs are used for chemoprophylaxis as they not only kill the parasites but also prevent only new infection or new circulation of parasites due to the remanence of sustainable curative dose in the serum of animals under chemoprophylaxis.

T. evansi infections releases sialidase and phospholipase that damages the erythrocyte membrane causing oxidative stress in RBC's and reduces the antioxidant capacity of RBC. Trypanosoma affected buffaloes showed hypoglycemia, anaemia with hepatotoxicity (Sinha *et al.*, 2013) [28].

Increased AST values decreased glucose level with haematological mean values which on post-treatment decreased showed marked improvement in all clinico haemato-biochemical alternations in all the groups but maximum clinical recovery and higher mean values were obtained in the buffaloes treated in T3 group using isometamidium chloride with Enrofloxacine @ 5mg/kg b.wt. I/M for three days along with I/V fluid therapy, haematinic, hepatoprotective, antipyretic drugs.

So, out of the three anti trypanosomal drugs Quinapyramine sulfate in (T1), Diminazene aceturate in (T2) and Isometamidium chloride in T3. Isometamedium was found more effective than diminazine aceturate and quinapyramine sulphate.

At last, due to the more complex epidemiology of *T. evansi* as a result of diversity of its hosts and vectors it shows extremely variable clinical effects as per the host and the geographical area. The characteristic surra is not only a multispecies but also a polymorphic disease. In fact it may even constitute a complex of diseases induced by a group of parasites named *T. evansi*.

Though efforts for development of vaccine are made by the researchers but they could not succeeded because of capacity of parasite to modulate its own antigen (antigenic variation) i.e ability of parasite to regularly switch it surface coat glycoprotein and maintain immunodeficiency to the host.

The control of *T. evansi* infection is complex as reliable epidemiological information is lacking. However, following adaptive measures such as use of chemoprophylactics, eradication campaigns are being suggested

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