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Evaluation of Clinico-Hematological and Biochemical Changes in Camels with Trypanosomiasis in the Cholistan Region, Bahawalpur

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ABSTRACT

The current research conducted on the 500 camels in the Bahawalpur district of Punjab, Pakistan, aimed to examine the presence of trypanosome flagellate protozoan parasites and to determine the alterations in the hemato-biochemical parameters of diseased camels in the Bahawalpur district. The collected blood samples were immediately used to prepare fresh thin blood smears on glass slides, air-dried, and then fixed with absolute methanol. The smears were subsequently stained with Giemsa stain, and trypanosomes were identified microscopically. Different physiological parameters like temperature, heart beat and breathing rate, along with other clinical signs including depression, anorexia, dehydration, lethargy, and edema of pads were also recorded. The results revealed a significant increase ($P<0.05$) in white blood cells (WBCs), including neutrophils, basophils, eosinophils, and monocytes, as well as in mean corpuscular hemoglobin concentration (MCHC) in the infected camels. However, the study observed a significant reduction ($P<0.05$) in the hemoglobin concentration, lymphocyte count, hematocrit, and red blood cell (RBC) count. The blood biochemical parameters, like aspartate aminotransferase (AST), alkaline phosphatase (ALP), and alanine aminotransferase (ALT), were found to be significantly elevated ($P<0.05$) in the infected camels. While serum albumin, total proteins, calcium, magnesium, and phosphorus were significantly lowered ($P<0.05$) in the diseased camels compared to the healthy ones. However, levels of serum lipid peroxidation product (malondialdehyde) were significantly increased ($P<0.05$) in the infected camels. The microscopic examination of blood smears from infected camels revealed the presence of trypanosome parasites along with various morphological changes in the erythrocytes.

Key words: Diseased Camels, Blood samples, Microscopic examination, Giemsa stain, Trypanosome parasites

INTRODUCTION

Livestock is pivotal to Pakistan's agriculture, contributing 53.2% to the sector (Muhammad et al. 2021). Approximately 35 million people engaged in animal husbandry, particularly focusing on camels (Colli et al. 2018; Babege et al. 2021). Pakistan is ranked as the fourth largest milk producer following China, India, and the US (Rahman et al. 2019). In desert regions, camels are highly adaptable animals providing wool, milk, meat and serving roles in racing and transportation (Sahoo 2020). Pakistan is the third-largest camel-breeding country. The majority of the camel population in Pakistan is found in Balochistan (41%) and their special breeding purpose is draught (Fatih et al. 2021). Pakistan has a significant camel population with approximately 1 million camels out of the global population of 17.4 million (Faraz 2022).

Studies suggest that camels have lower disease susceptibility compared to other animals (Selim et al. 2023). However, Pakistani dairy cows and camels face

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various infections with blood-borne parasites identified as a significant factor contributing to reduced milk and meat production (Jabbar et al. 2015). Blood parasites like trypanosomes pose a great threat to global livestock health, affecting animals in Latin America, Asia, and Africa (Desquesnes et al. 2022). Trypanosomiasis (Surra), an endemic disease in camels, is caused by a vector-borne parasite affecting various animals and humans worldwide, including Pakistan (Mehnaz et al. 2023; Zahoor et al. 2023).

Trypanosomiasis is caused by single-celled parasites belonging to the genus *Trypanosoma* (Tauheed et al. 2022). Trypanosomes exhibit a size range from 8 to 50µm, displaying distinctive appearances, shapes, and sizes based on their types. The *Trypanosoma evansi* affects the animals of tropical and subtropical areas, and it also increases the growth of disease in the blood of targeted animals (Hussain et al. 2018; 2021).

Earlier research work showed the infections of different types of *Trypanosoma* in buffalo (Ponnudurai et al. 2015), camels (Getahun et al. 2022), dogs (Muhammad et al. 2023), deers (Garcia et al. 2020), horses (Vourchakbe et al. 2020; Yamazaki et al. 2022), cattle (Matovu et al. 2020) and donkeys (Vourchakbe et al. 2020). The disease causes enormous financial losses to farmers due to poor draught power, high morbidity, abortion, infertility, decreased milk production, and various neuropathies (Kim et al. 2023) that lead to the death of infected animals (Ponnudurai et al. 2015; Singh et al. 2016). Medically, the disease is recognized by observing the symptoms like depression, anemia, dullness, high fever, sometimes abortion, nervous signs and may pass away in case of no treatment (Tariq et al. 2022). Parasitological techniques like microscopic examination of wet or stained blood films are employed for detecting parasites (Chagas et al. 2020). Despite their low sensitivity and limited effectiveness in chronic cases, these methods remain popular due to their affordability and speed (Kim et al. 2023). Alterations in blood components such as white blood cells (WBCs), red blood cells (RBCs) and platelets serve as valuable indicators for identifying anemia (Agina et al. 2021). Limited data exists on Trypanosomiasis infections in camels. Keeping in view the importance of trypanosomiasis in camels, this study was conducted to investigate the prevalence, biochemical alterations, and clinical hematology in naturally infected camels.

MATERIALS AND METHODS

A total of 500 morbid camels of different sexes and ages were randomly selected based on clinical signs of the infection in the Cholistan region of Bahawalpur, Southern Punjab, Pakistan. The data related to the gender and age of camels were recorded. Screening of animals for Trypanosomiasis was done on the basis of different clinical ailments like fever, anorexia, depression, dehydration, frequent urination, pale mucus membrane, lacrimation, hyperemic and bulging eyes. To identify the *Trypanosoma* species, blood samples were collected from the marginal ear vein of each diseased animal in vacutainers with and without anticoagulant (EDTA 1mg/mL). For hematological and biochemical analysis, an equal number of blood samples were obtained from infected camels, then stored in the ice box and shifted to the laboratory (Hussain et al. 2021).

Parasitological examination

For identification of *T. evansi*, thin blood smears glass slides were prepared from fresh blood from each camel (Hussain et al. 2019). Fresh blood samples were used to prepare thin blood smear slides. All smears of blood were air dried and fixed in anhydrous methanol for 5-7 minutes and ultimately stained with the Giemsa stain. Glass slides were examined under the light microscopes for detection of *T. evansi* in blood circulation and various morphological changes in erythrocytes on the basis of standard methods (Abo-Aziza and Zaki 2017).

Hematological parameters

Samples of blood were collected into glass vacutainers with and without anticoagulant and analyzed for various hematological parameters such as mean corpuscular hemoglobin concentration (MCHC), hemoglobin concentration (HGB), total erythrocyte counts (TEC), hematocrit percentage, mean corpuscular volume (MCV), differential leukocyte count (DLC) of neutrophils, monocytes, eosinophils, lymphocytes and total leukocyte count (Ghaffar et al. 2018; Hussain et al. 2021).

Biochemical parameters

Various biochemical parameters of serum, such as albumin, total serum protein, aspartate aminotransferase (AST), alkaline phosphatase (ALP), and alanine aminotransferase (ALT), were evaluated using a UV spectrophotometer according to standard procedure (Ghaffar et al. 2018; Hussain et al. 2019).

Oxidative stress parameters

Oxidative stress parameters like malondialdehyde (MDA) concentration were determined according to the method of Placer et al. (1966) and Zhou et al. (2021). Briefly, about 0.3mL of serum was added to 1.2mL of 0.2mol/L Tris and 0.15mol/L KCl buffer (pH 7.3). Tris-buffered saline (TBS) (1.4mL) was added, and the samples were placed in boiling water for 10 minutes. After that, all the samples were cooled, and pyridine–butanol (3mL) and NaOH (1mL) were added, and readings were measured at 548nm using a UV spectrophotometer.

Statistical analysis

Data related to the prevalence of trypanosomiasis was analyzed through frequency analysis by employing a chi-square test, along with their odds ratios and 95% confidence intervals were also computed. Additionally, data related to hemato-biochemical parameters were evaluated by using Student's *t*-test in SPSS software, with statistical significance set at $P<0.05$.

RESULTS

A total of 500 blood samples were screened for the camels that were suspected clinically positive for Trypanosomiasis. Based on the microscopic examination of the blood smears, 47 samples were found positive for *T. evansi* flagellated protozoan parasite. The results of this study revealed that the overall prevalence of Trypanosomiasis was 9.4% via microscopic smear examination. The results about the prevalence of *T. evansi* in camels based on Giemsa smear staining are illustrated in the Table 1.

Table 1: Prevalence of *T. evansi* in camels on the basis of Giemsa smears staining

Species/ sex/age	No. of animals	Positive N	Positive %	95% C.I.	Odd Ratio/ P-value
Giemsa smear examination					
Camel					
Male	177	13	7.34	4.15-11.93	1.71[Reciprocal =
Female	323	34	10.52	7.52-14.24	0.93]
Age groups					
< 1	91	7	7.69	3.43-14.62	Mantel-Haenszel
2-4	145	11	7.58	4.05-12.80	chi-sq. P = 0.05
5-6	147	10	6.80	3.51-11.79	
> 7	117	19	16.23	10.37-23.76	

The results showed a statistically significant (P<0.05) prevalence of infection in old animals. No significant (P>0.05) variation was observed in the prevalence of infection based on gender.

Microscopic examination of blood smears

Examination of blood films from infected camels revealed several distinct morphological changes in erythrocytes. These changes included the presence of tear droplet cells, elliptical cells, microcytes, stomatocytes and macrocytes with nuclear remnants, paler cells, hypochromia, and polychromia, have shown in Fig. 1-3, and their values are given in Table 2.

Table 2: Different abnormalities in red blood cells of camels

Parameters	Healthy	Infected	P-value
Stomatocytes	2.11±0.13	6.22±1.13	0.01
Hypochromia	1.18±0.22	7.35±1.34	0.03
Polychromia	2.22±1.11	8.88±1.76	0.01
Microcytes	1.55±0.23	5.33±1.11	0.01
Macrocytes	2.21±1.11	11.13±2.11	0.01
Tear shaped	1.11±0.23	4.41±1.11	0.01

Hematological parameters

The results on different blood parameters in *Trypanosoma*-positive and healthy camels are presented in Table 3. Results showed a significant (P<0.05) decrease in red blood counts, monocyte values, hematocrit levels, and HGB concentration, while the white blood count, MCHC, MCV values, neutrophil counts, eosinophil counts, and basophil counts were significantly (P<0.05) elevated in infected camels than healthy ones.

Table 3: Blood parameters (Mean±SD) of healthy and *Trypanosoma*-positive camels

Parameters	Healthy	Infected	P-value
White blood cell counts (10^3/µL)	12.01±1.11	18.15±1.43	0.001
Red blood cell counts (10^6/µL)	7.23±0.43	4.142±0.141	0.001
HGB concentration (g/dL)	12.35± 0.54	9.11±0.23	0.001
MCHC(g/dL)	29.10±3.01	32.44±3.13	0.309
Neutrophil (%)	33.31±1.28	48.12±2.89	0.001
Lymphocyte (%)	51.11±7.22	37.62±3.18	0.001
MCV(fL)	57.01±5.94	61.05±3.71	0.315
Eosinophil (%)	2.10±0.11	4.13±0.11	0.02
Monocyte (%)	2.14±0.21	4.15±0.55	0.01
Hematocrit (%)	43.42±2.44	26.67±2.11	0.01
Basophil (%)	0.6±0.11	2.11±0.05	0.01

A P<0.05 indicates a significant difference in *Trypanosoma*-positive camels.

Serum biochemical parameters

The serum biochemical parameters of normal and infected camels are presented in Table 4. Results on serum biochemical parameters showed that levels of different serum enzymes, such as ALT, ALP and AST, were significantly (P<0.05) elevated in *Trypanosoma*-positive camels. Meanwhile, serum total proteins and serum

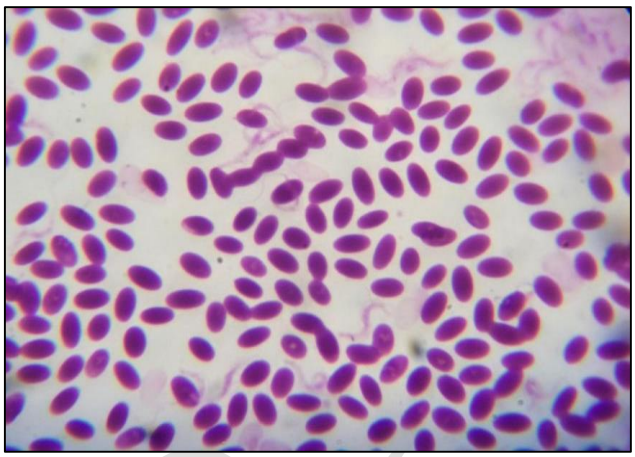

Fig. 1: Photomicrograph of blood smear of camel showing anisocytosis and presence of *Trypanosoma evansi.*

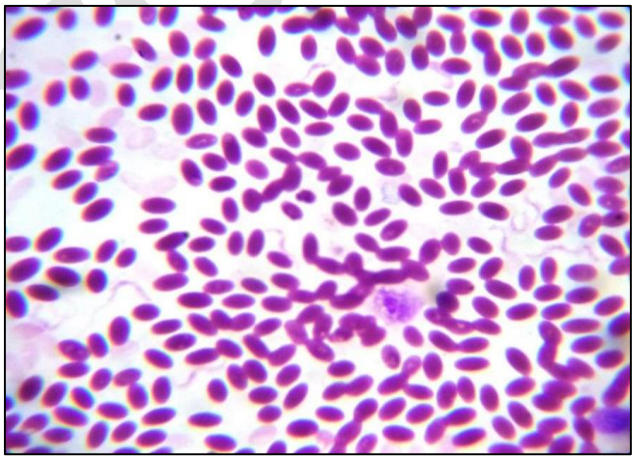

Fig. 2: Photomicrograph of blood smear of camel showing microcytes, macrocytes and *Trypanosoma evansi.*

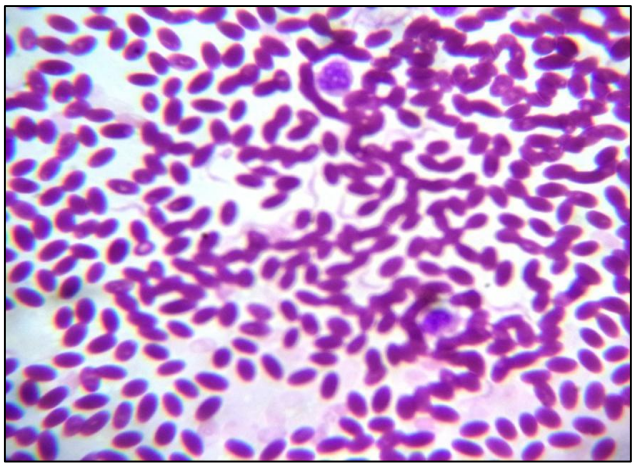

Fig. 3: Photomicrograph of blood smear of camel showing morphological changes in red blood cells and presence of *Trypanosoma evansi.*

albumin levels were significantly reduced (P<0.05) in diseased animals as compared to healthy animals. According to present results, the levels of calcium, magnesium, and phosphorus were significantly lowered (P<0.05) in infected camels as compared to healthy ones. The levels of malondialdehyde were significantly elevated (P<0.05) in healthy camels as compared to normal animals.

Table 4: Serum biochemical parameters (Mean ± SD) of normal and *Trypanosoma*-positive camels

Parameters	Healthy	Infected	p-value
ALT (U/L)	13.19±2.22	27.13±3.77	0.01
ALP (U/L)	103.17±8.62	137.77±5.37	0.01
AST (U/L)	26.17±1.53	37.27±2.39	0.01
Total proteins	5.88±0.71	3.55±0.13	0.01
Albumin	3.88±0.81	2.02±0.11	0.01
Phosphorus (mg/dL)	7.03±0.04	4.31±0.13	0.01
Magnesium (mg/dL)	2.33±0.22	1.11±0.19	0.02
Calcium (mg/dL)	12.13±0.33	8.05±0.09	0.01
Lipid per oxidation product	1.51±0.11	3.13±0.44	0.01

A p-value less than 0.05 indicates the significant difference in *Trypanosoma* positive camels

DISCUSSION

The current study was conducted in different areas of District Bahawalpur, Punjab, Pakistan. The population of Bahawalpur is 798, 509 and it is the 11th largest city in Pakistan. In study areas, the temperatures range from –2°C to 45°C but can reach 50°C in summer and –10°C in winter. So, the environment of this region favors many blood protozoan infections, especially *T. evansi*, which infects camels. More than 52% of the landscape based on agriculture has been reported in this area, which accounts for 32% of the total population of this province, and a large number of people rely on dairy animals for their income (Hussain et al. 2021). In many desert areas such as Asia, the Middle East, and Africa, the main source of income for people is camels. In this area, poor husbandry management enhances the possibility of the transmission as well as the occurrence of various infectious agents in farm animals (Hussain et al. 2021). Hence, constant observation of diseases is essential to check and eradicate different endemic infections of parasites in animals (Ali et al. 2020). Therefore, blood parasites such as *Trypanosoma* can pose serious health, production and economic issues to the dairy industry. Observing and detecting parasitic infections in the blood of camels is essential to achieve optimal production. So the purpose of the current study was to check the presence as well as to evaluate various biochemical changes due to *Trypanosoma* infections in camels in tropical and subtropical climates. In the present study, different clinical signs like fever, anorexia, dullness, depression, dehydration, frequent urination, pale mucus membrane, lacrimation, hyperemia, and bulging eyes were recorded in the camels infected with *T. evansi*.

The clinical signs observed in *Trypanosoma*-infected camels were brisket edema, edematous legs, lacrimation, pyrexia with lethargy and depression, which aligned with previous studies on *T. evansi* infections in camels. These symptoms highlight the systemic impact of the disease, affecting multiple bodily systems and overall health (Hussain et al. 2016). Notably, infection of *T. evansi* in endemic regions is noticed as the biggest issue in the veterinary field globally, which is harmful for health status, working capacity, and productivity of the camels (Abd El-Baky and Salem 2011). Yet, alterations in the rates of prevalence might be related to different factors that are linked with host, parasite, applied diagnostic method and sample (Al-Afaleq et al. 2015; Al-Abedi et al. 2020). The overall prevalence of trypanosomiasis in our study (9.4%) was lower when compared to different investigations conducted by researchers such as Aslam et al. (2010), Hussain et al. (2021). On the other hand, it is higher than the findings reported by Hussain et al. (2016) in camels from different regions of Pakistan.

In the current study, no significant variation in the prevalence of trypanosomiasis between male and female camels was observed which is correlated with the findings of Bogale et al. (2012). A previous report by Al-Abedi et al. (2020) revealed that both male and females are relatively susceptible to *T. evansi* infection. This may be explained by the fact that both genders have equal exposure to stress factors, for example, females are involved in lactation and gestation (Shah et al. 2004) and males are stressed due to fertilization and load carrying (Bogale et al. 2012). However, former reports in Pakistan had shown a sex-based difference in trypanosomiasis prevalence, with females (15.79%) being more affected than males (9.84%). The proposed explanation, stress from gestation and lactation compromising female camels' immune systems, provides a plausible rationale for this disparity. This highlights the importance of considering sex-specific factors in disease susceptibility and management strategies (Giro and Jilo 2020). In contrast, earlier research in Asia has shown significant sex-related differences in the prevalence of trypanosomiasis, with a lower prevalence in males (11.76%) as compared to females (15.68%) (Giro and Jilo 2020).

The recent study indicated no significant variation in the prevalence of parasitism between various age groups, and their findings are similar to the previous study by Hussain et al. (2016). Nevertheless, the infection rate was higher in older camels (along with a trend to drastically increase with age, more than 7-10 years) when compared to younger ones. Higher infection rates in older age might be correlated with factors like poor management practices, frequent relocation, and the stress associated with transporting goods. However, lower infection rates in younger ones <1 year, possibly due to the maternal immunity, on the other hand, while decreased tendency of the adults could be attributed to increased resistance and an increase in specific immunity for consequent infections (Al-Abedi et al. 2020). Similar findings have been reported in other studies (Bogale et al. 2012; Al-Abedi et al. 2020). Contrary to our findings, the prevalence of disease observed in young age animals was greater than in old age animals (Kassa et al. 2011).

According to current study findings, lowered hematologic scores, including hematocrit value, red blood cell counts, and hemoglobin levels, were indicative of anemia as documented in *Trypanosoma*-positive camels (Abo-Aziza and Zaki 2017). Anemia is considered to be the most important indicator of camel *Trypanosoma* as well as human African *Trypanosoma* (Ismail-Hamdi et al. 2022). Furthermore, lower RBCs counts results in decreased hematocrit value which is also accountable for vascular

dysfunctions as well as abnormalities and leads to anoxia in different tissues of body. An anemia is caused by a parasitic infection that triggers the removal of huge erythrocytes amount because of the mononuclear phagocytic response in the lymph nodes as well as in the spleen (Hussain et al. 2016). Additionally, anemia can indeed lead to increased erythrocyte oxidation, resulting in cell destruction, membrane damage, and increased osmotic fragility. Chronic infection with *Trypanosoma* can also exacerbate these effects, contributing to anemia's pathophysiology. Oxidative stress and membrane damage can further compromise RBCs' integrity, worsening anemia (Hussain et al. 2016). The findings of the study showed that macrocytic (large RBCs, as evidenced by high MCV) and hypochromic (reduced hemoglobin concentration within RBCs, as indicated by low MCHC) anemia were found in *Trypanosoma*-infected camels. That could be due to disruption in normal red blood cell production or function, potentially related to nutritional deficiencies, bone marrow issues, or chronic disease processes in the infected camels. The results of this study revealed macrocytic, hypochromic anemia, as indicated by elevated levels of MCV and decreased levels of MCHC in diseased camels. Increased MCV, reduced MCHC, leukocytosis and lymphocytosis were observed in *Trypanosoma*-infected camels (Hussain et al. 2016). But other studies have reported hypochromic and microcytic anaemia on the basis of decreased MCH and MCV values in positive camels (Ismail-Hamdi et al. 2022). Anode (2019) had confirmed similar findings and reported that the iron deficiency was the cause of hypochromic and microcytic anaemia in the camels.

Changes in the WBC counts (10^3/μL) parameter were studied both in infected and healthy camels. Their values were significantly increased in infected animals. This happened because of the immune response to the infection thus supplying additional antibodies to fight the infection which leads to the upsurge in WBCs. These results are similar to the findings of Hussain et al. (2021). In *Trypanosoma* infection, leukocytosis could be due to enhanced activity of mononuclear phagocytic system (Ahmadi-hamedani et al. 2014; Abo-Aziza and Zaki 2017). Lymphocytes decreased in *Trypanosoma*-infected camels as compared to healthy camels. The reduced lymphocyte counts observed in the infected group can likely be attributed to the immunosuppression effects of *Trypanosoma* infection (Hussain et al. 2021). Contrarily, this finding was dissimilar to the findings recorded in studies of Hussain et al. (2016) and Abo-Aziza and Zaki (2017).

Sulaiman and Adeyemi (2010) highlighted the probable explanation for lymphocytosis in the acute phase of a disease, attributing it to generalized lymphoid tissue hyperplasia and heightened reactivity of the spleen and lymph nodes. In contrast, chronic infection may lead to immune system downregulation and decreased lymphoid cell activity. This insight provides a clear understanding of immune responses across different disease stages. While a significant increase population of neutrophils, eosinophils, and basophils was detected in the present study. Additionally, similar changes had been recorded previously in trypanosomiasis (Padmaja 2012; Hussain et al. 2021).

Blood films examined microscopically from diseased camels revealed the existence of several distinct morphological alterations in erythrocytes. Different abnormalities of RBCs, including stomatocytes, hypochromia, hyperchromia, microcytes, macrocytes, and other changes, were also observed in *Trypanosoma*-infected animals, and these findings are similar to the findings of Hussain et al. (2016). These alterations included the presence of tear droplet cells, elliptical cells, microcytes, stomatocytes, paler cells, microcytes with nuclear remnants, hypochromia, and polychromia. Hypochromic cells, macrocytes, target cells, Howell-Jolly bodies, burr cells and stomatocytes are the main abnormalities found in red blood cells. Previous research has also documented different morphological alterations such as polychromia, stomatocytes, hypochromia, poikilocytosis, and anisocytosis in naturally occurring cases of trypanosomiasis in camels and experimentally infected rats (Hussain et al. 2016). Many alterations in serum biochemical parameters were found in the present study. The levels of serum total proteins and serum albumin proteins were significantly reduced in infected camels than healthy ones. These results are similar to the study of Hussain et al. (2016). Hypoalbuminemia could be due to either the severe degenerative alterations in the liver or the compensatory mechanism to keep osmolarity (Al-Abedi et al. 2020). Additionally, trypanosomes usually use albumin for their multiplication and growth, which may result in hypoalbuminemia (Al-Abedi et al. 2020).

However, previous studies have documented that hypoalbuminemia and hyperglobulinemia in camels, which might be due to hepatic injuries and centrilobular degeneration caused by hypoxia (Hussain et al. 2016). Also, increased values of globulins and total protein found in *T. evansi*-positive camels might be linked with the presence of *Trypanosoma* in blood circulation, which stimulates the immune system of the host for activation and secretion of immunoglobulins to oppose the infection (Al-Abedi et al. 2020). Meanwhile, the levels of various serum enzymes like ALT, ALP, and AST were increased in infected camels. These increased indices of the hepatic enzymes (ALP, ALT, AST) might be linked with centrilobular degeneration which is caused by severe oxidative stress as a result of parasitic infection and hypoxia too. Similar findings have been reported in camels as well as in rats infected with trypanosomiasis (Abd El-Baky and Salem 2011; Hussain et al. 2016).

Findings of the current study have shown a significant increase in the levels of malondialdehyde in infected camels as compared to normal animals (Table 4). Previously, it was reported that a significant elevation of MDA generation indicates elevated lipid peroxidation, which also reflects the elevated free radical levels in erythrocytes and serum of infection by *T. evansi* in camels (Saleh et al. 2009). Earlier studies conducted by Saleh et al. (2009) and Eljalii et al. (2015) concluded that Trypanosomiasis infection in camels was linked with oxidative stress as well as lipid peroxidation.

The levels of serum lipid peroxidation products and serum biochemicals were significantly higher in diseased animals as compared to healthy animals. According to previous results, these changes could be due to the sudden onset of oxidative stress, centrilobular liver degeneration, as well as hypoxic state in various tissues of the body (Abd El-Baky and Salem 2011; Hussain et al. 2021).

The levels of serum magnesium, serum calcium, and phosphorus were significantly decreased in infected camels than in healthy ones. A significant decrease in various serum minerals may be linked with irregular physiological alterations caused by oxidative stress, which results in lower absorption and deficient bioavailability in diseased animals (Khan et al, 2023). A significant decrease in blood phosphorus levels in infected camels was found in the present study, which conflicted with that reported by Al-Abedi et al. (2020). However, it was noticed that phosphorus plays a vital role in adenosine triphosphate (ATP) production, particularly in muscles. Surra, caused by *T. evansi*, can lead to significant changes in host physiology. The destruction of host tissues and decline in ATP production could indeed contribute to alterations in serum phosphorus levels. This might be due to tissue damage releasing phosphorus into the bloodstream or disruptions in normal metabolic processes affecting phosphorus regulation. (Al-Abedi et al. 2020).

Conclusion

Current results indicate that the presence of *Trypanosoma* infection in camels has led to changes in blood biochemical parameters. The findings demonstrate that the average values of hematological and biochemical parameters in the serum of naturally infected camels exhibited significant deviations from those of non-infected camels, suggesting a clear association between *Trypanosoma* infection and physiological disturbances. In this study, blood smears showed different forms of trypanosome parasites. Various trypanosomes, namely *T. evansi* and *T. brucei* are found in camels in different parts of southern Punjab. However, *T. evansi* was found to be the predominant species, and it is the main cause of trypanosomiasis in the winter season. The seasonal prevalence of the infection suggests that environmental factors may play a role in influencing the transmission dynamics of the parasite. Overall, these findings highlight the impact of *Trypanosoma* infection on the health of camels, emphasizing the need for effective disease monitoring and control strategies to mitigate the adverse effects on livestock health and production.

Recommendation: On the basis of results of this study that morbid animals having similar clinical signs should be treated for parasitic infections. Moreover, it is suggested that further large-scale studies are needed to establish these facts in camels. Therefore, continuous screening of *T. evansi* in camel should be conducted during summer and winter seasons.

DECLARATIONS

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Conflicts of Interest: The authors declare no conflict of interest.

Data Availability: All the data related to this study is available with the corresponding author and can be obtained on reasonable request.

Ethics Statement: This study and the animal experimentations were approved by the Board of studies of the CMS department, The Islamia University of Bahawalpur, Pakistan (CMS-2/2022-563 Dated: 06-12-2022).

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