

The effect of melarsenoxyde cysteamine hydrochloride (Cymelarsan®) on the clinico-pathology of an experimental *Trypanosoma evansi* infection in dromedary camels (*Camelus dromedarius*)

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Abstract

The effect of Cymelarsan® on clinicopathology of *Trypanosoma evansi* infection in camels was evaluated. Groups B and C served as infected and uninfected controls respectively. Groups A and D served as infected/treated and uninfected/treated respectively. All parameters were determined using standard methods. A pre-patent period of 4 days in *T. evansi* experimentally infected dromedaries was accompanied by pyrexia; staring fur coat; depression; anorexia; pallor of ocular and buccal mucous membranes; oedema of the brisket; circling gait; elevated pulse, respiratory and heart rates; enlarged retropharyngeal lymph nodes; weight loss; and death. In Group B, parasitaemia reached its peak (400.2 ± 2.50) value by day 36 post-infection (p.i.) as PCV declined significantly ($p < 0.05$) to 12.0 ± 0.43). Mortality was 100% in Group B and 0% in the other groups. At necropsy, 15.3 liters of serosanguineous fluid was seen in the peritoneal cavity following rupture of the spleen in 3 of the dromedaries in Group B. The heart had ecchymotic haemorrhages while the retropharyngeal lymph nodes and kidneys appeared enlarged and congested. Histopathologically, degeneration of myocardial fibers was seen while the kidneys had glomerulosclerosis. The lymph nodes appeared highly reactive while the spleen had considerable haemosiderosis. The brain had areas of multi-focal congestion while calcification of the seminiferous tubules and eruption of spermatogenic cells was seen in the testis. It is therefore concluded that *T. evansi* caused severe clinicopathological effects which were alleviated following treatment with Cymelarsan®.

Keywords: clinico-pathology, Cymelarsan®, dromedary camel, *Trypanosoma evansi*

Introduction

Camel trypanosomosis, commonly called 'surra', is caused by

Trypanosoma evansi, a haemoflagellate belonging to the sub-genus *Trypanozoon* (Soulsby, 1982). The disease is responsible for severe

economic losses in camel producing areas as well as in other livestock, dogs and some wildlife in Asia and South America (Njiru et al., 2002; Enwezor and Sackey, 2005). Outbreaks of surra have been reported in the Pantanal, Brazil, and in several other countries in South and in Latin America among cattle and horses (Silva et al., 1995; Davila and Silva, 2006) and captive Asian tigers (*Panthera tigris*) in Nandankanan Zoo (Parija and Bhattacharya, 2005). Previously it was thought that *T. evansi* infection was exclusive to animals; however, recent report of its occurrence in India showed that it can affect humans (Joshi et al., 2006; Desquesnes et al., 2013). The disease in camels has a duration of 7–42 days (Cadioli et al., 2006) and occurs either in the acute or chronic form (Aradib and Majid, 2006), followed by a significant immunosuppressive effect (Njiru et al., 2004), infertility and retarded growth (Gutierrez et al., 2000). Terminally, the infection results in emaciation and death in chronic cases (Cadioli et al., 2006).

In as much as information on the chemotherapy of surra in animals exists, such information remains scanty for dromedaries experimentally infected with *T. evansi* and the effect of Cymelarsan® in alleviating the typical symptom of the attendant disease and its deleterious effect on organs and tissues. It is with this view that camels were experimentally infected with a field strain (CT/29) of *T. evansi* to study the effect of melarsenoxide cysteamine hydrochloride (Cymelarsan®), a trivalent arsenical, in reversing the clinical changes in the

animal and the gross and histopathological changes in various organs and tissues.

Materials and methods

Experimental Animals

Twenty apparently healthy camels (*Camelus dromedarius*) of both sexes (11 males and 9 females) aged 3–4 years and weighing 300–337 kg were purchased from Maiduguri Cattle Market in the arid region of north eastern Nigeria. They were routinely screened for blood, intestinal and external arthropod parasites according to standard methods (Hansen and Perry, 1994) and were all found to harbor only *Strongyle* species in their faeces. Thereafter, they were dewormed orally with morantel (Pfizer LTD, USA) at 400mg/kg. They were kept for 60 days acclimatization period at the Large Animal Clinic of the Veterinary Teaching Hospital of the Faculty of Veterinary Medicine, University of Maiduguri, Nigeria, where the experiment was conducted. It lies between latitude 12°N and 14°N and longitude 13°E and 15°E. The animals were housed on concrete-floored and fly-proof houses and fed lush grasses, groundnut husks, wheat bran, fresh acacia leaves, chopped cucumbers, watermelons and concentrates; and water was provided *ad libitum*. The experiment was approved by the Ethics Committee of the Faculty of Veterinary Medicine, University of Maiduguri. All handling and experimental procedures were in accordance with the international guidelines for the use of animals for biomedical research (Brooms and Johnson, 1993).

Source of trypanosomes

The field strain used for the study was isolated in the course of the study from a natural infection of surra in camels at the Department of Veterinary Microbiology and Parasitology, Faculty of Veterinary Medicine, University of Maiduguri, Nigeria. Initial identification was based on morphology and negative blood inhibition and infectivity test (BIIT), stabilized in Wister albino rats and then sent to the Nigeria Institute for Trypanosomosis and Onchocercosis Research (NITOR) Vom, Nigeria, where it was authenticated as *T. evansi*, using polymerase chain reaction, (PCR) and assigned the strain number (CT/29). Approximately 1×10^3 trypanosomes per ml was injected into 6 donor Wister albino rats in order to multiply the trypanosomes which were monitored for development of parasitaemia until 5×10^3 trypanosomes per ml of blood was achieved. The infected blood was diluted serially with phosphate buffered saline glucose (PBSG, pH 7.2) until 1×10^3 trypanosomes per 0.5ml was obtained. Subsequently, each camel was inoculated intravenously via the prominent lateral abdominal vein with a uniform dose (0.5 ml) of the inoculums.

Experimental design

The camels were randomly separated into four groups (A-D) of five each. Group A was infected but treated via the intramuscular route with a single dose of melarsenoxyde cysteamine hydrochloride bis (amino ethylthio)-4 melamino-phenylarsine dihydrochloride (Cymelarsan®) at a

dose rate of 0.25mg/kg as recommended by the manufacturers (Meriel, France) by day 20 post-infection (p.i.) at the peak of parasitaemia. Group B was the infected / untreated control, while Group C served as uninfected control. Group D was uninfected but treated with Cymelarsan® by day 20 (p.i.). The work was conducted during the rainy season in September 2013 with an average rainfall of 166 ± 3.88 and an ambient temperature of 35°C .

Detection of parasitaemia

Parasitaemia were determined every 4 days by the wet mount and haematocrit buffy coat microscopy (Soulsby, 1982) for 36 days (p.i.) when the experiment was terminated following the death of all the camels in the infected control (Group B). Thereafter, those that were infected but treated (Group A) were monitored for a period of 12 months for the possibility of a relapse parasitaemia. The degree of parasitaemia was estimated by the rapid matching technique (Herbert and Lumsden, 1976).

Haematological analysis

Blood samples were collected aseptically every 4 days for a period of 36 days via the prominent lateral abdominal vein into vacutainers containing anticoagulant (ethylenediaminetetracetate). Packed cell volume (PCV) was determined by the microhaematocrit centrifuge technique as described by Woo (1969).

Clinical parameters

Rectal temperature was determined using thermometer,

respiratory rate was determined by counting the rise and fall of the flank per minute, heart rate was determined by auscultation of the heart beat per minute using stethoscope (Littmann®) while the pulse rate was determined by feeling the pulsation of the femoral artery per minute as described by Radostitis et al. (1997). All the parameters were taken twice daily in the morning between 7am and 10am. Physical changes in hair coat, colour of mucous membranes, appetite, body condition, palpation of lymph nodes, and behavioral changes were observed and recorded daily. The weight of the camels were determined using the Tru-Test® multipurpose digital livestock scale (Algen Scale Corporation Bohemia, New York) model XHD with extra heavy load bars and an aluminum alloy weight platform placed inside a crush.

Gross and histopathology

Following the death of all the camels in Group B (infected control) at day 36 d.p.i., and some that were euthanatized (n=2) per Groups, A, C and D also by day 36 d.p.i., the animals were subjected to detailed necropsy. The brain, heart, spleen, lungs, livers, kidneys, lymph nodes, testis and ovaries were collected, weighed and carefully examined for the presence of gross lesions. Samples from these organs were collected and fixed in 10% formalin, embedded in paraffin wax, sectioned at 5µm, stained with haematoxyline and eosin stain (H&E) as described by Drury and Wallington (1976). The stained sections were examined under various magnifications of the light

microscope (Olympus, Japan model BX51) for histopathological lesions.

Statistical analysis

The data obtained from the study were summarized as means \pm standard deviation and the differences between the means determined at 5% level of significance using the analysis of variance ANOVA (Graph Pad Instat 2000).

Results

Parasitaemia

The mean parasite count of the camels infected with *T. evansi*, treated with Cymelarsan® with the infected and untreated controls is presented in Figure 1. In Groups A and B infected with the parasite, a uniform pre-patent period of 4 days was observed. In Group A, the parasitaemia reached a peak count of 210.2 ± 1.81 by day 20 (p.i.). Following treatment with Cymelarsan®, the parasitaemia declined significantly ($p < 0.05$) and was eliminated by day 32 (p.i.) or by day 12 post-treatment (p.t.). In Group B (Infected Control), parasitaemia appreciated significantly ($p < 0.05$) to a peak count of 400.2 ± 2.50 by day 36 (p.i.).

Packed cell volume changes

The packed cell volume (%) changes of the camels with the infected and untreated controls are presented in Figure 2. In Group A, the pre-infection PCV of 38.9 ± 0.78 declined significantly ($p < 0.05$) from day 4 (p.i.) to 19.0 ± 0.54 by day 20 (p.i.). Following treatment with Cymelarsan®, its pre-infection value was attained by day 36 (p.i.) or by day 16 (p.t.). In Group B, the pre-infection PCV of 38.7 ± 0.78 declined

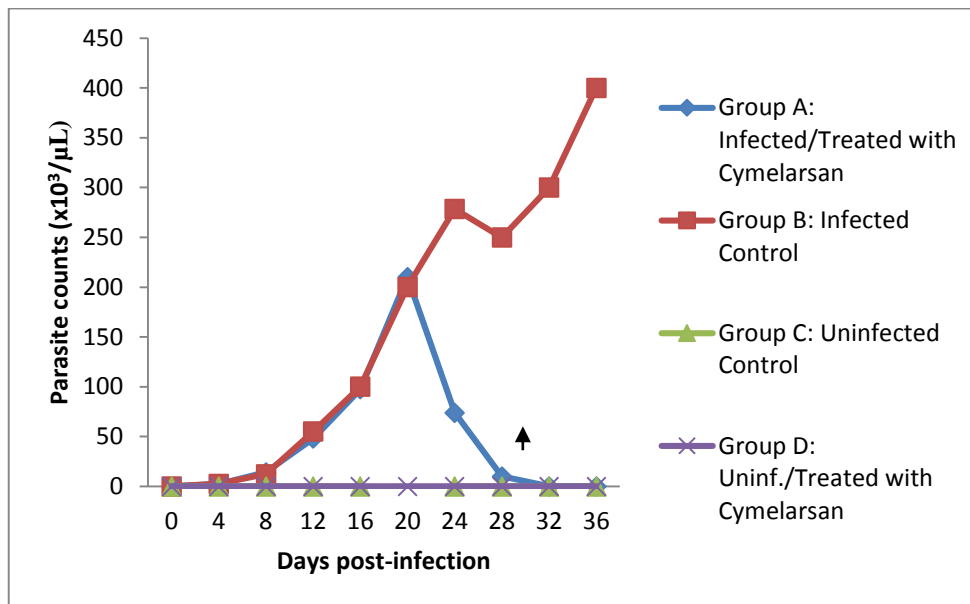


Figure 1. Mean parasite counts ($\times 10^3/\mu\text{L}$) of the one humped camels (*Camelus dromedarius*) experimentally infected with *Trypanosoma evansi* and treated with melarsenoxyde cysteamine hydrochloride (Cymelarsan®) with the infected / untreated control groups.

Key: Day of treatment (arrowed)

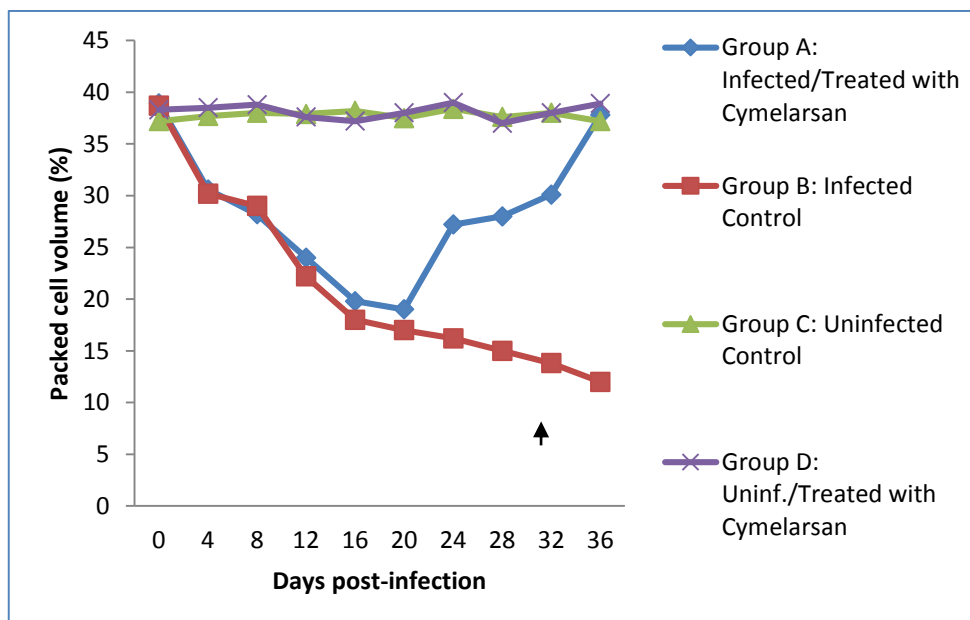


Figure 2. Mean packed cell volume (%) of the one humped camels (*Camelus dromedarius*) experimentally infected with *Trypanosoma evansi* and treated with melarsenoxyde cysteamine hydrochloride (Cymelarsan®) with the infected / untreated control groups.

significantly ($p < 0.05$) to 12.0 ± 0.43 by day 36 (p.i.). Meanwhile, the pre-infection PCV for Group C and D remained fairly constant ($p > 0.05$) throughout the study.

Clinical parameters

Clinical signs observed after a pre-patent period of 4 days were pyrexia, staring fur coat, depression, anorexia, pallor of ocular and buccal mucous membranes, oedema of the brisket, circling gait and enlarged retropharyngeal lymph nodes. The body temperature changes of the camels are presented in Figure 3. The pre-infection values of 38.3 ± 0.77 and 38.2 ± 0.77 for Groups A and B both reached a peak value of 40.0 ± 0.80 by day 16 (p.i.). Following treatment with Cymelarsan® in Group A, it dropped significantly ($p < 0.05$) to its pre-infection value by day 36 (p.i.) or by day 16 (p.t.). In Group B it appreciated significantly ($p < 0.05$) to 48.2 ± 0.87 by day 36 (p.i.), while in Groups C and D it remained fairly constant ($p > 0.05$). The respiratory changes of the camels with the infected and untreated controls are presented in Figure 4. The pre-infection respiratory rates of 30.2 ± 0.68 and 30.8 ± 0.68 for Groups A and B increased significantly ($p < 0.05$) to 54.3 ± 0.92 and 56.6 ± 0.94 by day 20 (p.i.) respectively. Following treatment with Cymelarsan® in Group A, it declined significantly ($p < 0.05$), attaining its pre-infection value by day 36 (p.i.) or by day 16 (p.t.). For Group B it rose significantly ($p < 0.05$) to 35.2 ± 0.74 by day 36 (p.i.), while in Groups C and D the values remained fairly constant ($p > 0.05$).

Heart rates of the camels with the infected and untreated controls are presented in Figure 5. For Groups A and B the pre-infection values of 85.2 ± 1.15 and 84.2 ± 1.15 appreciated significantly ($p < 0.05$) to 120.2 ± 1.37 and 129.0 ± 1.42 respectively. Following treatment with Cymelarsan® for Group A the heart rates declined significantly ($p < 0.05$) to pre-infection value by day 36 (p.i.) or by day 16 (p.t.). In Group B it appreciated significantly ($p < 0.05$) to 134.0 ± 1.45 by day 36 (p.i.), while it remained fairly constant ($p > 0.05$) in Groups C and D.

Pulse rates of the camels with the infected and untreated controls are presented in Figure 6. The pre-infection values of 120.2 ± 1.37 and 138.3 ± 1.47 for Groups A and B appreciated significantly ($p < 0.05$) to 142.2 ± 1.49 and 145.6 ± 1.51 by day 20 (p.i.) respectively. Following treatment with Cymelarsan®, in Group A, pre-infection value was attained by day 36 (p.i.) or by day 16 (p.t.). In Group B it rose significantly ($p < 0.05$) to 160 ± 1.58 by day 36 (p.i.). In Groups C and D the values remained fairly constant ($p > 0.05$).

Weight changes of the camels with the infected and untreated controls are presented in Figure 7. The pre-infection values of 327.0 ± 2.26 and 325.0 ± 2.25 for Groups A and B declined significantly ($p < 0.05$) to 270.0 ± 2.05 and 200.0 ± 1.77 respectively by day 20 (p.i.). Following treatment with Cymelarsan® for Group A it appreciated significantly ($p < 0.05$) to its pre-infection value by day 36 (p.i.) or by day 16 (p.t.) while for Group B

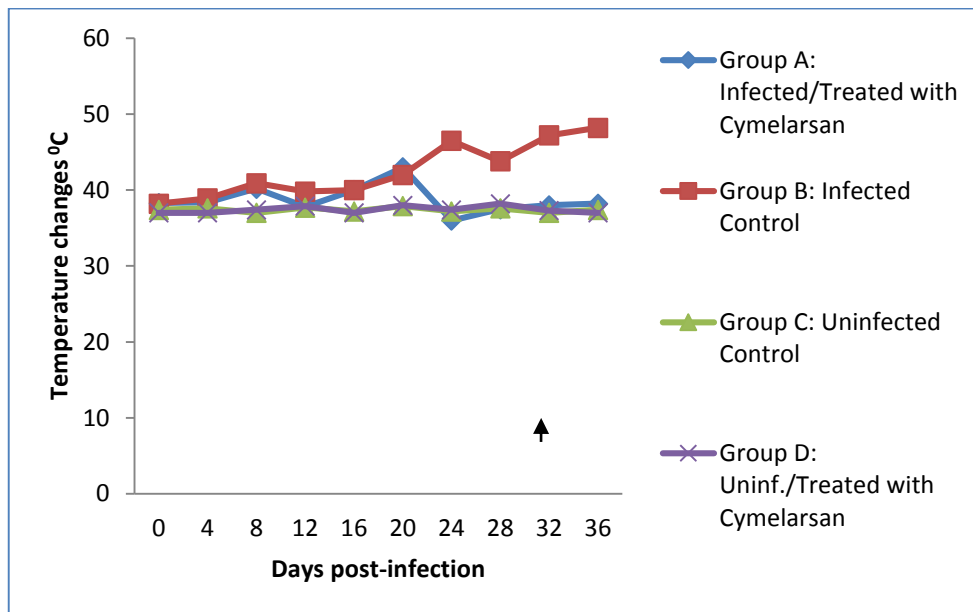


Figure 3. Mean temperature ($^{\circ}\text{C}$) changes of the one humped camels (*Camelus dromedarius*) experimentally infected with *Trypanosoma evansi* and treated with melarsenoxyde cysteamine hydrochloride (Cymelarsan[®]) with the infected / untreated control groups.

Key: Day of treatment (arrowed)

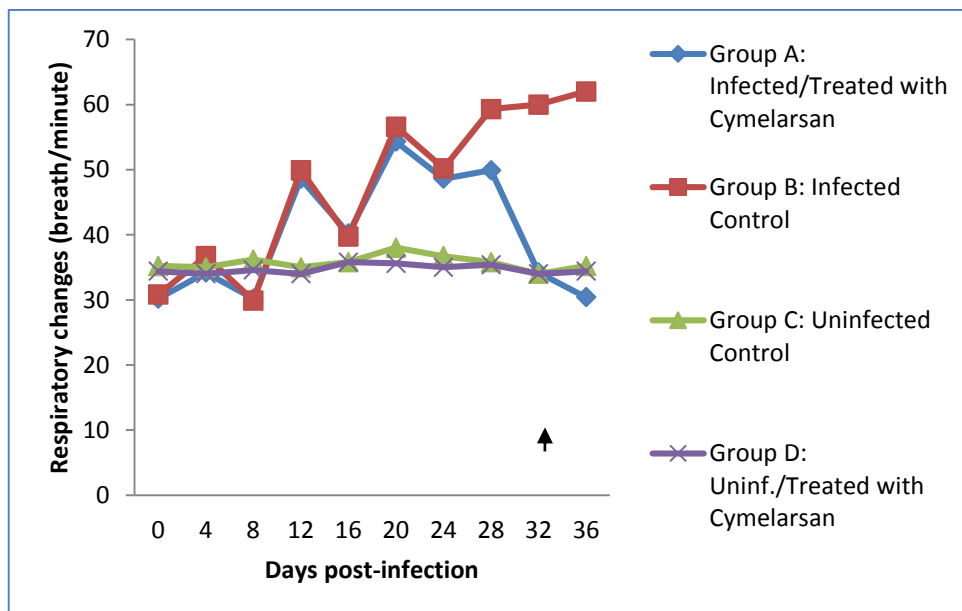


Figure 4. Mean respiratory changes (breath/minute) of the one humped camels (*Camelus dromedarius*) experimentally infected with *Trypanosoma evansi* and treated with melarsenoxyde cysteamine hydrochloride (Cymelarsan[®]) with the infected / untreated control groups.

Key: Day of treatment (arrowed)

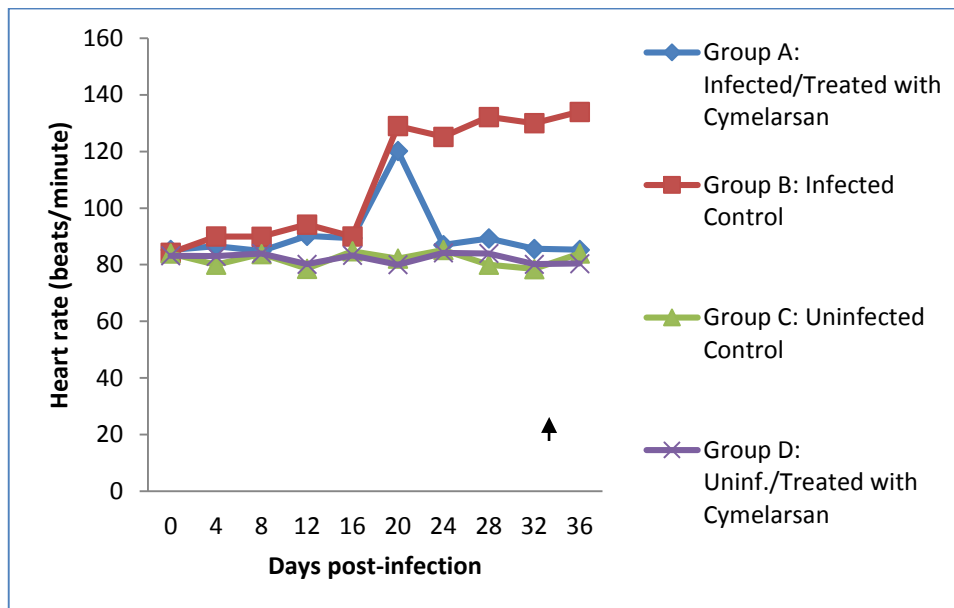


Figure 5. Mean heart rate (beats/minute) of the one humped camels (*Camelus dromedarius*) experimentally infected with *Trypanosoma evansi* and treated with melarsenoxyde cysteamine hydrochloride (Cymelarsan®) with the infected / untreated control groups.

Key: Day of treatment (arrowed)

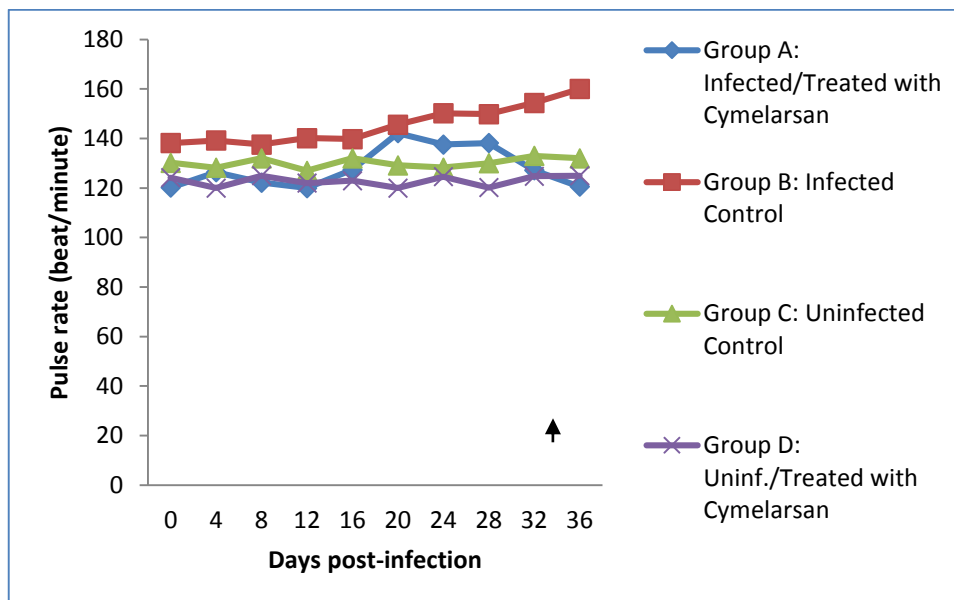


Figure 6. Mean pulse rate (beats/minute) of the one humped camels (*Camelus dromedarius*) experimentally infected with *Trypanosoma evansi* and treated with melarsenoxyde cysteamine hydrochloride (Cymelarsan®) with the infected / untreated control groups.

Key: Day of treatment (arrowed)

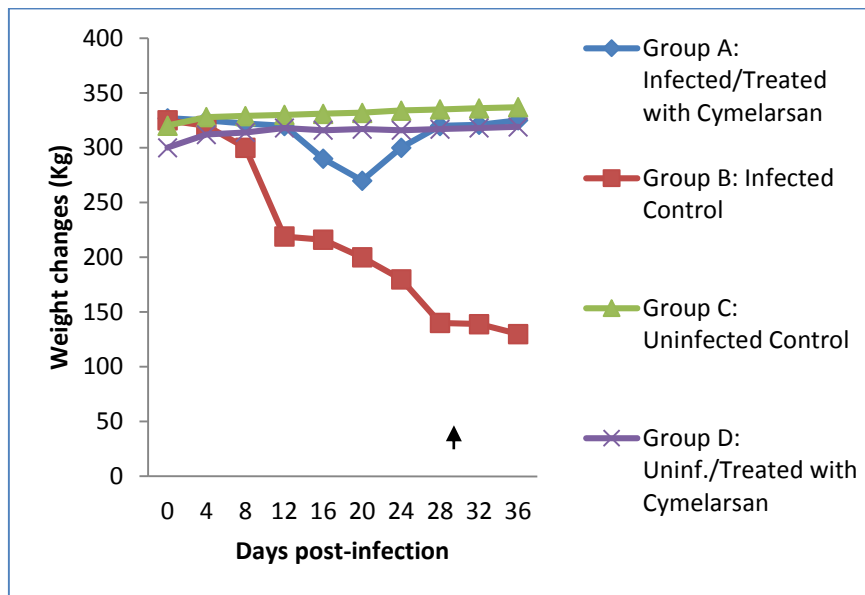


Figure 7. Mean weight changes (Kg) of the one humped camels (*Camelus dromedarius*) experimentally infected with *Trypanosoma evansi* and treated with melarsenoxyde cysteamine hydrochloride (Cymelarsan®) with the infected / untreated control groups.
Key: Day of treatment (arrowed)

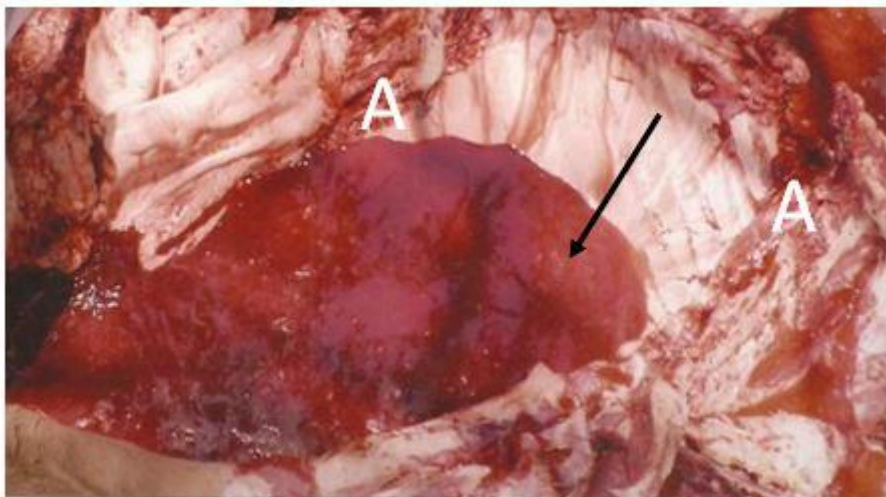


Plate 1. The abdominal cavity of a *T. evansi* infected/untreated camel (*Camelus dromedarius*) containing massive quantity of serosanguineous fluid (arrow) with extensive sheaths of blood clots adherent to the viscera (A).

it declined significantly ($p < 0.05$) to 130.0 ± 1.34 by day 32 (p.i.) while it remained fairly constant ($p > 0.05$) for Groups C and D.

Mortality pattern

In Group A (infected but treated with Cymelarsan[®]), Group C (uninfected control) and Group D (uninfected but treated with Cymelarsan[®]), the mortality rate was 0% as all the camels in these groups survived. However, In Group B (infected control) mortality was 100%. One camel died by day 28 (p.i.) while the remainder died by day 36 (p.i.).

Postmortem findings

No gross lesions were seen in the brain, heart, spleen, lungs, livers, kidneys, lymph nodes, testis and ovaries of the camels in Groups A (infected but treated with Cymelarsan[®]), C (uninfected control) and D (uninfected but treated with Cymelarsan[®]). However, in 3 camels of the infected control (Group B), the abdominal cavity contained a massive quantity (15.3 liters) of serosanguineous fluid with extensive sheaths of blood clots adherent to the viscera (Plate 1). The retropharyngeal lymph nodes appeared swollen and haemorrhagic in all the camels in the group (Plate 2a). The epicardium and endocardium of the heart showed diffuse areas of ecchymotic (paint brush) haemorrhages (Plate 3a). The kidneys appeared slightly enlarged with areas of cortical congestion (Plate 4a) while the spleen was markedly enlarged with an area of capsular rupture at the cranial border in 3 of the camels in the group (Plate 5a).

Histopathological findings

Tissue samples from the brain, heart, spleen, lungs, livers, kidneys, lymph nodes, testis and ovaries of camels in Groups A, C and D showed no lesions. Meanwhile, in the infected control (Group B), The retropharyngeal lymph node appeared highly reactive with the presence of numerous secondary follicles containing large lymphocytes and lymphoblast, moderately depopulated medulla and the presence of large numbers of macrophages (Plate 2b). The heart showed multifocal areas of myocardial degeneration and mononuclear cellular aggregations (Plate 3b). The kidneys showed widespread glomerulosclerosis and tubular nephrosis, especially at the corticomedullary junction, and the presence of pinkish casts in the tubules (Plate 4b), while the spleen showed considerable haemosiderosis with extensive trabaculae (Plate 5b). Although gross lesions were not seen on the brain and testicles, the tissue sections of the brain showed areas of multi-focal congestion (Plate 6) while the testicles showed severe calcification of the seminiferous tubules and eruption of spermatogenic cells (Plate 7).

Discussions

The results of the present study indicated that Cymelarsan[®] at 0.25mg/kg body weight was capable of relieving, in camels experimentally infected with *T. evansi*, elevated body temperature, respiratory rate, pulse rate, heart rate, oedema of the brisket, weight loss, circling gait, staring fur coat, pallor of ocular and buccal membranes, and enlarged



Plate 2a. Retropharyngeal lymph nodes of a *T. evansi* infected/untreated camel (*Camelus dromedarius*) appearing swollen (A) and haemorrhagic (arrowed).
Plate 2b. Photomicrograph of the highly reactive retropharyngeal lymph node with numerous secondary follicles (A), containing large lymphocytes and lymphoblasts, moderately depopulated medulla (B) and presence of large numbers of macrophages (arrowed) (H&E x 350).

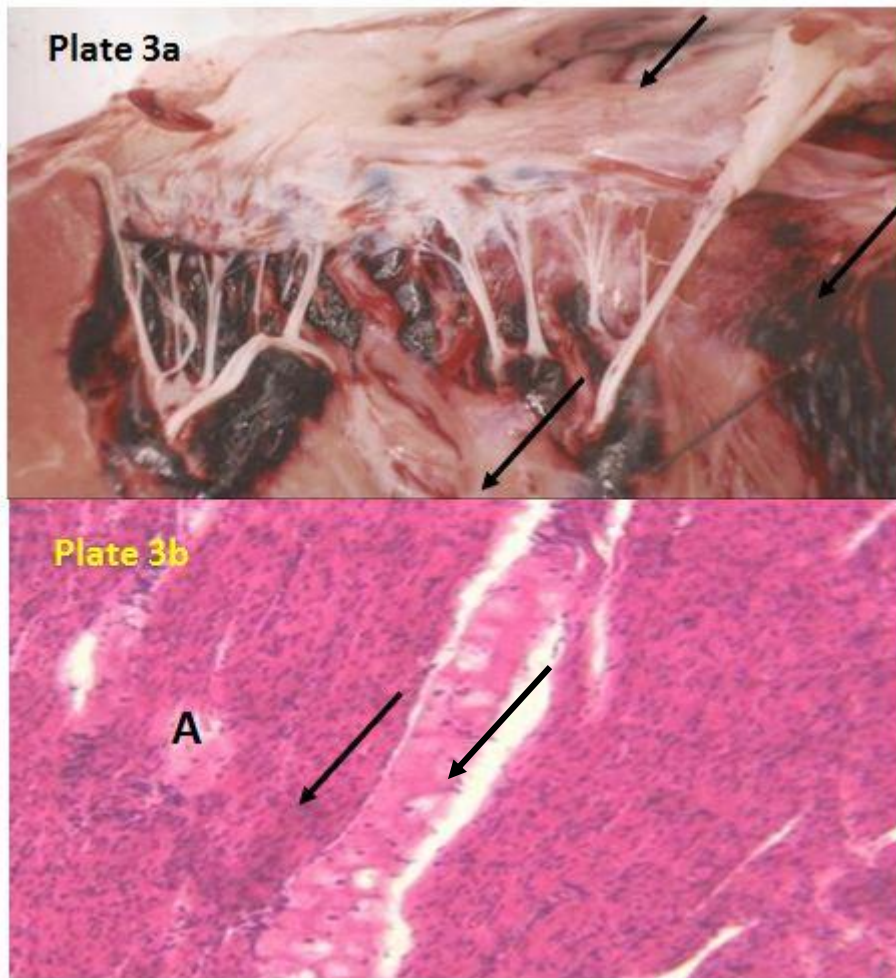


Plate 3a. The heart of a *T. evansi* infected/untreated camel (*Camelus dromedarius*) showing diffuse areas of ecchymotic (paint brush) haemorrhages (arrows) in the epicardium and endocardium.

Plate 3b. Photomicrograph of the heart showing multifocal areas of myocardial fiber degeneration (A) and mononuclear cell aggregations (arrowed) (H&E x 350).

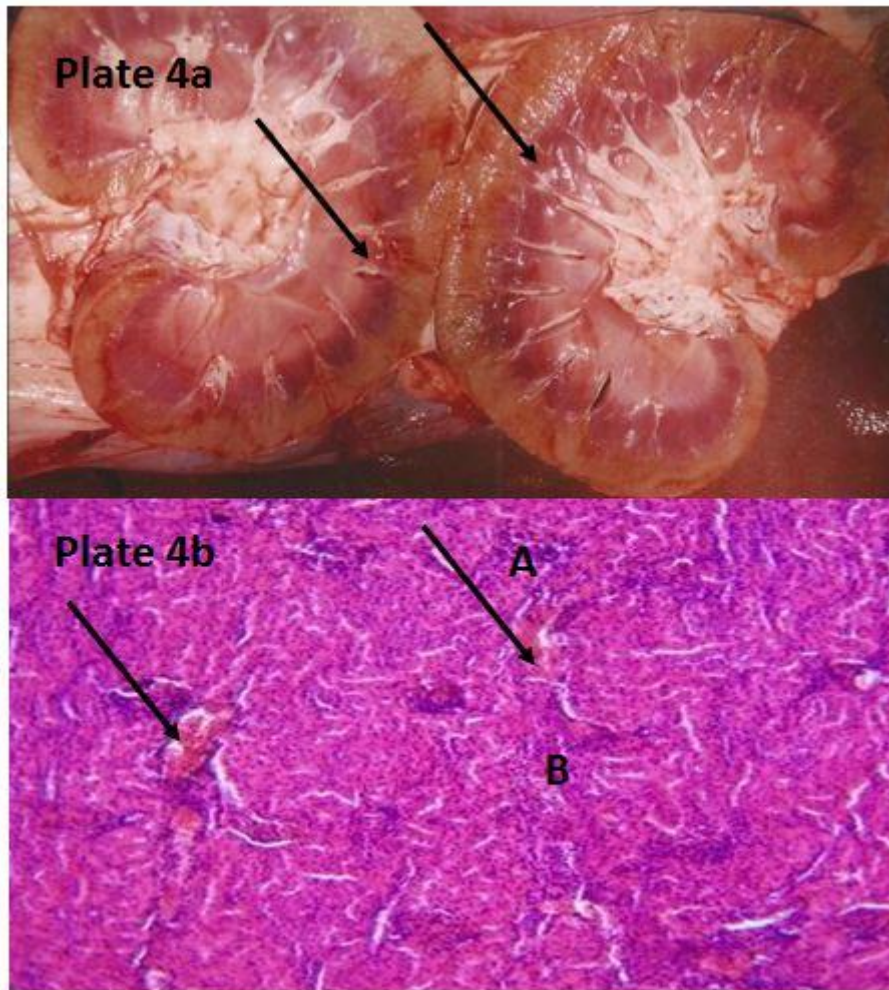


Plate 4a: Kidneys of a *T. evansi* infected/untreated camel (*Camelus dromedarius*) appearing slightly enlarged with areas of cortical congestion.

Plate 4b: Photomicrograph of the kidneys showing widespread glomerulosclerosis (A) and tubular nephrosis (B), especially at the corticomedullary junction and presence of pinkish casts in tubules (arrowed) (H&E X 200).

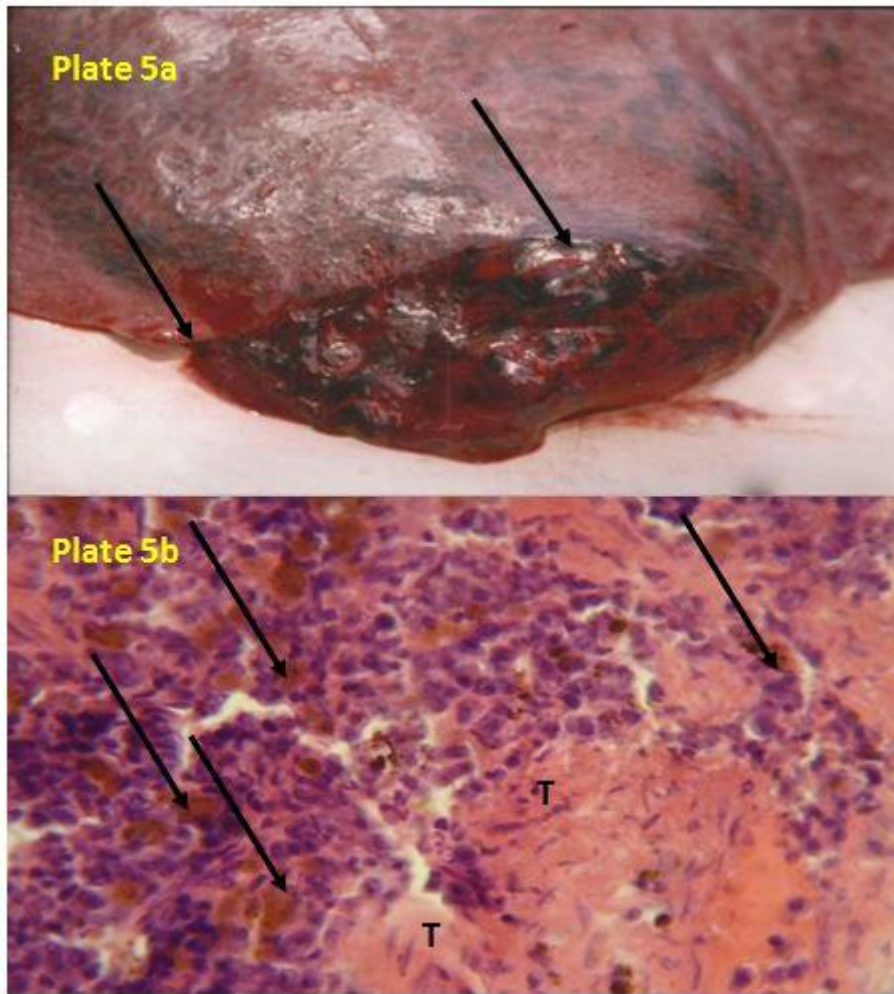


Plate 5a. A markedly enlarged spleen of a *T. evansi* infected/untreated camel (*Camelus dromedarius*) showing an area of capsular rupture at the cranial border of the organ.

Plate 5b. Photomicrograph of the spleen showing trabaculae (T) and brown patches of haemosiderin granules (H&E x 400).

retropharyngeal lymph nodes. Similarly it was able to reverse the deleterious effects of the infection in various organs and tissues. The reverse was the case among the infected/untreated camels. In the infected/treated camels, the pre-infection values of the various parameters were attained between days 32-36 (p.i.). The reversal of the clinical signs with the commencement of the Cymelarsan® therapy is consistent with earlier reports in white Asian tigers (*Panthera tigris*) naturally infected with *T. evansi* (Parija and Bhattacharya, 2005), in mixed infections of *T. brucei* and *T. evansi* in camels (Zweygarth et al., 1992) and in *T. brucei* infected red fronted gazelles (*Gazella rufifrons*) (Mbaya et al., 2009b). The undulating pyrexia showed a direct relationship with parasitaemia, respiration, pulse and heart rates which were probably associated with the presence of circulating trypanosomes and toxic metabolites produced by dying trypanosomes (Tizard et al., 1978). In addition, the undulating fever might have contributed to erythrocyte destruction. This view is supported by the observation that exposure of erythrocytes to temperatures above normal increased their osmotic fragility, membrane permeability and decreased their plasticity such that their life span was decreased *in-vivo* (Igbokwe, 1994; Mbaya et al., 2012). The fact that extensive testicular damage was encountered among the infected control might be associated with the elevated body temperatures encountered in the course of the infection. Elevated body temperatures

have been reported to affect spermatogenesis adversely (Mbaya et al., 2011). Similarly, the ability of *T. evansi* to cause extensive damage to testicular tissue is associated with its tissue invasiveness. The additive effects of anoxia due to anaemia, immunological factors, biologically active and toxic substances released by the organism could equally disrupt the architectural integrity of the testis (Mbaya et al., 2011). The increase in heart rate among the infected camels was probably a compensatory mechanism in response to the anaemia in the host, and may relate to the fact that camel trypanosomosis is often associated with increase in cardiac output and stroke volume (Jatkar and Purohit, 1971; Enwezor and Sackey, 2005). Similarly, the circling gait encountered among the infected camels was a clear indication of a central nervous system (CNS) involvement. This is so because the photomicrograph of the brain showed multi-focal areas of congestion associated with the infection. Surra in camels has been associated with brain tissue damage due to cerebral anoxia and the presence of the organism in the CNS (Enwezor and Sackey, 2005). The occurrence of oedema in the brisket of the camels in this study was probably associated with a decline in the levels of albumin. Decline in albumin levels in camel trypanosomosis is a consistent feature of trypanosomosis which alters the osmotic pressure in the blood, leading to excessive accumulation of fluid in the interstices of the dependent parts of the body (Enwezor and Sackey, 2005). During the study, parasitaemia fluctuated by 28 d.p.i. then increased

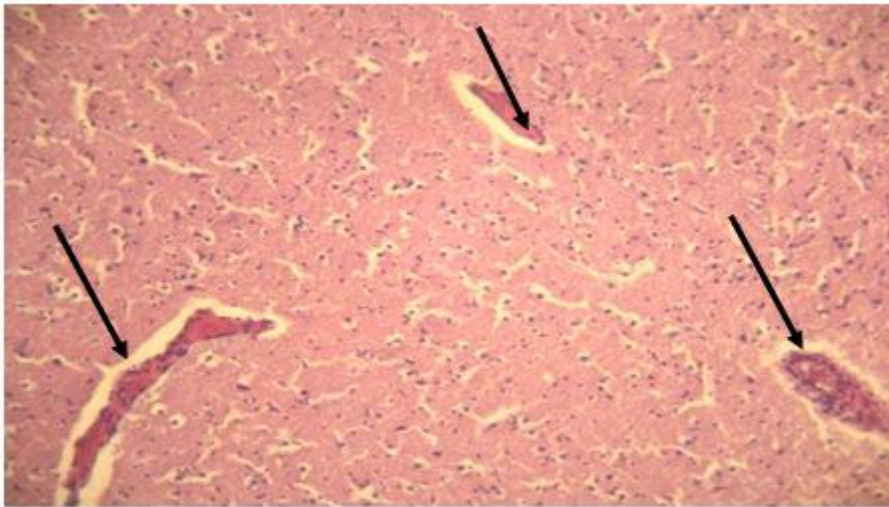


Plate 6. Photomicrograph of the brain of a *T. evansi* infected/untreated camel (*Camelus dromedarius*) showing multi-focal areas of hyperaemia congestion.

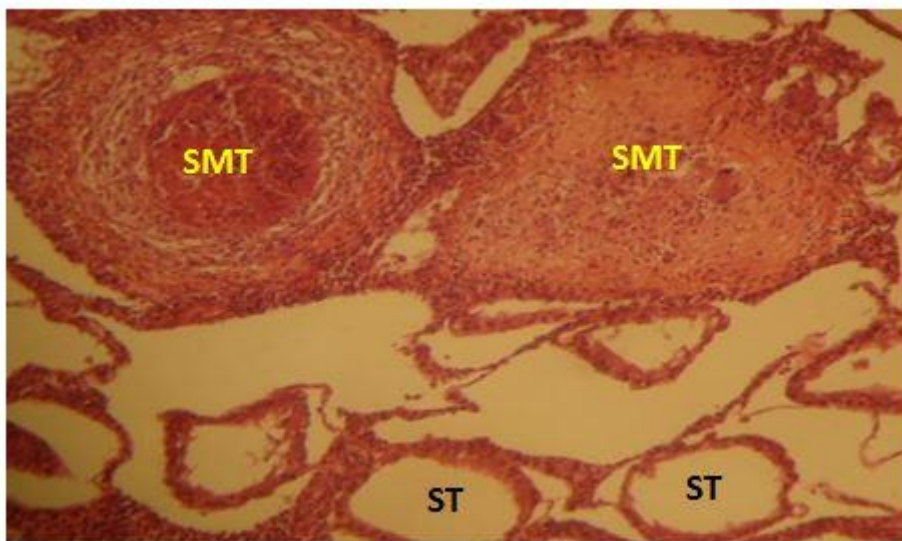


Plate 7. Photomicrograph of the testis of a *T. evansi* infected/untreated camel (*Camelus dromedarius*) showing severe calcification of the seminiferous tubules (SMT) and degeneration of spermatogenic cells (ST) H&E x400.

again. It is an established characteristic of the salivarian trypanosomes like *T. evansi* to show antigenic variation which is responsible for fluctuations of parasitaemia (Nwosu and Ikeme, 1992). The uniform pre-patent period of 4 days encountered among the infected camels was probably associated with the standard dose of the inoculum administered. This suggests therefore that the standard dose of the inoculum administered multiplied at the same rate. This has been reported in *T. brucei* infection in dogs (Nwosu and Ikeme, 1992) and in red fronted gazelles (*G. rufifrons*) (Mbaya et al., 2011).

The anaemia encountered in all the infected groups was associated with pallor of buccal and ocular mucous membranes and a significant decline in PCV, which corresponded with waves of parasitaemia. Similarly, the pre-infection PCV was attained by day 36 p.i. or by day 16 post-treatment among the infected camels treated with Cymelarsan® at 0.25mg/kg body weight. The gradual decline in PCV during periods of parasitaemia and an increase during periods of low parasitaemia shows an inverse relationship between PCV and parasitemia. This is a consistent trend in trypanosomosis in general (Anosa, 1983; Nwosu and Ikeme, 1992; Mbaya et al., 2009a). The anaemia in trypanosomosis is haemolytic in nature and the etiology is often complex and multifactorial (Anosa, 1983). However, the expanded and active mononuclear phagocytic system (MPS) might have necessitated an increased demand on the system to remove tissue cells,

trypanosomes and antigen antibody complexes and to participate in immune responses which might have contributed immensely to the destruction of RBC and hence low PCV (Anosa, 1988).

During necropsy, 15.3 liters of serosanguineous fluid was recovered from the peritoneal cavity in 3 of the camels in Group B. This was probably due to the rupture of the splenic capsule at the cranial border following an extensive splenomegally. The gross lesions commonly encountered on the spleen of *T. evansi* infected camels are either splenomegally or the presence of necrotic foci seen on the serosal surface of the organ (Rottcher et al., 1987). This is therefore the first account of a splenic rupture following *T. evansi* infection with the extravasations of large quantities of serosanguineous fluid in to the peritoneal cavity. At the cellular level, a considerable haemosiderosis was seen in the spleen of the infected camels. The considerable amount of haemosiderin granules encountered during the course of the infection is probably associated with phagocytosis of erythroid cells and subsequent sequestration of haemosiderin granules in the macrophage phagocytic system of the spleen. This has been demonstrated in the spleen of *T. brucei* infected deer mice (*Peromyscus maniculatis*) (Anosa and Kaneko, 1983). The fact that the retropharyngeal lymph nodes were grossly enlarged and congested and at the cellular level appeared highly reactive with large lymphocytes, secondary follicles, lymphoblasts and large numbers of

macrophages was an indication of an intense antigenic stimulation commonly encountered in trypanosomosis. This is a clear demonstration of both cell mediated and humoral antigenic response to the infection. Generalized lymphoid tissue hyperplasia is a common feature of surra in camels (Rottcher et al., 1987). The ecchymotic (paint brush) haemorrhages seen on the epicardium and myocardium of the heart, coupled with the congestions of the retropharyngeal lymph nodes and the cortical region of the kidneys, are probably caused by haemolysis involving the expanded mononuclear phagocytic system (Enwezor and Sackay, 2005). The various degenerative changes and mononuclear cellular infiltrations seen in the tissues of the infected camels could be attributed to tissue hypoxia due to the anaemia encountered in the course of the infection – similar observations have been reported in *T. brucei* infection of goats (Igbokwe, 1999) and in red fronted gazelles (*G. rufifrons*) (Mbaya et al., 2009). However, the organism often invades tissues and cause mechanical injury through the lashing actions of their flagella and their microtubule reinforced bodies (Igbokwe, 1999; Mbaya et al., 2009). In addition, ischaemia associated with disseminated intravascular coagulation by microthrombi or immune complexes are factors indirectly involved in the pathogenesis of organ and tissue damage in trypanosomosis (Igbokwe, 1995; Mbaya et al., 2011). It is therefore concluded that severe clinicopathological effects occurred

following infection with *T. evansi* among the camels. However, the deleterious effects of the infection among camels treated Cymelarsan® was reversed 100%, and it is therefore also concluded that treatment with Cymelarsan® is relatively safe given that no symptoms of toxicity nor death were recorded among the uninfected but treated camels.

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