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Clinical and laboratory findings associated with naturally occurring babesiosis in dromedary camels

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Abstract

Clinical, haematological, and biochemical changes induced by naturally occurring babesiosis in dromedary camels were described. Of 258 dromedary camels studied, 34 camels suffered from fever, appetite loss, weakness, depression, and reluctant movement; abortion and/or infertility were also observed. Parasitological blood examinations were performed using Giemsa-stained blood smears. The clinically affected animals were diagnosed with babesiosis, with 13.17% overall morbidity. Camels that suffered from babesiosis were subjected to haematological and biochemical analyses and the affected group was compared with a control group containing 34 healthy camels. The affected animals showed a highly significant ($P<0.001$) reduction of the total red blood cell (RBC) count, haemoglobin (HGB) concentration, and mean corpuscular volume (MCV) as well as a highly significant reduction ($P<0.01$) of haematocrit (HCT) and a significant reduction of ($P<0.05$) mean corpuscular haemoglobin (MCH). Additional, highly significant increases ($P<0.01$) in white blood cell (WBC) count and plateletcrit (PCT) percentage were detected. However, other haematological parameters were not significantly altered. There was a very significant reduction ($P<0.001$) of the blood iron level and a very significant increase ($P<0.001$) in blood urea nitrogen (BUN) and lactate dehydrogenase (LDH) in the affected camels. Additionally, significant increases in total protein, albumin, γ-glutamyltransferase (GGT), aspartate aminotransferase (AST), and total bilirubin were observed in the affected camels. It was concluded that babesiosis highly affects the haematobiochemical parameters of dromedary camels, including the liver, kidney, and muscle functions. These results represent novel findings concerning natural babesiosis in camels.

Key words: dromedary camel, babesiosis, haematology, biochemistry.

Introduction

In recent years, the number of studies on the camelid family, in terms of science and research, has greatly increased. Knowledge of the diseases that affect camels and how to prevent them, as well as general health surveillance, nevertheless remains relatively limited (14, 25). Although camels are hardy animals and can tolerate the harsh conditions of arid regions, these animals face a wide variety of diseases. Large numbers of ticks are often found on camels (8), but despite this very few reports concerning tick-borne pathogens in camels have been published. Among these reports, our recent study describes the clinical, parasitological, haematological, and biochemical findings induced by naturally occurring theileriosis in *Camelus dromedaries* (10). *Theileria equi* and *Babesia caballi* have also been identified by PCR in Jordanian dromedaries (19). The first report of *Babesia*-like infection in camels failed to provide any description of the parasite in the blood cells of the animals (5). However, camels showed haemoglobinuria, haemoglobinaemia, haemolytic anaemia, anisocytosis, and polychromasia, which coincide with observations in other animals with babesiosis (25).

Species of the *Babesia* genus are tick-transmitted protozoan haemoparasites that are of great economic, veterinary, and medical interest worldwide. They are

one of the most common blood parasites of mammals; additionally, they infect birds (7, 21). The significant effect of *Babesia* infections are reported in domestic animals, humans, and some wildlife species.

The study of blood components can provide valuable information on the general health of an animal. The observation of deviations from norms in certain blood parameters could help the diagnosis or differential diagnosis of the disease (4, 10).

The aim of the study was to describe naturally occurring babesiosis in dromedary camels and its influence on some haematological and biochemical parameters.

Material and Methods

Animals and clinical examination. The study was performed on a dromedary camel herd containing 258 animals aged 4-8 years, from the Riyadh region, Kingdom of Saudi Arabia. This study took place between January 2011 and February 2012. Thirty-four camels showed the clinical signs of babesiosis often observed in other animals, such as fever, anaemia, and occasional haemoglobinuria. Thirty-four clinically healthy camels were selected from the same herd as control animals, and complete analyses were performed to confirm that the animals were free from any disease. The selected camels had been reared under similar management, feeding systems, and environmental conditions.

Sampling. Faecal samples were collected from the rectum of all camels studied. Blood samples were collected from the jugular vein from control and affected camels. Blood collected in ethylenediaminetetraacetic acid (EDTA) tubes was used to estimate haematological parameters. Sera obtained from clotted blood samples were used to determine biochemical parameters. The obtained sera were stored at -20ºC until processed.

Parasitological examination. Blood smears prepared on slides were stained with Giemsa to detect blood-borne protozoa. Blood samples collected in EDTA tubes (10 mL) were centrifuged for 15 min in microhaematocrit tubes, and the resulting buffy coat layers were examined for the presence of *Trypanosoma evansi* (26). A standard flotation sedimentation test (3) was performed on faecal samples to detect the presence of gastrointestinal nematodes and *Balantidium coli*.

Haematological analysis. A complete blood count was performed using a BC-2800 automatic blood cell counter (Mindray Medical International, China). The following parameters were examined (6): white blood cell count (WBCs), total red blood cell count (RBCs), haemoglobin concentration (HGB), haematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), red distribution width (RDW), platelet count (PLT), mean platelet volume (MPV), plateletcrit (PCT), and platelet distribution width (PDW).

Biochemical analysis. The biochemical analysis was performed using a Biosystems A-15 Automated Biochemistry Analyser (Biosytems, Spain). The biochemical analyses included analysis of the liver, kidney, and muscle functions as well as an analysis of the concentrations of iron. The following parameters were tested: total protein, albumin, globulin, γ-glutamyltransferase (GGT), aspartate aminotransferase (AST), alanine aminotransferase (ALT), lactate dehydrogenase (LDH), total bilirubin, creatinine, blood urea nitrogen (BUN), and iron.

Statistical analysis. The Statistical Products and Service Solutions (SPSS) programme (IBM, USA) was used for all analyses according to Borenstein *et al.* (2). Data were expressed as the mean ± standard error (SE). Comparisons among groups were evaluated using an analysis of variance (ANOVA) test. A difference was considered significant at $P < 0.05$.

Results

Clinical findings. Thirty-four out of 258 camels examined were clinically affected, with 13.17% morbidity rate. These camels showed clinical symptoms of babesiosis observed in other animals, such as: fever, anaemia, haemoglobinuria, icterus, weakness, appetite loss, depression, and gastrointestinal stasis.

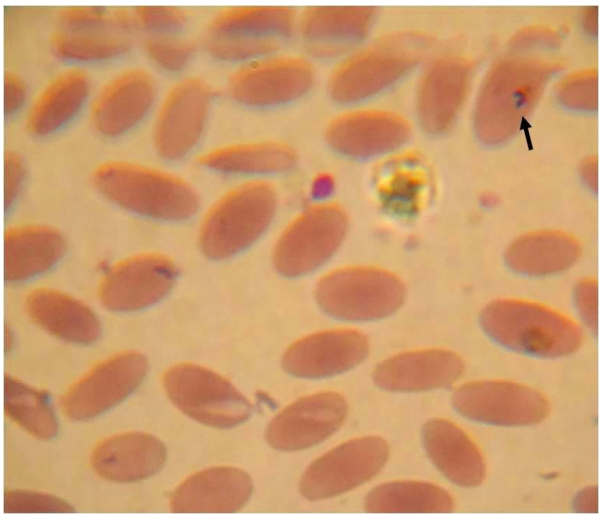


Fig. 1. Blood smear from a naturally infected dromedary camel with *Babesia* sp. trophozoites (pear shaped and arranged in pairs) near the margin of infected RBCs (Giemsa, 100×)

Parasitological findings. *Babesia* was detected in Giemsa-stained blood smears from 34 out of 258 camels (Fig. 1) indicating that all camels with clinical symptoms of the disease had *Babesia* organisms in their blood. The observed *Babesia* sp. was pear-shaped and arranged in pairs with acute or wide angles near the margin of the infected RBCs. The *Babesia* cells varied

in size from 1 to 2 μm for pairs with acute angles and from 3 to 4 μm for pairs with wide angles. Sixteen camels out of 34 were infected with *Babesia* alone. The other 18 camels were infected with *Babesia* and other pathogens. Six camels showed mixed infection of *Babesia* and *Theileria*, ten camels showed mixed infection of *Babesia* and gastrointestinal nematodes, and two camels showed mixed infection of *Babesia* and *Balantidium coli*. Gastrointestinal nematodes and *Balantidium coli* were detected by faecal examination. The degree of *Babesia* infection varied from mild to severe based on the percentage of infected RBCs, which ranged between 1% and 13% (mild 1%-4%, moderate 5%-8%, and severe 9%-13%). No *Trypanosoma* organisms were detected in the buffy coat layers of these animals.

Haematological findings. The mean values of the haematological parameters including the standard error (SE) are presented in Table 1. The tabulated parameters for both clinically healthy animals and *Babesia* infected animals are: WBC count × 10^9/L, RBC count × 10^{12}/L, HGB g/dL, HCT%, MCV fL, MCH pg, mean corpuscular haemoglobin concentration (MCHC) g/dL, RDW%, platelet (PLT) × 10^9/L, MPV fL, PCT%, and PDW%. The affected camels showed a very significant ($P < 0.001$) reduction of the total RBC count, HGB concentration, and MCV as well as a highly significant ($P < 0.01$) reduction of HCT and a significant reduction ($P < 0.05$) of MCH compared to the controls. These differences indicate that the infected camels may suffer from a microcytic hypochromic type of anaemia.

Table 1. Haematological parameters in clinically healthy and *Babesia* infected camels. The data represent mean ± standard error (minimum - maximum values)

Items	Clinically healthy control camels (n = 34)	Camels infected with *Babesia* alone (n = 16)	Camels infected with *Babesia* and other pathogens (n = 18)
WBC count × 10^9/L	11.97 ± 0. 59 (9.60 - 15.30)	14.39 ± 1.1** (11.30 - 19.10)	18.88 ± 2.67*** (12.20 - 28.80)
RBC count × 10^{12}/L	10.86 ± 0.42 (9.44 - 13.91)	9.35 ± 0.49*** (7.80 - 10.90)	7.48 ± 0.28*** (6.01 - 8.80)
HGB g/dL	13.98 ± 0.43 (11.70 - 16.60)	11.04 ± 0.89*** (8.20 - 14.90)	8.94 ± 0.49*** (7.30 - 11.50)
HCT%	32.74 ± 1.17 (28.50 - 39.20)	29.19 ± 1.26** (26.30 - 35.70)	24.94 ± 2.12** (19.20 - 34.60)
MCV fL	34.34 ± 1.05 (32.20 - 43.10)	28.59 ± 0.89*** (24.90 - 32.90)	27.92 ± 0.99*** (22.70 - 32.00)
MCH pg	13.15 ± 0.23 (11.80 - 14.00)	11.79 ± 0.48* (10.08 - 13.60)	11.92 ± 0.55* (9.50 - 13.80)
MCHC g/dL	41.82 ± 0.51 (37.90 - 44.30)	39.56 ± 0.98$^{n.s}$ (36.08 - 44.60)	40.87 ± 1.44* (34.70 - 44.50)
RDW%	17.59 ± 0.38 (16.10 - 20.60)	15.28 ± 0.38$^{n.s}$ (12.90 - 16.20)	27.47 ± 12.21* (11.20 - 125)
PLT × 10^9/L	125.27 ± 5.32 (107 - 153)	134.25 ± 6.63$^{n.s}$ (109 - 162)	132.11 ± 4.00** (111 - 151)
MPV fL	6.16 ± 0.11 (5.70 - 6.60)	6.10 ± 0.29$^{n.s}$ (4.80 - 7.00)	6.27 ± 0.23$^{n.s}$ (5.30 - 7.50)
PCT%	0.073 ± 0.003 (0.06 - 0.09)	0.09 ± 0.001*** (0.09 - 0.10)	0.08 ± 0.003*** (0.07 - 0.09)
PDW%	14.21 ± 0.05 (13.90 - 14.50)	13.85 ± 0.17$^{n.s}$ (12.90 - 14.60)	13.88 ± 0.18$^{n.s}$ (13.06 - 14.70)

*** P < 0.001, ** P < 0.01, * P < 0.05, n.s. - non-significant

Table 2. Biochemical parameters of liver, kidney, and muscle functions and iron content in clinically healthy and *Babesia* infected camels. The data represent mean ± standard error (minimum - maximum values)

Items	Clinically healthy control camels (n = 34)	Camels infected with *Babesia* alone (n = 16)	Camels infected with *Babesia* and other pathogens (n = 18)
		Liver function	
Total protein g/dL	5.81 ± 0.10 (5.17 - 6.20)	6.80 ± 0.46** (4.90 - 8.10)	5.24 ± 0.38$^{n.s}$ (3.79 - 7.10)
Albumin g/dL	3.49 ± 0.16 (2.06 - 3.90)	3.84 ± 0.41* (2.32 - 4.90)	2.83 ± 0.24* (2.00 - 3.58)
Globulin g/dL	2.76 ± 0.23 (2.00 - 3.7)	4.60 ± 0.41** (2.90 - 5.90)	2.91 ± 0.21* (2.21 - 4.00)
GGT μ/L	8.48 ± 1.26 (2.70 - 15.30)	14.74 ± 2.26* (4.90 - 26)	21.6 ± 6.17** (7.39 - 66)
AST μ/L	93.35 ± 4.61 (52.90 - 111)	134.17 ± 111.2** (81.00 - 163)	175.46 ± 27.35*** (69 - 322)
ALT μ/L	12.28 ± 0.92 (6.40 - 17.00)	13.98 ± 1.78$^{n.s}$ (7.46 - 21.00)	16.41 ± 2.96*** (6.22 - 31.00)
Total bilirubin	0.27 ± 0.02 (0.20 - 0.40)	0.55 ± 0.06** (0.20 - 0.74)	0.77 ± 0.20*** (0.20 - 1.80)
LDH μ/L	726.98 ± 24.26 (543.82 - 805)	1219.4 ± 136.7*** (962 - 1887)	2133.91 ± 358.9*** (899.7 - 3867)
		Kidney function	
Creatinine mg/dL	1.46 ± 0.10 (1.00 - 2.01)	1.68 ± 0.32* (0.75 - 3.10)	1.21 ± 0.09$^{n.s}$ (0.78 - 1.69)
BUN mg/dL	25.34 ± 1.72 (17.00 - 35.33)	49.93 ± 3.81*** (38 - 67)	28.28 ± 1.98* (22.0 - 39)
		Elements	
Iron mg/dL	129.22 ± 3.78 (100.19 - 144.60)	79.07 ± 6.49*** (56.00 - 103)	63.91 ± 8.86*** (21.00 - 96.50)

*** P < 0.001, ** P < 0.01, * P < 0.05, n.s. - non-significant

Additionally, highly significant increases ($P < 0.01$) in the WBC count and the PCT% were detected in the infected camels relative to the controls. The other haematological parameters were similar to normal values. Camels suffering from mixed infections of *Babesia* and other pathogens, including *Theileria*, gastrointestinal nematodes, and *Blantidium coli*, exhibited approximately the same values for parameters tested as camels infected with *Babesia* alone. However, significant differences in WBC and RBC counts and HGB concentration were observed in the mixed infection group as compared with the group infected with *Babesia* alone. Sex, age, lactation, and seasonality were shown to influence haematological parameters, although no significant differences were observed as a result of these variables (results not shown).

Biochemical Findings. Biochemical parameters of the liver, kidney, and muscle functions, as well as the iron concentration in *Babesia* infected and clinically healthy camels are shown in Table 2. A very significant reduction ($P<0.001$) in the blood iron level was detected in the affected camels in comparison with the controls. These animals also exhibited significantly higher ($P < 0.001$) BUN and LDH levels. Additionally, significant increases in total protein, albumin, GGT, AST, and total bilirubin were observed in the affected camels. There was no significant difference in most parameters between animals suffering from mixed infections of *Babesia* and other pathogens, including *Theileria*, gastrointestinal nematodes and *Blantidium coli*, and animals infected with *Babesia* alone; however, significant differences in the levels of AST, ALT and total bilirubin were observed in the mixed infection group compared to the group infected only with *Babesia*.

Discussion

Studies of *Babesia* sp. have mainly been influenced by the interest in controlling causative agents of the disease in humans and animals. However, considering the broad diversity of mammals and birds which have been described as vectors of *Babesia* sp., it can be expected that virtually all vertebrates are susceptible to infection by these parasites, provided they are adequate hosts for the various *Babesia*-vector ticks. In addition to the likely presence of undiscovered novel species, a large number of *Babesia* sp. continue to be found infecting unexpected or non-traditional hosts (23). Only one poorly documented case of *Babesia* infection in camels, which lacked a description of the parasite in the blood cells of these animals, has been published to date (5). Uilenberg (24) reported that there is no convincing evidence in the literature of *Babesia* infections in camels and yaks.

Here, we describe the clinical, parasitological, haematological, and biochemical characteristics of naturally occurring babesiosis in dromedary camels. Clinically, the morbidity rate was 13.17%, and the affected camels showed several clinical symptoms of babesiosis observed in other animals, such as: fever, anaemia, haemoglobinuria, icterus, weakness, appetite loss, depression, and gastrointestinal stasis. *Babesia* infections can vary in their manifestation, from asymptomatic to life threatening, due to variations in the immunological status of the host. The reported clinical cases are mostly associated with the recrudescence of existing infections due to stress or with the introduction of naïve animals raised in tick-free areas into tick-infested areas (23). Another recent study determined the prevalence and effect of parasitic infection on erythrocyte indices in trade camels slaughtered in Maiduguri, Nigeria (20). This study does not observe or describe the clinical picture of *Babesia* infection.

Babesia was detected in the Giemsa-stained blood smears from 34 out of the 258 camels, and it had a pear shape and was arranged in pairs with an acute (1-2 μ) or wide angle (3-4 μ) near the border of infected erythrocytes (Fig. 1). However, identification of the species cannot be established, due to developmental changes in *Babesia's* shape and size at different parasitic stages in the RBC, and also due to the fact that some piroplasmid species may differ in shape and size when infecting different vertebrate hosts (pleomorphism) (9). Furthermore, one vertebrate host may be infected by several different piroplasmid species, and likewise "vertebrate host specificity" is not a reliable taxonomic criterion. Currently, numerous parasite species are usually found in a single animal species by molecular methods, and the differentiation of the parasite species by microscopic observation is not always possible (11, 12, 17, 18, 22). The mixed infection with other parasites which was observed in our study is in accordance with Rabana *et al*. (20) and Ismael *et al*. (10).

In the present study, the mean values of the haematological parameters of clinically healthy camels fell within the normal ranges previously reported by Nazifi *et al*. (16), Al-Qarawi (1), Mal *et al*. (15), and Kabir and Vazir (13). These normal ranges can vary with time and geographic location, which may affect the validity of the analysis. Therefore, we used a control group from the same herd; these animals had been reared under similar feeding systems and management and environmental conditions throughout the study period. The affected camels showed significant reduction in total RBC count, HGB concentration, MCV, HCT, and MCH. These results indicated that the infected camels might suffer from a microcytic hypochromic type of anaemia. Such a reduction in MCH could be attributed to haemolysis resulting from the replication of *Babesia* within the RBCs. Haemolysis results in profound anaemia, jaundice, and haemoglobinuria (21). Rabana *et al*. (20) showed values which were different to some extent, which might be attributed to the location and time.

The mean values of the biochemical parameters in clinically healthy camels were also within the normal

range previously reported by Kabir and Vazir (13). A significant decrease ($P<0.001$) in the blood iron level was detected in affected camels. On the other hand, significant increases in BUN, total protein, albumin, GGT, AST, total bilirubin, and LDH were observed in the affected camels compared to the controls. Some of these changes in biochemical parameters are similar to those reported by Dessouky (4), who observed elevated total protein levels in camels affected by babesiosis. Ischaemic changes in skeletal and heart muscles have also been observed in animals which suffered from chronic babesiosis for an extended period (21).

It can be concluded that babesiosis has a deleterious effect on the health of camels, as indicated by the altered haematological and biochemical parameters of infected animals. These findings suggest that our knowledge of which species can harbour *Babesia* parasites is far from complete, and many important concepts remain to be discovered. The accumulating identifications and descriptions of new *Babesia* species in a wide range of hosts encourage us to predict that its research will become a highly dynamic field in the next few years. The piroplasmids that have been reported to date from dromedary camels can be either specific to these hosts or may represent species identified in other host organisms, which have been transmitted to camels via shared ticks; one such example is *Babesia caballi*, which has been recently demonstrated to infect camels (19). Therefore, further studies using PCR-based identification of the infecting *Babesia* sp. are necessary, as are also studies focusing on host specificity and on the genetic diversity of piroplasmids in camels.

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