Biochemistry Unit,
Animal Health Research Institute, New-Valley Laboratory

STATUS OF BLOOD SERUM MACRO-ELEMENTS IN DROMEDARY CAMELS IN THE NEW-VALLEY

(With 4 Tables and 2 Figures)

By

A. ABOU EL-ELA

(Received at 20/11/2008)

صورة العناصر المعدنية في مصل دم الإبل وحيدة السنام في الوادى الجديد

علي أبوالعلا محمد

لعمل تقرير إكلينيكي ذو دلالة لتشخيص الحالات الغير طبيعية في الجمل لابد أن يكون هناك قيم مرجعية مألوفة تأخذ في الاعتبار عوامل الرعاية و البيئة التي تعود عليها الحيوان. وقد هدفت هذه الدراسة إلى تقديم فكرة عن قيم العناصر المعدنية الكبرى في الجمل في منطقة الوادي الجديد. هذا وقد تم اختيار عدد ١٦٠ جمل من البيئة الطبيعية في الواحات الخارجة وتم تقسيمهم بالتساوي حسب العمر والجنس والحالة التناسلية وفصول السنة. وتم قياس العناصر المعدنية الكبرى في الحشائش التي ترعى عليها الحيوانات وفي مصل دم هذه الإبل. وقد أوضحت النتائج أن تركيز الكالسيوم كان هامشيا بينما كان تركيز الفسفور في الحشائش اقل من احتياج الجمال. وقد سجل المتوسط الكلي العام لقيم العناصر المعدنية الكبرى (مليمول/لتر) في هذه الجمال القيم التالية: ٢,٠٢٢ ±٠,٠٥ (١,٢-٣,١) للكالسيوم و ١,٤٨٣ ±٠,٠٣ (٠,٨-٢,١) للفسفور و ٠,٩٨٤ ±٠,٠٢ (٠,٦-١,٥) للماغنسيوم و ١٥١,٩ ±١,٣ (١٢٥-١٨٢) للصوديوم و ٥,١٦ ± ٠,٠٩٤ للبوتاسيوم و ٩٨,٦ ±١,١٢ للكلوريد. هذه القيم تم تسجيلها من حيوانات سليمة اكلينيكيا ويمكن إعتبارها قيم استرشادية. وقد أوضحت الدراسة أن قيم الكالسيوم و الفسفور كانت تتناقص مع زيادة العمر ($P<0.05$) وفي الإناث أقل من الذكور ($P<0.01$) وأيضا كانت القيم أقل في كل من الجمال العشر والحلابة ($P<0.05$). ومن ناحية أخرى كان متوسط قيم الصوديوم والكلوريد أعلى في الصيف عنه في الشتاء ($P<0.01$) وكانت أقل في الجمال الحلابة. هذا ولم تتأثر المتوسطات العامة لكل من عنصري الماغنيسيوم والبوتاسيوم معنويا بهذه العوامل. ومن هنا أظهرت هذه الدراسة اختلافات ملحوظة في تركيز العناصر المعدنية الكبرى بين الجمال التي ترعى على نفس الحشائش وهذا قد يرجع إلى بعض العوامل مثل عمر وجنس والحالة الإنتاجية والتناسلية للحيوان بالإضافة إلى بعض عوامل البيئة.

SUMMARY

For a meaningful diagnostic clinical report of abnormality in the camel, there must be a standard of familiar reference values regarding the management and environmental factors in which the animal acclimatized. The aim of the present study was to give an idea on the values of macro-mineral in healthy dromedary camels in the New-Valley area. A total number of 160 apparently healthy camels were selected from their natural habitat in rural areas of El-Kharga oasis and equally classified according to their sex, age, season and reproductive status. Macro-minerals were determined in the grasses browsed by camels and blood serum of these camels. Results showed that Ca concentration in the pasture was marginal whereas P concentration was deficient than the requirement of camels. The recorded over all-mean values of macro-elements (mmol/l) in serum of these camels (and ranges) were 2.044 ±0.051 (1.2-3.1) for Ca, 1.483 ±0.032 (0.8-2.1) for P, 0.984 ±0.022 (0.6-1.5) for Mg, 151.9 ±1.299 (125-182) for Na, 5.16 ±0.094 (3.2-7.3) for K and 98.6 ±1.119 (76-123) for Cl. These concentrations were recorded for healthy camels and can be used as indicative values. The values of Ca and P decreased with increasing age ($P<0.05$), females had lower mean values than males ($P<0.01$) and also the values decreased in pregnancy and lactation ($P<0.05$). On the other hand, the mean values of Na and Cl were higher in summer than in winter season ($P<0.01$) and decreased ($P<0.05$) by lactation. The mean values of Mg and K in serum were not significantly affected by the physiological or environmental status. The present investigations show marked differences in the concentration of serum macro-minerals between camels when retained on similar pastures which may be attributed age, sex, productive and reproductive status of the animal as well as the environmental conditions.

Key words: *Macro-elements, dromedary camels, Egyptian oasis*

INTRODUCTION

The camels in many regions in the world often do not receive mineral supplements (Schmidt-Nielsen, 1997 and Faye et al., 2006). The allowed foods for these animals are of unknown dietary concentrations or highly variable due to the severe variations in soil and food mineral concentrations as well as the effect of season and location (McDowell, 1997).

Like soil and plants, animal potential is very important because the concentrations of minerals in animal are influenced by many factors including kind and levels of production, age, sex, and chemical form of elements, interrelationships with other nutrients, mineral intake, breed, and animal adaptation (Underwood and Suttle, 1998). The poor to moderate condition of the livestock may have been due in part to a deficiency of one or more of these minerals (Thornton, 2002).

In the field, severe mineral deficiency is identified by clinical signs, but marginal disorders are not readily identified (Miles *et al.*, 2001). Economically, these marginal disorders can be of considerable significance, because varying degrees of productivity and reproductivity are depressed without the problem being detected by the livestock owner (McDowell, 2003). For a diagnostic and or prognostic clinicopathological test report to be meaningful for abnormality detection in camel, there must be a standard of familiar reference values regarding the management and environmental factors in which the animal acclimatized (Higgins *et al.*, 1992). It is important to determine the mineral profile based on animal fluid and/or tissue concentrations in order to estimate the mineral needs of grazing ruminants, according to productive and reproductive status as well as the time of the year when they are most needed (Underwood and Suttle, 1998). Blood may be easily sampled with a minimum of time, so that blood serum is used as an indicator of the status of certain elements, and the levels of these elements in serum are of value in the determination of deficiency or toxicity states (Radostits *et al.*, 2000).

In dry arid deserts, camels browse wide areas, so they might go through periods searching for the scarcely distributed vegetation and bushes (Schmidt-Nielsen, 1997). The camels supreme other domestic animals for this traditional system (Gahlot, 2000 and Marai *et al.*, 2006). This superiority is governed by a precise partition of nutrients in the body throughout a short-term regulation or what is called homeostatic control (Yagil, 1986). Once these mechanisms are understood, the camel can be fully utilized in preference to other animals (Schmidt-Nielsen, 1997).

Metabolic profiles and mineral status has been established in several areas in the temperate and tropical regions (Nazifi *et al.*, 1998; Mohamed and Hussein, 1999; Achaaban *et al.*, 2000; Bogin, 2000; Romdhane *et al.*, 2003; Sayed and Abdel Raheem, 2003; Ahmed *et al.*, 2002; Ahmed *et al.*, 2003a,b; Kamalu *et al.*, 2003 and Rahman *et al.*, 2007). Seasons, some other physiological factors as well as the health

status are proved to have an influence on the mineral profile of camels (Faye *et al.*, 1995).

The aim of the present study was to give an idea on the values of macro-mineral in dromedary camels in the New-Valley area. Also, to investigate the effect of some physiological factors such as age, sex, and the reproductive status (pregnancy and lactation) of the animal as well as the effect of season on the levels of these macro-elements in healthy camels.

MATERIALS and METHODS

Study area and meteorological data:

New-Valley area covers most of the western Egyptian desert. The climate is very hot and dry in summer. According to the meteorological station at El-Kgarga oasis, the air temperature ranged between 18.1 ±3.1 °C in winter to 43.9 ±2.1 °C in summer. The relative humidity ranges from 61.1 ±7.1 % in winter to 20.2 ±2.1% in summer. There is no rainfall, surface water or rivers. This study was carried out during July (mid-summer) and December (thermoneutral) 2006.

Camels in this area reared under unorganized farming with unsatisfactory standards of animal management and feeding. Camels, in small flocks, are confined to small areas for grazing pastures grown around groundwater wells without supplementation with concentrates or minerals. Barseem Hegazy (*Medicago sativa)* is the main food available for camels in this area. Also, some patches of scattered grass as *Echinochloa colonum, Digitaria sanguinalis, Dicanthium annulatum, Haloxylon salicornicum, Cyperus conglomeratus* and *Cyperus conglomeratus* are used for grazing. The chance of watering depends on untreated water pumped from the few scattering ground wells or water passages when available.

Animals:

A total number of 160 apparently healthy camels were selected from their natural habitat in rural areas of El-Kharga oasis and used for investigation in this study. These camels were equally classified according to their sex (80 male and 80 females), age (80 juvenile, 3-4 years and 80 mature, 7-8 years), and season (80 camels during winter and 80 during summer).

According to the reproductive status, the female camels (n=80) were classified into non-pregnant non-lactating (n=35), pregnant non-lactating (n=20) and lactating (n=25). All camels were subjected to

careful clinical and laboratory examinations to ensure their healthy status according to Higgins (1986). All camels were treated with anti-parasitic medications two weeks before the investigations to exclude the effect of the parasitic infestation.

Sampling:

Blood was drained by jugular vein puncture in centrifuge tubes without anticoagulants. Serum was harvested by centrifugation and stored at -20°C until biochemical determination. From the grasses used for browsing by camels, representative samples were collected separately from each locality. These samples were dried, ground and stored in airtight containers for subsequent analysis.

Biochemical analysis:

Blood serum samples were used for determination of calcium, phosphorous and magnesium according to Norbert (1982) using commercially available test kits (Bayer diagnostics). The concentrations of blood serum sodium and potassium were carried out using flame-photometer (Corning 400) using calibrated standards for Na and K. Meanwhile, chloride concentrations in the blood serum were measured using a chloride analizer (Corning chloride meter 925).

Forage samples were dry ashed at 550°C for 6 h, wet digested (HCl-HNO3) and diluted with deionized water. Concentrations of Ca, P and Mg in the forages supernatants were estimated colorimetrically (AOAC, 1990) in the laboratory of soil fertility, El-Kharga, New-Valley, whereas, Na and K concentrations were measured in the supernatant using flame photometer (Corning 400).

Statistical analysis:

Obtained data were subjected to a software program (SPSS, Ver. 10) according to Borenstein *et al.* (1997). Values of macro-elements in the blood serum were evaluated dependently in all samples by use of linear general model ANOVA to asses the all mean values and to determine the effect of age, sex, season and the reproductive status on the measured variables. Differences between means were compared independently using paired t-test [P (T</= t) two-tail] with unequal variance, or Duncan's new multiple range test when needed for more than two groups (reproductive status).

RESULTS

Table 1 shows mineral concentration (mean ±SE) in pastures (ppm dry matter) used by camels. It was noticed that Ca concentration in

the pasture was marginal whereas P concentration was deficient according to the reports of McDowell (2003) for requirement of ruminants. The concentrations of Mg, Na and K were adequate but sample variance of Na and Cl was high indicating wide variation between levels of individual samples.

Table 2 shows blood serum macro-element concentrations in the Egyptian oasis healthy camel. The recorded over all-mean values of macro-elements of these camels (and ranges) were 2.044 ±0.051 (1.2-3.1) for Ca, 1.483 ±0.032 (0.8-2.1) mmol/l for P, 0.984 ±0.022 (0.6-1.5) mmol/l for Mg, 151.9 ±1.299 (125-182) mmol/l for Na, 5.16 ±0.094 (3.2-7.3) mmol/l for K and 98.6 ±1.119 (76-123) mmol/l for Cl concentrations (Fig. 1, 2).

Effect of age and sex on blood serum macro-mineral concentrations in dromedaries is shown in table 3 and Fig. 1, 2. As seen, there are distinct differences between the mean values of serum Ca and P in dromedaries based on age and sex effect ($P<0.05$ for age and $P<0.01$ for sex). The values of Ca and P decreased with increasing age and females had lower mean values than males. There were no obvious effects of age and sex on the mean concentrations of blood serum Mg, Na, K and Cl.

Effect of season on blood serum macro-mineral concentrations in dromedaries is shown in table 4 and Fig. 1, 2. Season had a significant effect on the mean values of blood blood serum Na and Cl concentrations ($P<0.01$). The mean values of Na and Cl were higher in summer than in winter season. The concentrations of other minerals (Ca, P, Mg and K) were not influenced by the effect of season.

The effect of reproductive status on blood serum macro-mineral concentrations in dromedaries is also shown in table 4 and Fig. 1, 2. Both pregnancy and lactation had significant effect on serum Ca and P concentrations ($P<0.05$). Blood serum Na and Cl concentrations were affected ($P<0.05$) by lactation. The mean values of Mg and K in serum were not affected by the reproductive status.

Table 1: Mineral concentration (mean ±SE) in pastures (ppm dry matter) used by camels.

Mineral	Ca (ppm)	P (ppm)	Mg (ppm)	Na (ppm)	K (ppm)
Concentration	1.6±0.6	1.1±0.4	4.6±1.2	0.8±0.7	0.7±0.1
Requirement*	1.5-4	1.3-3.2	1.2-2	0.7-1.2	5.0
Status*	Marginal	Low	Adequate	Adequate	Adequate

*According to McDowell (2003)

Table 2: The all mean serum macro-element concentrations (±SE) in the New Valley camels (n=160).

	Ca (mmol/l)	P (mmol/l)	Mg (mmol/l)	Na (mmol/l)	K (mmol/l)	Cl (mmol/l)
No of camels	160	160	160	160	160	160
Mean	2.044	1.483	0.984	151.9	5.16	98.6
SE	0.051	0.032	0.022	1.299	0.094	1.119
Sample Variance	0.412	0.169	0.078	270.1	1.428	200.4
Minimum	1.2	0.8	0.6	125	3.2	76
Maximum	3.1	2.1	1.5	182	7.3	123

Table 3: Effect of age and sex on serum macro-mineral concentrations (mean ±SE) in the New Valley camels.

	Effec of age		Effect of sex	
	Young (n=80)	Adult (n=80)	Male (n=80)	Female (n=80)
Ca (mmol/l)	2.228±0.075	1.76±0.068*	2.437±0.058	1.565±0.081**
P (mmol/l)	1.691±0.046	1.315±0.046*	1.701±0.041	1.289±0.052**
Mg (mmol/l)	0.992±0.031	0.977±0.031^{ns}	0.974±0.036	1. 04±0.42^{ns}
Na (mmol/l)	149.8±1.924	153.9±1.729^{ns}	152.6±2.01	150.1±1.89^{ns}
K (mmol/l)	5.199±0.126	5.118±0.141^{ns}	5.201±0.149	5.110±0.134^{ns}
Cl (mmol/l)	98.34±1.44	99.12±1.67^{ns}	99.27±1.56	98.23±1.64^{ns}

*, ** significant level at P<0.05 and P<0.01 respectively. ns: non significant variation.

Table 4: Effect of season and reproduction on serum macro-mineral concentrations (mean ±SE) in the New Valley camels.

	Effect of season		Effect of reproductive status		
	Winter (n=80)	Summer (n=80)	NP-NL (n=35)	Pregnant (n=20)	Lactating (n=25)
Ca (mmol/l)	2.03±0.07	1.94±0.07^{ns}	2.22±0.08^{a}	1.88±0.07^{b}	1.91±0.09^{b}
P (mmol/l)	1.46±0.06	1.51±0.05^{ns}	1.62±0.04^{a}	1.37±0.04^{b}	1.41±0.06^{b}
Mg (mmol/l)	0.98±0.04	0.98±0.03^{ns}	0.97±0.02^{a}	0.99±0.04^{a}	0.98±0.03^{a}
Na (mmol/l)	138.7±2.0	165.6±1.8**	159.2±2.2^{a}	154.1±1.9^{a}	144.4±1.9^{b}
K (mmol/l)	5.17±0.13	5.22±0.13^{ns}	5.20±0.14^{a}	5.16±0.13^{a}	5.19±0.12^{a}
Cl (mmol/l)	96.5±1.5	102.7±1.7**	103.1±1.4^{a}	99.1±1.4^{a}	96.4±1.3^{b}

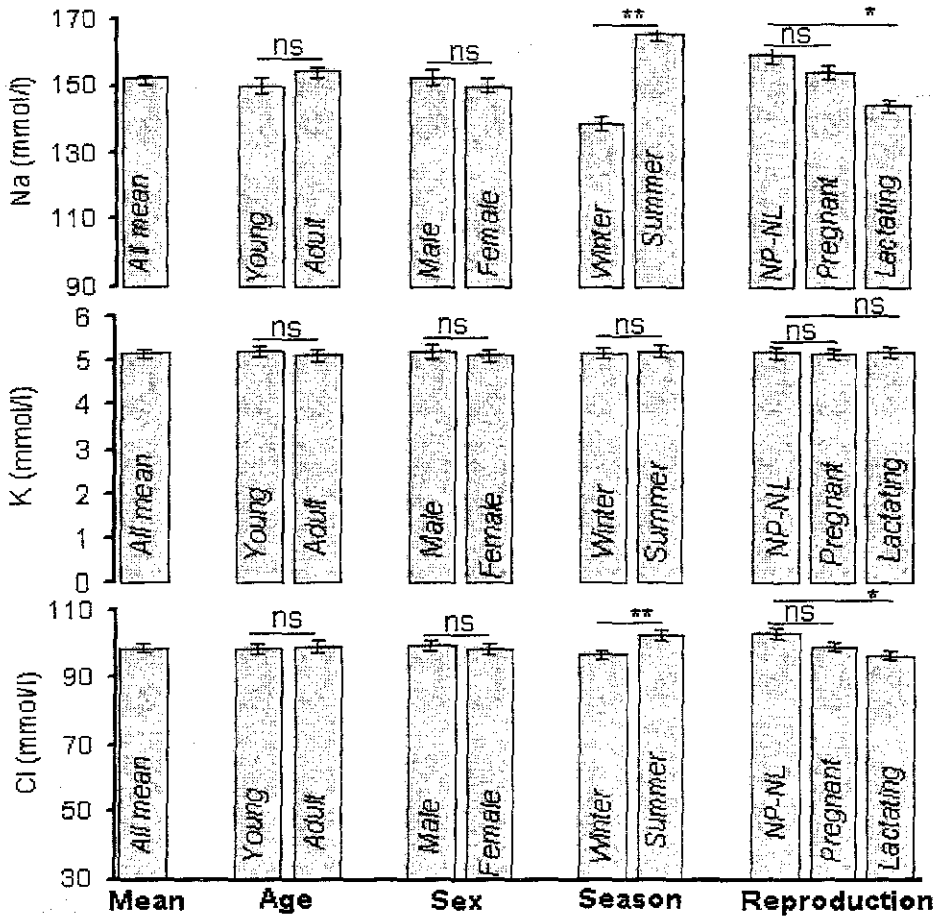

Fig. 1: the mean values (±SE) and the effect of age, sex, season and reproduction on Ca, P and Mg in the New Valley camels.

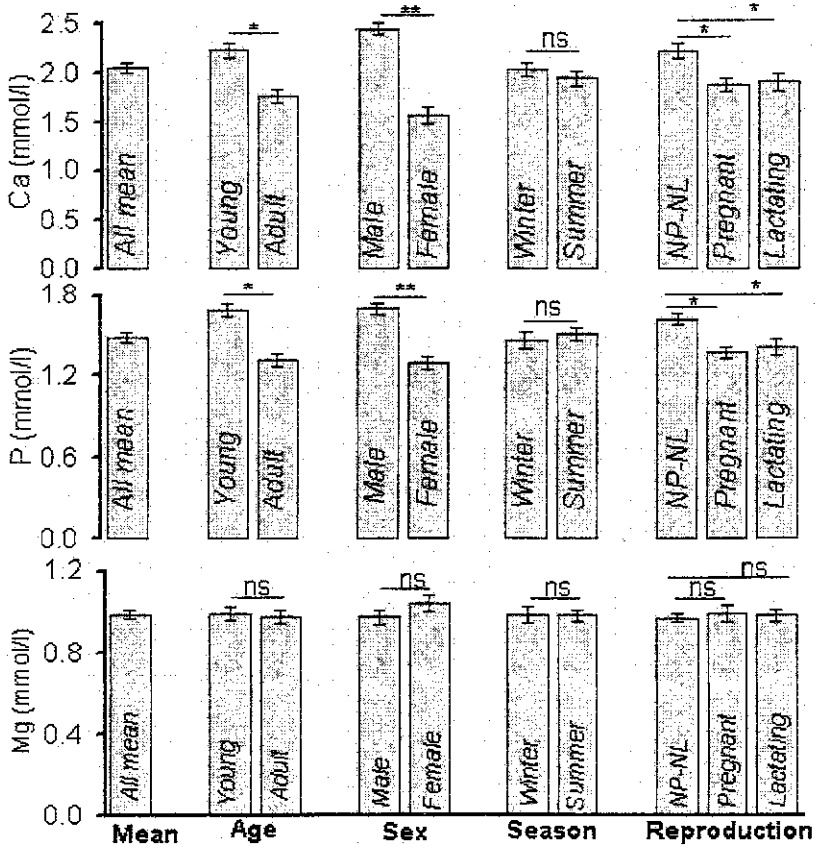

Fig. 2: The mean values (±SE) and the effect of age, sex, season and reproduction on Na, K and Cl in the New Valley camels.

DISCUSSION

A major goal in mineral research has been to discover and/or develop simple and accurate biochemical measurements of the status of animals for the minerals in which there are important practical problems (Miles *et al.* 2001). The normal values in the current work are established by the analysis of the statistical mean, standard errors and ranges of the various macro-minerals in the blood serum taken from normal healthy camels and can be used as reference values for camels reared in the Egyptian oasis. These defined criteria, describes the effect

of age, sex productive and reproductive status in addition to environmental conditions on the levels of these constituents Gahlot, 2000).

The obtained over all-mean values for blood serum Ca, Mg, Na, K and Cl in the current study are similar to those reported by Rezakhani *et al.* (1997) Abdel-Raheem (1998), Abu Damir (1998), Achaaban *et al.* (2000), Bogin (2000), Ahmed *et al.* (2002), Ahmed *et al.* (2003a,b), Kamalu *et al.* (2003), and Rahman *et al.* (2007), whereas P concentration was relatively lower than those reported in the previous studies and than the actual requirements for ruminants (Miles *et al.* 2001 and McDowell, 2003).

Blood serum calcium concentrations are hormonally controlled to maintain values greater than 2.0 mmol/l in ruminants (Underwood and Suttle 1998). Hypocalcaemia can result from depletion of calcium reserves or an inability of the animal to mobilise calcium reserves to meet the increased demands of late pregnancy or early lactation. It is suspected that diets high in cations, particularly potassium, can predispose lactating and pregnant animals to calcium deficiency (McDowell, 2003). Horst *et al.* (1990) reported that calcium metabolism undergoes sharp changes in pregnant and lactating animals (especially towards the end of pregnancy and beginning of lactation). In lactating ruminants, the Ca homeostasis is maintained by an increased rate of dietary Ca absorption, decreased rate of urinary Ca excretion, and mobilization of bone Ca under the complex physiological action of parathyroid hormone, calcitonin, and vitamin D (McDowell, 2003). During this period the calcium balance may be negative which is in agreement with the results of the current study.

In the current study, the effect of age of camels on the mean concentration of blood serum Ca was significant. The values decreased with increasing age. These results agree with those reported by Alonso, *et al.* (1997), Ahmed *et al.*, 2002 and Ahmed *et al.* (2003a,b). Underwood and Suttle (1998) reported that the efficiency of absorption of calcium decreases as animals' age. Young animals absorb calcium very efficiently and very old animals absorb calcium poorly. As animals age, there is a decline in vitamin D receptors in the intestinal tract, which is thought to reduce the ability to respond to 1,25-dihydroxyvitamin D (McDowell, 2003).

In herds reared at pasture, phosphorus can be considered, worldwide, the major mineral deficiency causing economic impact (Underwood and Suttle, 1998 and Hassan and El Said, 2000). For

grazing livestock, P is the mineral most likely to be deficient. Animals receiving the low-P diet had lower gains, exhibited pica, and had bone demineralization. Serum P values of less than 1.5 mmol/l was considered as risk of phosphorus deficiency (Underwood and Suttle 1998). The effect of age of camels on the mean concentration of blood serum P was significant in the current work. The values decreased with increasing age. The decrease of blood serum P with age was also reported by Rezakhani *et al.* (1997) Ahmed *et al.* (2002) and Ahmed *et al.* (2003a,b). The efficacy of absorption in young animals than old individuals and the maintenance of Ca:P ratio (Underwood and Suttle, 1998) may be responsible for these variations.

In the current work, the effect of sex was significant on blood serum P concentrations of camels. It seems that the variations in the productive and reproductive efficacy between the two sexes might be responsible for these variations. The effect of reproductive status showed significant effect ($P< 0.05$) of both pregnancy and lactation on the mean values of blood serum P concentrations in the Egyptian oasis camels. These variations coincide with the increased demand of these elements for fetal growth and for milk production (Underwood and Suttle 1998). These results agree with those reported by Ahmed *et al.*, 2002 and Ahmed *et al.* (2003a,b).

The Mg pool in ruminants to meet their metabolic needs is relatively small and can be readily depleted when animals fed on diets of low available Mg or reduced intakes. Also, K is one of the most abundant minerals in plants, and the K concentration in pastures usually exceeded the level required by livestock (McDowell, 2003). At the time of the survey, the metabolic pool of Mg and K was adequate in camels in the current study as indicated by blood serum Mg concentrations above 0.8 mmol/l, and blood serum K values above 4 mmol/l (Underwood and Suttle 1998).

Blood serum Na is considered the major osmotic ingredients responsible for stability of blood osmolality and maintenance of blood volume of camel (Igbokwe, 1997 and Gahlot, 2000). The observed increase in plasma sodium and consequently Cl in the current work might be a functional compensatory mechanism for retention of body water to insure efficient evaporative cooling (Schmidt-Nielsen, 1997). The other minerals such as Ca, K, and Mg were not affected as much as Na during environmental fluctuations suggesting that Na and Cl are the main factors responsible for thermoregulatory homeostasis during thermal fluctuations (Kataria *et al.* 2002). The lowered values of blood

serum Na and Cl in lactating animals in the present study is likely due to the high secretion of Na through milk (Miles *et al.* 2001 and Haddadin *et al.* 2008).

The survey showed that camels reared in the New Valley camels were at risk from macro-mineral disturbances. Also, the present investigations show marked differences in the concentration of blood serum macro-minerals between camels when retained on similar pastures. Variation in serum macro-mineral status in different animal classes may be attributed to many factors affecting mineral status which include age, sex, productive and reproductive status as well as the environmental conditions. The obtained values of blood serum minerals in this study can be used as indicative values to evaluate the minerals status of camels in health and disease.

REFERENCES

Abdel-Raheem, H.A. (1998): Metabolism of some minerals in camel. Ph. D. Thesis, Aus dem Institut für Ernährung der Veterinärmedizinischen Universität, Wien.

Abu Damir, H. (1998): Mineral deficiencies, tonicities and imbalances in the camel (Camelus dromedarius): a review. Veterinary Bulletin. 68: 1103-1119.

Achaaban, M.R.; Schroter, R.C.; Forsling, M.I. and Ouhsine, A. (2000): Salt balance in camels subjected to heat stress and water deprivation under two different environmental conditions. Journal of Camel practice and research, 7: 57-62.

Ahmed M.M.M.; Abead, S.M. and Barri, M.E.S. (2002): Some micro mineral profile in the serum of female camels as affected by the physiological state. Camel Newsletter, 19: 66-73.

Ahmed, M.M.M.; Abead, S.M. and Barri, M.E.S. (2003a): Effect of physiological status on some macromineral profiles in the serum of female camels. Journal of Camel Practice and Research. 10 (2): 107-110.

Ahmed M.M.M.; Awad, M.E. and Barri, M.E.S. (2003b): Some micro mineral profile in the serum of female camels as affected by the physiological state. Pakistan Journal of Biological Sciences. 6: 1853-1855.

Alonso, A.J.; de Teresa, R.; Garcia, M.; Gonzalez, J.R. and Vallejo, M. (1997): The effects of age and reproductive status on serum and blood parameters in Merino breed sheep. Journal of Veterinary Medicine, A, 44: 223-331.

AOAC, (1990): Official Methods of Analysis, 15th Edition. Association of Agricultural Chemists, Washington, DC.

Bogin, E. (2000): Clinical pathology of Camelides: present and future. Revue de Medecine Veterinaire 2000, 151: 563-568

Borenstein, M.; Rothstein, H. and Cohen, J. (1997): Sample Power Statistics. 1.0. SPSS Inc., Chicago.

Faye, B.; Bengoumi, M. and Seboussi R. (2006): Metabolism of some minerals in camel: A face of the adaptation to harsh conditions. Proceedings of the international scientific conference on camels, Qassim Univ. KSA, pp 1593-1618.

Faye, B.; Rotavonanahary, M.; Chacornac, J.P.; Soubre, P. (1995): Metabolic profiles and risks of diseases in camels in temperate conditions. Comparative Biochemistry and Physiology. 112A: 67-73.

Gahlot, T.K. (2000): Selected Topics on Camelids. The Camelid Publishers, Chandan Sagar Well, Bikaner, India.

Haddadin, M.S.; Gammoh, S.I. and Robinson, R.K. (2008): Seasonal variations in the chemical composition of camel milk in Jordan. Journal of Dairy Research75: 8-12.

Hassan, H.Y. and El Said, M.S. (2000): Some hematological and biochemical parameters of debilitating camels at Alexandria governorate. Assiut Veterinary Medical Journal. 2000. 43: 219-227.

Higgins, A. (1986): The Camel in Health and Disease, Baillere Tindall, London, Philadelphia, Toronto.

Higgins, A.J.; Allen, W.R.; Mayhew, I.G. and Snow, D.H. (1992): An introduction to the camel in health and disease. Proceedings of the First International Camel Conference, held at Dubai, UAE, 2-6 February 1992. Ed. Allen, W R; Higgins, A.J; Mayhew, I.G; Snow, D.H. and Wade, J.F., R&W Publication Ltd., pp. 17-19.

Horst, R.L.; Goff, J.P. and Reinhardt, T.A. (1990): Advancing age results in reduction of intestinal and bone 1,25-dihydroxyvitamin D receptor. Endocrinol. 126: 1053-1057.

Igbokwe, I.O. (1997): The effects of water deprivation in livestock ruminants: an overview. Nutritional Abstracts and Reviews (Series B), 67: 905-914.

Kamalu, T.N.; Okpe, G.C. and Williams, A. (2003): Mineral contents of extracellular fluids in camel and cattle in the North East Sahel region of Nigeria. Nigerian Veterinary Journal 24, 13-20

Kataria, N.; Kataria, A.K.; Agarwal, V.K.; Garg, S.L. and Sahni, M.S. (2002): Effect of long term dehydration on serum constituents in extreme climatic conditions in camel (Camelus dromedarius). Indian Journal of Physiology and Pharmacology. 46: 218-222.

Marai, I.F.M.; Zeidan, A.E.B.; Abdel-Samee, A.M.; Abizaid, A. and Fadiel, A. (2006): Camel Reproductivity and Physiological Performances as Affected by Environmental Conditions (Review Article). Proceedings of the international scientific conference on camels, Qassim Univ. KSA, pp 1707-1749.

McDowell, L.R. (1997): Minerals for Grazing Ruminants in Tropical Regions. Extension Bulletin. Animal Science Department, Centre for Tropical Agriculture, University of Florida, pp 81.

McDowell, L.R. (2003): Minerals in Animal and Human Nutrition, second ed. Elsevier Science, Amsterdam, pp 644.

Miles, P.H.; Wilkinson, N.S. and McDowell, L.R. (2001): Analysis of Minerals for Animal Nutrition Research, third ed. University of Florida, Gainesville, FL, USA, 119 pp.

Mohamed, H.A. and Hussein, A.N. (1999): Studies on normal haemtological and serum biochemical values of the 'Hijin' racing camels (Camelus dromedarius) in Kuwait. Veterinary Research Communications. 23: 241-248.

Nazifi, S.; Rezakhani, A. and Gheisari, H.R. (1998): Physical, biochemical and cytologic properties of blood and synovial fluid in clinically normal adult camel (Camelus dromedarius). Journal of Veterinary Medicine, A. 45: 155-160.

Norbert, W.T. (1982): Fundamentals of Clinical Chemistry. W.B. Saunders Company, Pheladelphia. USA.

Radostits, O.M.; Gay, C.C.; Blood, D.C. and Hinchcliff, K.W. (2000): Veterinary Medicine, 9th Ed. (Baillier Tindall, London, Philadelphia, New York).

Rahman, Zia-Ur; Ahmad, N.; Bukhari, S.A.; Akhtar, N. and Haq, I.U. (2007): Serum hormonal, electrolytes and trace element profiles in the rutting and non-rutting one-humped male camel (Camelus dromedarius). Animal Reproduction Science. 101: 172-178.

Rezakhani, A; Habibabadi, S.M. and Ghojogh, M. (1997): Studies on normal haematological and biochemical parameters of Turkmen camel in Iran. Journal of Camel Practice and Research. 4: 41-44.

Romdhane, S.B.; Romdane, M.N.; Feki, M.; Sanhagi, H.; Kaabachi, N. and M' Bazaa. (2003): Blood biochemistry parameters in dromedary (Camelus dromedarius). Revue de Medecine Veterinaire. 154: 695-702.

Sayed, A.N. and Abdel Raheem, H.A. (2003): The influence of different concentrate-roughage proportion on the metabolism of some minerals in camels. Assiut Veterinary Medical Journal. 49: 1-19.

Schmidt-Nielsen, K. (1997): Animal physiology. Adaptation and environment. 5th ed. Cambridge Univ. Press.

Thornton, I. (2002): Geochemistry and the mineral nutrition of agricultural livestock and wildlife. Applied Geochemistry 17: 1017–1028.

Underwood, E.J. and Suttle, N.F. (1998): The Mineral Nutrition of Livestock, 3rd ed. Commonwealth Agricultural Bureaux. Farnham Royal, Slough, UK.

Yagil, R. (1986): The camel: self-sufficiency in animal protein in drought-stricken areas. World Animal Review, FAO, 57: 2-10.