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Seasonal Variation in Blood Constituents of One-humped Camel (*Camelus dromedarius*)

[1]Alia S.A. Amin, [2]Khalid A. Abdoun and [1]Abdalla M. Abdelatif
[1]Department of Physiology and Biochemistry, Faculty of Veterinary Science, University of Nyala, Sudan
[2]Department of Physiology, Faculty of Veterinary Medicine, University of Khartoum, Sudan

Abstract: This study was carried out in southern Darfur, Sudan during dry-and green (wet) season and was designed to investigate the effects of season (dry-versus green season) on the blood constituents of the one-humped camel (*Camelus dromedarius*). Two hundred and ten blood samples collected from apparently healthy one-humped camels (*Camelus dromedarius*) of different age and sex groups were used in this study, out of which 110 blood samples were collected during the dry season, while 100 blood samples were collected during the green season. The data analysis revealed that the season had significant effects on some of the haematological indices and the blood metabolites and minerals concentrations. The red blood cells count, lymphocytes and basophils percentages increased significantly during the dry season, while the osmotic resistance, MCV, MCH and neutrophils percentage increased significantly during the green season. The serum levels of total protein, globulins and triglycerides increased significantly during the dry season, while the concentrations of plasma glucose and serum urea, creatinine, phosphorus (P) and calcium (Ca) increased significantly during the green season. The results obtained in the present study indicate that the nutritional status could induce significant changes in the physiological responses of the dromedary camel. The available forage during the green season improved the body condition, the blood metabolic and mineral profile in camels. The results indicate that despite camel's selectivity and unique adaptation to arid conditions; glucose, urea, P and Ca levels were lower during the dry season. Therefore, it could be beneficial to provide concentrate feed to camels kept under dry tropical conditions.

Key words: Camel, blood constituents, dry and green season

INTRODUCTION

The dromedary camels adapted themselves to the ecosystems of dry and arid zones where they are subjected to harsh conditions in addition to the severe fluctuations in the nutritional status, which in turn affect their general performance (Wardeh, 2004). The camel possesses unique features which make it superior to other domesticated animals in the hot and arid desert ecosystems. This is reinforced by the ability of camel to traverse considerable distances with much less effort than other species, moving from one patch of short-lived vegetation to another. Camel physiology and special features are therefore not only of a scientific interest, but are the basic substance for people who live in marginal dry land areas. This work was designed to investigate whether the seasonal changes in the pasture quality and the nutritional status could induce significant changes in the blood metabolic-and mineral profile in free ranging camels.

Protein is an essential nutrient for production of erythrocytes in mammals (Williams *et al*., 1972). The protein content of plant species consumed by camels would satisfy most of the protein requirements of camels to perform their various physiological functions (Wardeh and Farid, 1990). An increase in the percentage of neutrophils and eosinophils was reported in sheep fed concentrate diet of 14% CP compared to animals maintained on forage only (Thomas and Chiboka, 1984). However, a substantial fall in the total leukocyte count was reported during starvation (White *et al*., 1956). There were considerable differences in the osmotic fragility of erythrocytes of hydrated cattle and camels. The haemolysis was reported to begin at an osmolarity of 105 mOsm L^{-1} and to be complete at 70 mOsm L^{-1} in cattle, while haemolysis was reported to begin at an osmolarity of 65 mOsm L^{-1} and to be complete at 35 mOsm L^{-1} in camels (Siebert and Macfarlane, 1975).

The concentrations of blood metabolites are sensitive to seasonal changes in nutrient supply. Therefore, they could be used as indicators of nutritional status (Pambu-Gollah *et al*., 2000). Serum total protein and albumin levels are usually considered as useful indices of the nutritional status of animals (Lynch and

Corresponding Author: Khalid A. Abdoun, Institute of Veterinary Physiology, Oertzenweg 19b, 14163 Berlin, Germany
Tel: +49 (0) 30 83862582

Jackson, 1983). Serum protein levels of 8.31±0.85 and 8.07±0.25 g d L^{-1} were reported in Sudanese camels maintained at high and low protein diets, respectively (Heller and Hassan, 1966). Food deprivation decreases plasma glucose levels in both monogastric mammals and ruminants of similar size as the camel (Evans, 1971; Rule *et al*., 1985). However, serum glucose level of camels was maintained during fasting and was increased after feeding had commenced (Wensvoort *et al*., 2004). Camels have been reported to digest crude protein better than goats (Bakheit, 1985). Higher rate of urea recycling (94-97%) was reported in camels fed on dry desert grass of 3.2% crude protein (Mousa *et al*., 1983). Moreover, an inverse relationship between dietary protein content and urea recycling has been reported by Emmanuel *et al*. (1976). They reported an increase in urea recycling rates from 44% in camels fed on 13.1% crude protein diet to 86% in those fed on 6.1% crude protein diet. Blood urea concentration was increased in camels, steers and sheep during fasting (Wensvoort *et al*., 2004). Serum triglycerides concentration was higher in she-camels than that of cows and ewes (Osman and Al-Busadah, 2003). In camels, serum triglycerides concentration has been reported to be affected by diet (Wasfi *et al*., 1987). An increase in serum cholesterol level during starvation has been reported by Mirghani (1982). In Sudanese camels under grazing natural conditions, the normal range of serum minerals concentrations was reported to be 3.9-6.8 mg dL^{-1} for inorganic phosphorus and 6.3-11.0 mg dL^{-1} for calcium (Wahbi *et al*., 1984).

The pasture quality and quantity are influenced by the seasonal changes in rainfall (Lebon, 1965; Schwartz and Dioli, 1992), which in turn could influence the nutritional status and consequently the blood constituents of camels. Therefore, it was our intention to study the seasonal changes in the blood metabolic-and mineral profile of free ranging camels and to investigate if these could be used as indicators in the evaluation of pasture quality and the prediction of metabolic diseases.

MATERIALS AND METHODS

Survey background: This study was carried out in southern Darfur state, Sudan (Latitudes 8° and 13° North, Longitudes 22° and 28° East). It was conducted both during the dry season (March-May 2003) in camels' summer habitat (Masaif) and during the green season (August-September 2003) in camels' autumn habitat (Makharif). Blood samples were collected from apparently healthy camels of different sex and age. The camel herds were naturally ranging and had no feed supplementation except the provision of common salt (NaCl), where approximately 1 pound of salt was added to 20 L of water during the dry season as a traditional practice of nomads during this season. The camels have had access to water every 5-9 days during the dry season, while water was available *ad libitum* during the green season.

Climatic measurements: The daily maximum and minimum ambient temperatures (T_a), rainfall and relative humidity (RH) readings were obtained from Nyala Meteorological Unit in southern Darfur. The mean monthly values of ambient temperature, rainfall and relative humidity during the survey period were then computed.

Blood analysis: Samples of blood were collected from camels by jugular vein puncture. Seven milliliter blood samples were collected from each camel using 10 mL plastic disposable syringes. Two milliliter of the blood sample were immediately transferred to capped and heparinized tubes (Medical Disposable Industrial Complex, MDIC). These samples were used for the haematological analyses and the determination of plasma glucose concentration. The rest of the samples were allowed to clot for 2 h at room temperature, the sera were then separated by centrifugation at 3000 rpm for 15 min and stored frozen at -20°C for further analysis. Erythrocytic indices were determined according to the methods described in Schalm's Veterinary Haematology (Jain, 1986). The packed cell volume of erythrocytes was determined by the micro-haematocrit method using a special centrifuge. Haemoglobin concentration was determined by the cyano-methaemoglobin method as described by van Kampen and Zijlstra (1961). Erythrocyte osmotic fragility was measured by subjecting it to decreasing concentrations of sodium chloride (NaCl) solution (0.1-0.9%). Differential leukocyte count (DLC) was determined microscopically from a count of 100 leukocytes in thin May-Grünwald-Giemsa stained blood smears (Kelly, 1984). Serum total protein was determined by the Biuret reagent method according to King and Wooton (1965), serum albumin concentration was determined according to the method described by Bartholomew and Delany (1966) and the concentration of serum globulins was calculated by subtracting the concentration of serum albumin from the concentration of serum total protein. Plasma glucose level was determined by the enzymatic colorimetric method using a kit (Plasmatec Laboratory Products Ltd., Germany). The concentration of serum urea was determined by the colorimetric method according to Evans (1968). Serum creatinine concentration was determined by a colorimetric method as described by Henry (1974). Serum triglyceride

concentration was determined by enzymatic method using a kit (United Diagnosis Industry, Saudi Arabia). Serum phosphorus concentration was determined by the colorimetric methods as described by Varley (1967). Serum calcium concentration was measured by the colorimetric method as described by Trinder (1964).

Statistical analysis: The data obtained from the blood samples collected from the camels during both seasons have been subjected to standard methods of statistical analysis. The statistical analysis was performed using windows based SPSS (Version 10.0, 1999). The analysis of variance (ANOVA) test was used to evaluate the effects of season on blood constituents of the camels.

RESULTS

Climatic data: The prevalent maximum and minimum ambient temperature (T_a), rain fall and relative humidity (RH) during the survey period in the dry-(March-May) and green season (August-September) are shown in Fig. 1. The highest mean value of maximum ambient temperature (°C) and the minimum mean value of rain fall (mm) were recorded in March during the dry season, while the maximum mean value of rainfall was recorded in August during the green season. The minimum mean value of RH (%) was recorded in April during the dry season, while the highest mean value was recorded in August during the green season.

Seasonal variation in blood constituents of camel Erythrocytic indices: Total RBC count was significantly ($p<0.05$) higher during the dry season. The concentration of haemoglobin (Hb) and the Packed Cell Volume (PCV) did not show any significant seasonal variation. The calculated value of MCV and MCH were significantly ($p<0.05$) higher during the green season. However, the MCHC revealed no significant difference in relation to the season (Table 1).

Erythrocyte osmotic fragility: Camels' erythrocytes collected during both seasons did not show any sort of haemolysis when suspended in hypotonic NaCl solutions up to 0.5% (165.9 mOsm L^{-1}). Partial haemolysis of erythrocytes was first observed below 0.5% NaCl solutions in blood samples collected during the dry season. However, partial haemolysis of erythrocytes was first observed below 0.4% NaCl solutions (132.9 mOsm L^{-1}) in blood samples collected during the green season (Fig. 2). The erythrocytes collected during the green season were significantly ($p<0.05$) more resistant at 0.4, 0.3 and 0.2% NaCl solutions (132.9, 99.6 and 66.4 mOsm L^{-1}, respectively) compared to those collected during the dry season. About 86-94% of erythrocytes collected during both seasons were haemolysed at 0.2% NaCl solution (66 mOsm L^{-1}).

Table 1: Seasonal variation in the erythrocytic indices of camels (values are mean±SE)

Erytrocytic indices	Dry season	Green season	p-value
RBC ($\times 10^6$ μL^{-1})	6.41±0.15	5.79±0.14	0.003
PCV (%)	25.14±0.33	25.95±0.32	0.080
Hb (g dL^{-1})	10.67±0.19	10.73±0.18	0.821
MCV (fl)	40.09±0.81	46.43±0.79	0.000
MCH (pg)	16.99±0.43	19.44±0.42	0.000
MCHC (g dL^{-1})	42.49±0.63	41.62±0.61	0.321

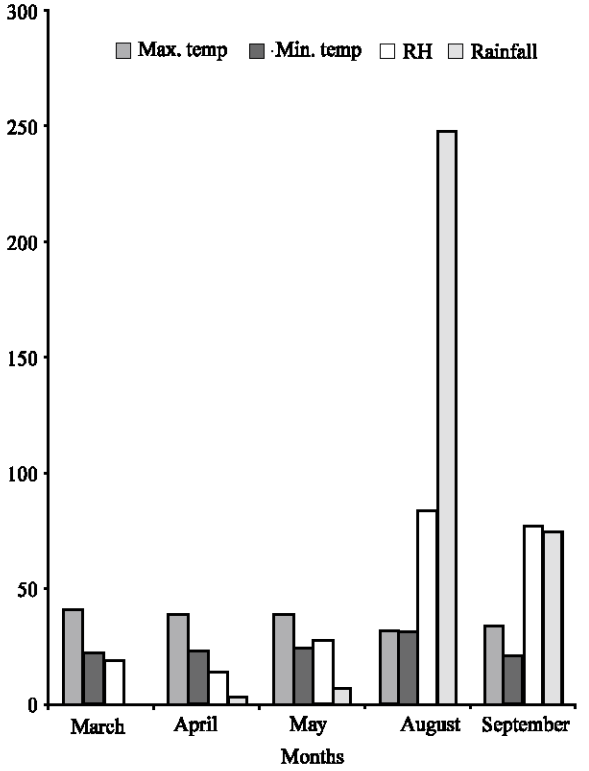

Fig. 1: Meteorological data during the study period at Nyala. The highest value of the maximum ambient temperature (Max. T_a) was recorded in March (40.1°C) during the dry season and the lowest value was recorded in August (32.5°C) during the green season. The highest value for minimum ambient temperature (Min. T_a) was recorded in August (31.9°C) during the green season, while the lowest value was recorded in March (21.7°C) during the dry season. The highest value of relative humidity (RH) was recorded in August (84%), whereas the lowest value was recorded in March (19%). The highest value of rainfall (246.7 mm) was recorded during the green season, while the lowest value (7.0 mm) was recorded during the dry season

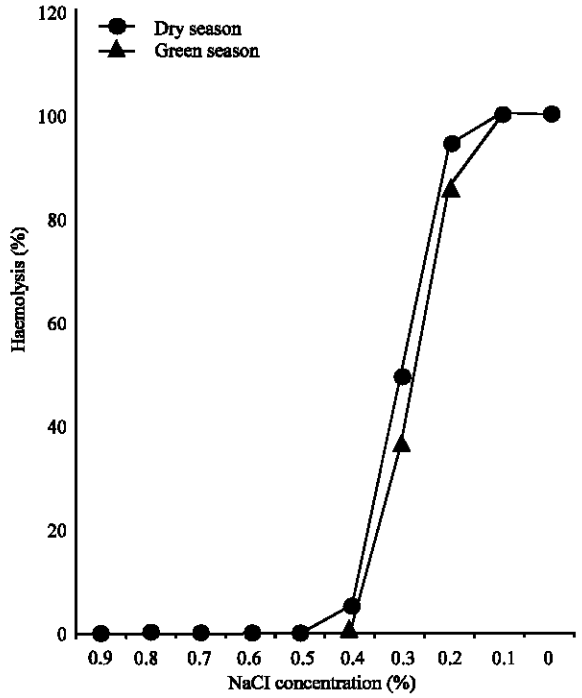

Fig. 2: Seasonal variations in the erythrocyte osmotic fragility of camels. The erythrocytes were more fragile during the dry season. Haemolysis of erythrocytes was started at 0.4% NaCl (132.8 mOsm L^{-1}) in blood samples collected during the dry season; while haemolysis was started at 0.3% NaCl (99.6 mOsm L^{-1}) in blood samples collected during the green season

Differential leukocyte count: Lymphocytes and basophils ratios were significantly ($p<0.05$) higher during the dry season, while the percentage of neutrophils was significantly ($p<0.05$) higher during the green season. However, the percentages of eosinophils and monocytes did not show any significant seasonal variation (Table 2).

Blood metabolites: Serum total protein, globulin and triglycerides concentrations were significantly ($p<0.05$) higher during the dry season. Although serum albumin concentration was slightly higher during the dry season, the difference was not statistically significant. However, plasma glucose, serum urea and creatinine concentrations were significantly ($p<0.05$) higher during the green season (Table 3).

Serum minerals: Serum inorganic phosphorus (P) and calcium (Ca) concentrations were significantly ($p<0.05$) higher during the green season (Table 4).

Table 2: Seasonal variation in the differential leukocytes count of camels (values are mean±SE)

Leukocytes	Dry season	Green season	p-value
Lymphocytes	56.24±1.57	34.93±1.54	0.000
Neutrophils	32.49±1.58	47.35±1.55	0.000
Eosinophils	6.04±0.54	6.67±0.52	0.414
Monocytes	4.40±0.42	4.70±0.41	0.603
Basophils	0.44±0.06	0.11±0.06	0.000

Table 3: Seasonal variation in the concentrations of blood metabolites in camels (values are mean±SE)

Blood metabolites	Dry season	Green season	p-value
Total protein (g dL^{-1})	8.43±0.08	7.08±0.08	0.000
Albumin (g dL^{-1})	3.17±0.05	3.09±0.05	0.241
Globulin (g dL^{-1})	5.83±0.39	4.00±0.38	0.001
Glucose (mmol L^{-1})	3.31±0.13	4.81±0.13	0.000
Urea (mmol L^{-1})	5.66±0.30	9.18±0.29	0.000
Creatinine (μmol L^{-1})	74.26±4.42	136.14±3.54	0.000
Triglycerides (mg dL^{-1})	34.24±1.55	26.71±1.51	0.001

Table 4: Seasonal variation in the concentrations of serum minerals in camels (values are mean±SE)

Serum minerals	Dry season	Green season	p-value
Phosphorus (mmol L^{-1})	1.94 ±0.03	2.35±0.03	0.000
Calcium (mmol L^{-1})	2.03±0.02	2.20±0.02	0.000

DISCUSSION

This study has been conducted to investigate the effect of season on blood constituents of one-humped camel (*Camelus dromedarius*), kept under tropical conditions in southern Darfur. The results obtained would be useful for establishment of normal haematological indices and normal serum metabolic and mineral profile for camels.

The meteorological data shown in Fig. 1 indicated that in the study period, the camels have been exposed to marked seasonal changes in ambient temperature (T_a), relative humidity (RH) and rainfall.

In the present study, the seasonal variation in blood constituents showed a marked effect on the total red blood cells count (Table 1). The observed increase in RBC count during the dry season could be due to the longer half-life and survival time of red blood cells during dehydration, which is common during dry season (Yagil *et al*., 1974). The RBC count obtained in the present study is slightly lower than that reported for Sudanese adult camels (Abdelgadir *et al*., 1984a). However, it is within the range reported by Wilson (1984). The observed increase in the MCV during the green season (Table 1) could be due to the negative correlation between the size and count of erythrocytes suggested by Holman (1952). The observed relative constancy in MCHC (Table 1) could be attributed to the concomitant increase or decrease in Hb concentration and PCV levels. Similarly, Scelza and Knoll (1982) reported an almost steady level of MCHC during different seasons in the Kangaroo rats. The

mean values of MCV, MCH and MCHC reported in the current study are within the range of the previous report (Abdelgadir *et al*., 1984a).

The observed increase in neutrophils ratio during the green season (Table 2) might be due to the improvement of the nutritional status of camels. Higher dietary protein content was reported to increase the neutrophils percentage in ewes (Thomas and Chiboca, 1984).

The erythrocytes osmotic fragility demonstrated significant seasonal differences (Fig. 2). It is known that dehydration increases survival and half times of erythrocytes in camels (Yagil *et al*., 1974) and that the age of erythrocytes is one of the intrinsic factors affecting the erythrocytes osmotic fragility (Jain, 1986). Therefore, the observed seasonal differences in erythrocytes osmotic fragility could be due to the varying degree of dehydration. In the present study, camels' erythrocytes commenced haemolysis at 0.4% NaCl solution during the dry season. This demonstrates that camels have more resistant erythrocytes than that of *Bos indicus* which commence haemolysis at 0.6% NaCl solution (Sant'Ana *et al*., 2001). Furthermore, the erythrocytes of camels are particularly resistant to haemolysis in hypotonic fluids and would be undamaged by rapid rehydration unlike cattle (Siebert and Macfarlance, 1975).

The observed increase in the concentrations of serum globulin and total protein during the dry season (Table 3) could be attributed to the stresses to which camels were subjected under dry conditions. Abokouider *et al*. (2001) reported an increase in serum total protein level during the dry season in camels kept under natural conditions. The overall mean values of serum total protein, albumin and globulins obtained in the present study are within the range reported for camels in the Sudan (Abdelgadir *et al*., 1984b).

The observed decrease in the concentration of plasma glucose during the dry season (Table 3) could be attributed to the decrease of available forage. Food deprivation was reported to decrease plasma glucose level in monogastric mammals and ruminants (Evans, 1971; Rule *et al*., 1985). Moreover, feeding camels after fasting was reported to increase plasma glucose level (Wensvoort *et al*., 2004). There are also previous reports on a decreased plasma glucose level during the dry season in camels (Wilson, 1984; Abokouider *et al*., 2001). The plasma glucose level obtained in the present study is within the range of the previous reports on camels (Azwai *et al*., 1990; Mohamed and Hussein, 1999).

The observed increase in the concentration of serum urea during the green season (Table 3) could be attributed to the availability and quality of forage during the green season. Payne (1990) reported a higher level of crude proteins of pasture plants in wet summer. Higher dietary protein in the racing season was reported to increase Blood Urea Nitrogen (BUN) of camels (Salman and Afzal, 2004). Further more, the idling and ruminating times were reported to be higher during growing season compared to the dry season (Kassilly, 2002). It has also been reported that the level of serum urea is related to the forage intake and consequently the energy and crude protein concentration (Grings *et al*., 1991). The serum urea concentration reported in this study is within the range of previous reports (Elias and Yagil, 1984; Azwai *et al*., 1990).

The observed increase in the concentration of serum creatinine during the green season (Table 3) could be attributed to the higher protein intake in the diet consumed by camels. Abokouider *et al*. (2001) reported lower concentration of creatinine during the dry season. However, Salman and Afzal (2004) reported that serum creatinine level did not show any seasonal variation. The serum creatinine concentration reported in the present study is lower than the previous reports on camels (Abdelgadir *et al*., 1984b; Mohamed and Hussein, 1999; Salman and Afzal, 2004).

The observed increase in the concentration of serum triglycerides during the dry season (Table 3) could be related to the poor dietary conditions. Triglycerides are known to provide the metabolic fuel for most tissues when the animal has energy deficit (Beitz, 1993). Moreover, it has been reported that reduced glucose metabolism is reflected on the output of free fatty acids (Mayes and Bothman, 2003). This increase in serum triglycerides concentration during the dry season is in agreement with the previous reports on camels (Mirghani, 1982; Abokouider *et al*., 2001). Serum triglycerides concentration reported in the present study is within the range reported by Wasfi *et al*. (1987).

The results of the present study showed seasonal variation in the concentrations of serum P and Ca in the dromedary camels. The observed marked increase in the concentrations of serum P and Ca during the green season (Table 4) may be attributed to the availability of plants rich in minerals (ash content) during the wet season (Kuria *et al*., 2004; Amin *et al*., 2006). Moreover, it has been reported that animals kept under natural range grazing could obtain their phosphorus requirement during the wet season (Wilson, 1984; Elmi, 1989). Rainfall can affect the mineral composition of pasture herbage. Phosphorus, for example, appears to be present in higher concentrations when the rainfall is high (McDonald *et al*., 1995). The mean serum P and Ca concentrations reported in this study are within the range of previous reports (Wahbi *et al*., 1984; Mohamed and Hussein, 1999).

CONCLUSIONS

The results obtained in the present study indicate that the nutritional status could induce significant changes in the physiological responses of the dromedary camel. The available forage during the green season

improved the body condition and the blood metabolic and mineral profile of camels. The results also indicate that despite camel's selectivity and unique adaptation to arid conditions, glucose, urea, P and Ca levels were lower during the dry season. Therefore, it could be beneficial to provide concentrate feed to camels kept under dry tropical conditions.

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