The Effect of Pregnancy, Management and the Environmental Condition on Blood Metabolites, Leukocytic and Erthrocytic Indices and Clinical Parameters in Butana Camels – Sudan

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Abstract: The present study was carried out to investigate the effect of the season, management system and physiological status on some blood constituents and Clinical Parameters. This study was done in Tambol, Butana area, Sudan. Sixty healthy one-humped she-camels (*Camelus dromedarius*) aged between 6 and 9 years were used in the study. The animals were divided into four groups: Group (1) non-pregnant penned she-camels, Group (2) pregnant penned she-camels, Group (3) non-pregnant free grazing she-camels and Group (4) pregnant free grazing she-camels. Blood samples (10ml) were collected from jugular vein, monthly throughout the experimental period. Red blood cells count, haemoglobin concentration (Hb), packed-cell volume (PCV), erythrocyte indices, total and differential leukocytes count, total protein, albumin, globulin, cholesterol, triglyceride and glucose were determined using the standard laboratory methods. It was found that, rectal temperature (^{o}C), respiration rate (breath/min) and pulse rate (beat/min) increased significantly during summer (37.86+0.41, 14.84+1.47, 41.83+3.75), respectively. Group (1) registered higher rectal temperature and respiratory rate, and lower pulse rate compared with the group (2). Group (3) showed higher pulse rate than group (4). RBCs (X 106/mm3) decreased during summer (7.00+0.92) compared to autumn (7.12+0.97) and winter (7.21+1.01). Significantly ($p<0.001$) lower values of PCV (%) and MCV (fl) were obtained during autumn (27.68+3.43, 39.19+3.94) and no significant differences were observed during summer and winter, while the significantly ($p<0.001$) higher value of MCHC (g/dl) was recorded during autumn (39.74+4.94) compared to the values recorded during winter (36.15+4.32) and summer (36.29+3.87). Group (2) and group (3) showed significantly ($p<0.001$) increases in RBCs count and PCV, and decreases in MCV values. The highest value of TWBCs (X 103/mm3) was recorded during autumn (17.72+3.57) while the lowest value was recorded during summer (13.46+2.62). The lowest neutrophils percentage (%) was observed during winter (44.70+4.27) while the highest value was recorded during summer (54.52+5.34). The highest values of lymphocytes percentage (%) was recorded during winter (47.84+4.64) compared to the values obtained during summer (37.84+3.19) and autumn (43.74+3.86). Group (2) registered higher TWBCs and lymphocytes, and lower neutrophils, eosinophils and monocytes compared with group (1). Group (3) registered higher TWBCs, eosinophils, basophils and monocytes, and lower neutrophils compared with group (4). Serum total protein (g/dl), albumin (g/dl), and cholesterol (mg/dl) increased during autumn (6.86+0.77, 3.63+0.65, 50.40+7.34), respectively, compare to summer (5.73+0.66, 2.51+0.42, 25.24+4.11) and winter values (5.82+0.6, 2.82+0.36, 25.05+3.68). During summer, triglycerides (mg/dl) (25.72+2.52) concentration decreased but glucose (mg/dl) (107.58+5.87) increased compared to autumn (35.77+3.89, 99.05+4.48) and winter (35.06+3.23, 103.84+5.63). Group (2) registered higher total protein and glucose values than group (1), while group (1) registered higher cholesterol than group (2). Pregnancy significantly reduced serum concentration of albumin, cholesterol and glucose.

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1. Introduction

The Camels provide meat, milk and wool to the rural society, also for transporting goods and crops. Camel export in some countries began to participate substantially to national economy. Camel racing practiced in some Arab countries has furnished new and extra proportion in camel industry.

In Sudan the efficiency of the camel to thrive in the arid and semi-arid areas western and eastern Sudan made it an important source of livelihood to nomadic people in these parts of the country (Hashim et al., 2015). Camels' population is found in two main regions, the Butana in the East and the States of Darfur and Kordofan in the West of Sudan. These regions differ in their soil, temperature, rainfall and pasture (Ishag et al 2011). The climate influences both distribution of animals and the nutritive value and chemical composition of pasture plants (Parker and

Plowey, 1976). Changes in rainfall during seasons of the year have influence on pasture quantity and quality. Therefore, could influence the nutritional status and subsequently the blood constituents of camels (Amin et al., 2007).

Pregnancy is a dynamic process characterized by dramatic physiological changes that may influence biochemical values in human and animal (Aziz khan et al., 2014). Evaluation of adaptability to hot environments has been studied using physiological adaptation tests involving heart rate, respiratory rate and body temperature (Abdoun et al., 2012). Studies determining normal values of blood constituents in camels are limited and the way they are affected by nutritional status and other factors seem to be limited (Omer et al., 2007). Comparison of blood values under different managemental systems seems to be essential as these values may reflect the well-being of the animal and could be used as diagnostic tools in disease and health of animals (AL-Shami, 2009). Since the camel is an adaptable species, the standard serum biochemical and haematological values need to be determined in a number of animals in variable environmental conditions (AL-Busadah, 2007).

The specific objective of this study is to determine the seasonal variations, management system and pregnancy of the clinical parameters, haematological values, blood metabolites, blood minerals and thyroid hormones of camels.

2. Material and Methods

The present study was done in Butana area, Sudan, which it lays approximately between latitude 14º-16º N and longitude 33º-36º E.

This study was carried out on sixty one-humped she-camels (*Camelus dromedarius*) aged between 6 and 9 years. Animals were divided into four groups: non-pregnant penned she-camels, pregnant penned she-camels, non-pregnant free grazing she-camels and pregnant free grazing she-camels. All the camels were clinically healthy and free from any physical abnormalities. Thirty camels were free grazing in pasture and the other thirty camels were housed at open partially shaded yard in Tambol Camel Research Centre. Stockyard dimensions are 30 m wide and 54 m long. Shade dimensions are 6 m wide, 18 m long with 4 m high North side and 4.5 m high South side.

The penned animals were fed twice daily, sorghum straw and a concentrate composed of molasses 30%, bagasse 20%, sorghum grain 15%, groundnut cake 17%, wheat bran 15%, urea 2% and salt 1%.

The most available grasses for free grazing camels are (Tabar) *Ipomoea cardofana*, (Hantout) *Ipoboea blepharosepala*, (Sharia) *Indigofera hochstetteri*, (Um assabi) *Dactyloctenium aegyptiacum*, (Taffa) *Urochloa trichopus*, (Gubbein) *Solanum dubium*, (Rihana) *Ocimum basilicum* and (Um Galagil) *Aristolochia bracteolate*.

Meteorological data during the study period, which are ambient temperature (Ta) and relative humidity (RH), were provided monthly for Butana area (14o-16oN, 33o-36oE) by the Meteorological Unit, Wad-Medani city.

Table 1. Metrological Data for Butana area

		Mean Temperature (°C)		Relative Humidity (%)
Season	Month	Minimum	Maximum	Mean
Summer	March	19.4	40.7	21
	April	21.6	41.5	19
	May	25.5	43.1	26
	June	25.5	41.2	41
Mean		23	41.63	26.75
Autumn	July	24.9	38.5	51
	August	22.7	34.1	70
	September	23.2	37	59
	October	21.9	38.4	46
Mean		23.18	37	56.5
Winter	November	18.7	37.6	30
	December	16.5	33.9	29
	January	15.7	34.4	30
	February	16.3	35.2	30
Mean		16.8	35.28	29.75

Clinical parameters

Rectal temperature, respiration rate and pulse rate were measured weekly during different seasons of the year. Rectal temperature (Tr) of the camel was measured by using a digital thermometer (ACON). The animals were handled gently and the probe was inserted into the rectum 10cm touching the wall of the rectum for two minutes. Respiration rate was obtained visually by counting the frequency of flank movement per minute using a stopwatch. Pulse rate was determined by counting the frequency of the jugular vein with hand per minute using a stopwatch.

Blood collection

Blood samples (10ml) were collected monthly from jugular vein using 5 ml plastic disposable syringes and 6ml vacutainers tube with gel. Immediately, 3ml of the blood were delivered into vials containing di-soduim ethylenediamine-tetra-acetate (Na2 EDTA) as an anticoagulant for the haematological analyses and 1ml was delivered into vials containing sodium fluoride for the determination of glucose.

Blood were taken by jugular venipuncture into vacutainers tube without any anticoagulant used for serum separation. The rest of blood was allowed to clot at room temperature and then centrifuged at 600rpm for 15 minutes for the separation of serum and stored in a deep freezer at –20°C for later analysis of total protein, albumin, globulin, cholesterol, and triglyceride.

Haematological values

The methods described by Jain (1998) was used for determination of erythrocyte count, packed cell volume (PCV), haemoglobin concentration (Hb), total leukocyte count (TWBCs) and differential leukocyte count (DLC). The erythrocytic indices, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC), were calculated according to formulae of Dacie and Lewis (1991).

Blood metabolites

Plasma total protein, albumin, cholesterol, Triglycerides and glucose concentration was determined by spectrophotometric method using a commercial kit (SPINREACT, Spin). Plasma globulin was obtained by the difference between plasma total protein and plasma albumin (King and Wooton, 1956).

Statistical analysis

Data were analyzed as with a 3x2x2 factorial arrangement of treatments using analysis of variance, treatments means were compared by Duncan's multiple range tests and ANOVA table, and an interaction between three factors (season, management system and physiological status of animals) analyzed by general linear model by using SPSS version 16 computer programs.

3. Results

The effects of season, management system and physiological status on the clinical parameters are displayed in Table (2). Rectal temperature (Tr) and pulse rate varied significantly with the season. The mean value of rectal temperature and pulse rate measured during winter were the lowest values while the highest one was measured during summer. The animal registered significantly lower values for respiratory rate during winter while no variation was found between summer and autumn. Grazing camels registered significantly higher values for pulse rate compared with penned ones while the penned camels registered significantly higher values for rectal temperature and respiratory rate compared with the grazing ones. Rectal temperature and respiratory rate did not vary with the physiological status. Pulse rate was significantly higher in pregnant animals than that registered in non-pregnant ones.

Table (3) shows the effect of season, management system and physiological status on erthrothytic indices. RBCs count, PCV, MCV and MCHC varied significantly among all seasons, while Hb concentration and MCH did not vary with the seasons. The mean value of RBCs count determined during winter was significantly higher than the values measured during summer. During autumn the animal registered significantly lower PCV and MCV values and higher MCHC value than the values obtained in summer and winter. Penned camels registered significantly lower RBCs count and PCV and higher MCV than the values obtained by grazing camel. Hb, MCH and MCHC were not affected by management system. Significantly higher values of RBCs and PCV were registered by pregnant camels than non-pregnant ones while value MCV was increased in mean non-pregnant. Hb, MCH and MCHC were not vary with the physiological status.

The effect of season, management system and physiological status on leukocytic profile are shown in Table (4) TWBCs count, neutrophils, and lymphocytes varied significantly with the season while eosinophils, basophils and monocytes were not vary with the season. TWBCs count increased during autumn and lymphocytes increased during winter while both were decreased during summer. The highest value of neutrophils was obtained during summer, while the lowest value was obtained during winter. Penned camels registered significantly lower TWBCs count and lymphocytes and higher neutrophils, eosinophils and monocytes than the values obtained by the grazing camel. Basophils did not vary between the two groups. TWBCs, eosinophils, basophils and monocytes were increased in pregnant camels than non-pregnant camels. Neutrophils were decreased in pregnant camels than non-pregnant camels while lymphocytes did not vary.

The effect of Seasonal changes, management system and physiological status on the concentration of blood metabolites are presented in Table (5).

Significantly higher values of total protein, albumin, globulin and cholesterol were registered during autumn than those observed during summer and winter. Significantly lower value of triglycerides was observed during summer than that observed during autumn and winter. Glucose concentration varied significantly with the season, the highest value was obtained during summer, while the lowest value was obtained during autumn. Total protein and glucose registered by penned camels were significantly lower than those registered by grazing ones while cholesterol and globulin increased in penned camels and decreased in grazing ones. There was no effect due to the management on Albumin and Triglyceride. Total protein and triglyceride were not affected by the physiological status. Non-pregnant camels registered significantly higher values for albumin, serum cholesterol and glucose while pregnant camels registered significantly higher values for globulin. There was an interaction between season and management type on all the blood metabolites, while there was an interaction between season and physiological status on globulin, cholesterol and glucose.

Table 2. The effect of the season, management system and physiological status on clinical parameters

Factors		Parameters					
		Rectal temperature (^{0}C)		Respiratory rate (breaths/min)		Pulse rate (beats/min)	
Management System	Season	Pregnant	Non-pre	Pregnant	Non-pre	Pregnant	Non-pre
Grazing Camels	Summer	37.86	37.82	15.00	14.56	42.98	42.62
	Autumn	37.69	37.67	15.20	15.18	41.91	39.71
	Winter	37.34	37.62	12.16	13.90	39.75	37.44
Penned Camels	Summer	37.88	37.87	15.22	14.56	42.73	38.98
	Autumn	37.84	37.81	14.69	14.53	39.89	38.91
	Winter	37.47	37.63	14.31	14.27	42.18	35.60
Overall mean ±SD		37.71±0.49		14.46±2.10		40.23±6.51	
Main effect (mean±SD)							
Season Summer		37.86^{a}±0.41		14.84^{a}±1.47		41.83^{a}±3.75	
Autumn		37.75^{b}±0.37		14.90^{a}±1.54		40.11^{b}±6.49	
Winter		37.51^{c}±0.37		13.66^{b}±1.97		38.74^{c}±4.78	
Level of Significant		***		***		***	
Management System Grazing Camels		37.67^{b}±0.44		14.33^{b}±1.98		40.74^{a}± 5.32	
Penned Camels		37.75^{a}±0.37		14.59^{a}±1.53		39.72^{b}± 5.19	
Level of Significant		*		***		*	
Physiological Status Pregnant Camels		37.68^{a}±0.34		14.43^{a}±1.6		41.57^{a}±5.52	
Non-pregnant Camels		37.73^{a}±0.47		14.50^{a}±2.00		38.88^{b}±4.65	
Level of Significant		N.S		N.S		***	
Season*Management System		N.S		***		N.S	
Season*Physiological Status		**		*		*	
Manage. System*Physiological Status		N.S		N.S		**	
Season*Manage.System*Physiol.Status		N.S		*		*	

a, b and c means values within the same column having different superscripts, differ significantly.
N.S: not significant, *: (P< 0.05), **: (P< 0.01), ***: (P< 0.001).

Table 3. The effect of the season, management system and physiological status on erythrocytic indices

Factors		Parameters											
		RBCs (*10^{6}/mm^{3})		PCV (%)		Hb (g/dl)		MCV (fl)		MCH (pg)		MCHC (g/dl)	
Management System	Season	Pregnant	Nonpre	Pregnant	Nonpre	Pregnant	Nonpre	Pregnant	Nonpre	Pregnant	Nonpre	Pregnant	Nonpre
Grazing Camels	Summer	7.76	6.86	31.13	28.13	11.07	10.24	40.37	41.25	14.36	15.11	35.57	36.44
	Autumn	7.65	7.40	29.62	28.20	11.69	11.16	38.81	38.30	15.28	18.08	39.46	39.58
	Winter	8.08	6.88	33.13	28.16	11.81	10.15	41.14	41.29	14.67	14.68	35.75	35.89
Penned Camels	Summer	6.65	6.74	28.82	29.00	10.36	12.78	43.40	44.09	15.71	16.14	36.18	36.98
	Autumn	6.69	6.72	25.78	27.13	10.38	10.65	38.80	40.85	15.58	15.89	49.68	39.24
	Winter	7.03	6.85	29.07	30.09	10.79	10.36	41.69	43.18	15.51	15.18	37.45	35.50
Overall mean		7.11±1.08		29.02±4.41		10.95±1.70		41.10±5.12		15.52±1.98		37.39±5.84	
Main effect (mean+SD)													
Season Summer		7.00^{b} ± 0.92		29.27^{a} ± 3.64		11.11^{a} ± 1.58		42.28^{a} ± 3.67		16.07^{a} ± 1.42		36.29^{b} ± 3.87	
Autumn		7.12^{ab} ± 0.97		27.68^{b} ± 3.43		10.97^{a} ± 1.57		39.19^{b} ± 3.94		15.46^{a} ± 1.30		39.74^{a} ± 4.94	
Winter		7.21^{a} ± 1.01		30.11^{a} ± 4.12		10.78^{a} ± 1.55		41.82^{a} ± 4.36		15.01^{a} ± 1.61		36.15^{b} ± 4.32	
Level of Significant		*		***		N.S		***		N.S		***	
Management System Grazing Camels		7.44^{a} ± 1.09		29.73^{a} ± 3.85		11.02^{a} ± 1.65		40.19^{b} ± 3.32		15.36^{a} ± 1.50		37.12^{a} ± 3.71	
Penned Camels		6.78^{b} ± 0.69		28.32^{b} ± 3.76		10.89^{a} ± 1.42		42.00^{a} ± 4.80		15.67^{a} ± 1.77		37.67^{a} ± 5.49	
Level of Significant		***		***		N.S		***		N.S		N.S	
Physiological Status Pregnant Camels		7.31^{a} ± 0.94		29.59^{a} ± 3.67		11.01^{a} ± 1.54		40.70^{b} ± 3.97		15.18^{a} ± 1.88		37.52^{a} ±5.40	
Non-pregnant Camels		6.91^{b} ± 0.95		28.45^{b} ± 3.97		10.89^{a} ± 1.45		41.49^{a} ± 4.43		15.85^{a} ± 1.47		37.27^{a} ± 3.86	
Level of Significant		***		***		N.S		*		N.S		N.S	
Season*Management System		N.S		*		N.S		N.S		N.S		N.S	
Season*Physiological Status		**		*		N.S		N.S		N.S		N.S	
Manage. System*Physiological Status		***		***		N.S		N.S		N.S		N.S	
Season*Manage.System*Physiol.Status		N.S		N.S		N.S		N.S		N.S		N.S	

a, b and c means values within the same column having different superscripts, differ significantly.
N.S: not significant, *: (P< 0.05), **: (P< 0.01), ***: (P< 0.001).

Table 4. The effect of the season, management system and physiological status on leukocytic profile

Factors		Parameters											
		TWBCs (*10^{3}/mm^{3})		Netrophils (%)		Lymphocytes (%)		Eosinophils (%)		Basophils (%)		Monocytes (%)	
Management System	Season	Pregnant	Nonpre	Pregnant	Nonpre	Pregnant	Nonpre	Pregnant	Nonpre	Pregnant	Nonpre	Pregnant	Nonpre
Grazing Camels	Summer	17.04	15.94	49.96	55.02	42.53	37.88	4.81	4.78	0.42	0.33	2.28	2.01
	Autumn	22.40	21.08	39.64	42.10	53.02	51.51	4.73	4.62	0.38	0.20	2.26	1.87
	Winter	19.63	19.08	36.87	47.38	55.63	45.62	4.80	4.62	0.40	0.42	2.30	2.02
Penned Camels	Summer	10.59	10.30	58.07	55.05	33.56	37.40	5.30	5.09	0.40	0.31	2.68	2.16
	Autumn	14.84	12.56	56.63	57.56	34.76	35.67	5.46	4.45	0.44	0.20	2.72	2.12
	Winter	14.24	10.97	49.56	44.97	42.00	48.11	5.47	4.53	0.46	0.20	2.61	2.18
Overall mean		15.72±3.92		49.40±5.53		43.14±4.97		4.89±1.45		0.35±0.06		2.27±0.80	
Main effect (mean+SD)													
Season Summer		13.46^{c} ± 2.62		54.52^{a} ± 5.34		37.84^{c} ± 3.19		5.00^{a} ± 1.26		0.37^{a} ± 0.04		2.28^{a} ± 0.62	
Autumn		17.72^{a} ± 3.57		48.98^{b} ± 4.89		43.74^{b} ± 3.86		4.82^{a} ± 1.05		0.31^{a} ± 0.03		2.24^{a} ± 0.52	
Winter		15.98^{b} ± 2.91		44.70^{c} ± 4.27		47.84^{a} ± 4.64		4.86^{a} ± 1.18		0.37^{a} ± 0.04		2.25^{a} ± 0.59	
Level of Significant		***		***		***		N.S		N.S		N.S	
Management System Grazing Camels		19.19^{a} ± 3.92		45.16^{b} ± 4.63		47.69^{a} ± 4.55		4.72^{b} ± 1.00		0.34^{a} ± 0.03		2.12^{b} ± 0.47	
Penned Camels		12.25^{b} ± 2.48		53.65^{a} ± 5.22		38.59^{b} ± 3.71		5.06^{a} ± 1.29		0.34^{a} ± 0.04		2.35^{a} ± 0.71	
Level of Significant		***		***		***		***		N.S		***	
Physiological Status Pregnant Camels		16.46^{a} ± 3.17		48.45^{b} ± 4.75		43.58^{a} ± 3.80		5.09^{a} ± 1.31		0.41^{a} ± 0.05		2.47^{a} ± 0.74	
Non-pregnant Camels		14.98^{b} ± 2.73		50.34^{a} ± 5.05		42.69^{a} ± 3.25		4.68^{b} ± 0.94		0.24^{b} ± 0.02		2.06^{b} ± 0.42	
Level of Significant		*		*		N.S		***		**		***	
Season*Management System		N.S		***		***		N.S		N.S		N.S	
Season*Physiological Status		N.S		N.S		N.S		N.S		N.S		N.S	
Manage. System*Physiological Status		N.S		***		***		***		N.S		N.S	
Season*Manage.System*Physiol.Status		N.S		N.S		N.S		N.S		N.S		N.S	

a, b and c means values within the same column having different superscripts, differ significantly.
N.S: not significant, *: ($P< 0.05$), **: ($P< 0.01$), ***: ($P< 0.001$).

Table 5. The effect of the season, management system and physiological status on blood metabolites

Factors		Parameters											
		Totalprotein (g/dl)		Albumin (g/dl)		Globulin (g/dl)		Cholesterol (mg/dl)		Triglyceride (mg/dl)		Glucose (mg/dl)	
Management System	Season	Pregnant	Nonpre	Pregnant	Nonpre	Pregnant	Nonpre	Pregnant	Nonpre	Pregnant	Nonpre	Pregnant	Nonpre
Grazing Camels	Summer	6.14	6.11	2.58	2.41	3.56	3.7	19.87	20.20	25.87	26.60	106.11	145.80
	Autumn	7.48	7.06	3.66	3.73	3.82	3.33	37.27	57.53	34.49	33.80	116.91	106.04
	Winter	5.92	5.96	2.73	2.71	3.19	3.24	26.64	23.64	34.53	34.90	124.93	121.98
Penned Camels	Summer	5.34	5.34	2.24	2.82	3.10	2.43	30.47	30.42	23.40	27.00	87.77	90.67
	Autumn	6.34	6.54	3.35	3.77	2.99	2.77	53.42	53.38	36.11	37.89	86.66	86.60
	Winter	5.63	5.77	2.85	3.20	2.78	2.76	24.64	25.27	36.53	34.21	84.72	83.76
Overall mean		6.14±0.91		2.98±0.70		3.15±0.89		33.56±9.25		32.11±3.98		103.50±7.54	
Main effect (mean+SD)													
Season Summer		5.73^{b} ± 0.66		2.51^{c} ± 0.42		3.22^{a} ± 0.67		25.24^{b} ± 4.11		25.72^{b} ± 2.52		107.58^{a} ± 5.87	
Autumn		6.86^{a} ± 0.77		3.63^{a} ± 0.65		3.23^{a} ± 0.87		50.40^{a} ± 7.34		35.77^{a} ± 3.89		99.05^{c} ± 4.48	
Winter		5.82^{b} ± 0.60		2.82^{b} ± 0.36		2.99^{b} ± 0.61		25.05^{b} ± 3.68		35.06^{a} ± 3.23		103.84^{b} ± 5.63	
Level of Significant		***		***		***		***		***		***	
Management System Grazing Camels		4.66^{a} ± 0.88		2.97^{a} ± 0.68		3.47^{b} ± 0.61		30.86^{b} ± 5.40		31.70^{a} ± 3.18		120.29^{a} ± 6.65	
Penned Camels		5.83^{b} ± 0.64		3.01^{a} ± 0.69		3.82^{a} ± 0.63		36.27^{a} ± 5.02		32.66^{a} ± 3.20		86.69^{b} ± 4.47	
Level of Significant		***		N.S		***		***		N.S		***	
Physiological Status Pregnant Camels		6.14^{a} ± 0.83		2.90^{b} ± 0.67		3.24^{a} ± 0.68		32.05^{b} ± 5.47		31.96^{a} ± 3.19		101.18^{b} ± 4.96	
Non-pregnant Camels		6.13^{a} ± 0.84		3.07^{a} ± 0.69		3.06^{b} ± 0.76		35.07^{a} ± 4.98		32.41^{a} ± 3.21		105.81^{a} ± 4.89	
Level of Significant		N.S		***		**		**		N.S		**	
Season*Management System		***		**		*		***		*		***	
Season*Physiological Status		N.S		N.S		*		***		N.S		***	
Manage. System*Physiological Status		**		***		N.S		**		N.S		**	
Season*Manage.System*Physiol.Status		*		**		***		***		N.S		***	

a, b and c means values within the same column having different superscripts, differ significantly.
N.S: not significant, *: ($P< 0.05$), **: ($P< 0.01$), ***: ($P< 0.001$).

4. Discussions

The mean value of rectal temperature (Tr) increased during summer while it decreased during winter. This comparable to the results of Al-Haidary (2006), Mohammed et al. (2007b), El-Harairy et al. (2010) and Abdoun et al. (2012) who concluded that the season had a significant effect on rectal temperature of camels being low in winter and high in summer. The increase in rectal temperature during the hot season is most probably minimizes temperature gradient between the body and the environment, thus resulting in a reduction of the body heat gain (Abdel-Samee and Marai, 1997). Reduction of the body heat gain will minimize the heat stress on the animals (El-Harairy, 2010). The reduction on respiratory rate during winter conforms to the results of Mohammed et al. (2007b) and El-Harairy et al. (2010) who reported that respiratory rate increases during summer. Fluctuation on respiratory rate is the secondary mechanism for heat dissipation. Respiratory rate increases very little with an increase in ambient temperature in camels unlike in other domestic animals that respond to hot condition by resorting to an increased respiratory rate and, in some cases, by panting (Kelly, 1974). However, the camels get back about 75% of respired water. The decrease on respiratory rate during cold season may be to conserve heat as a secondary mechanism. The mean value of pulse rate increased during summer while it's decreased during winter. This result on line with the finding of Mohammed et al. (2007b) and El-Harairy et al. (2010) who reported that pulse rate was significantly, lower during winter than summer. The reduction on pulse rate during cold season may be to conserve heat as a secondary mechanism. Grazing camels registered higher values for pulse rate compared with penned ones. This most probably due to stress caused the ongoing movement of the animals. Rectal temperature and respiratory rate did not vary with the physiological status, while pulse rate was increased significantly in pregnant camels than that registered in non-pregnant ones. This result agrees with Sarwar et al. (1998) with regard to the rectal temperature and respiration rate, and disagrees with regard to the effect of pregnancy on pulse rate. Pulse rate increase in pregnant camels due to pregnancy stress.

The results showed a reduction on RBCs during summer. Contradicting results were found among different researchers with regard to the effect of the season on RBCs. Al Sultan (2003), Ayoub et al. (2003) and Badaway et al. (2008) registered a significant reduction on RBCs count during summer conform to our result, while Amin et al. (2007), El-Harairy et al. (2010) and Babeker. et al (2013) reported significantly higher erythrocytes count during summer than the values of winter. Salman and Afzal (2004) reported that season did not influence the red blood cells count. The reduction on RBCs during summer may be due to nutritional deprivation that occurs in the summer as a result of poor pasture. Al Sultan (2003), Ayoub et al. (2003) and Badaway et al. (2008) attributed such changes to the haemodilution phase resulting from increasing water intake during hot season, where a considerable part is retained particularly in the extracellular compartment. El-Harairy et al. (2010) found that the increases of blood hematological parameters during summer may be due to reduced oxygen intake was caused by increasing ambient temperature, thus reducing metabolic heat production. Amin et al. (2007) attributed the rise on the erythrocytes count during dry season to dehydration increasing the half life of the RBCs. The overall mean of RBCs count observed in this work is comparable to the value found by AL-Busadah (2007), Barakat et al. (2007) and Badaway et al. (2008), lower than that obtained by El-Harairy et al. (2010) and Faroog et al. (2011) and higher than that found by Amin et al. (2007).

PCV decreased during autumn compared to summer and winter. This result agrees with Salman and Afzal (2004), Al-Haidary (2006) and El-Harairy et al. (2010) who reported that PCV increases during summer and disagree with Badaway et al. (2008) who reported that PCV decreases during summer and increases during autumn and winter, and Amin et al. (2007) who reported that season had no significant effect on PCV. The reduction on PCV during autumn most probably is due to virtual decreases of PCV associated with the increase in extracellular fluids. Which occur by increasing the water content of the forages during autumn. Waleed, (1987) reported that PCV was influenced by haemdilution or haemconcentration. Badaway et al. (2008) attributed the relative reduction in PCV values during hot season to the reduction in circulating erythrocyte and increased rate of destruction in red blood cells. The overall mean of PCV is comparable to the results found by Al-Haidary (2006) and El-Harairy et al. (2010), lower than that reported by Faroog et al. (2011) and higher than that found by Amin et al. (2007) and Babeker et al. (2013).

The results showed that Haemoglobin concentration did not vary with the seasons. This agrees with the finding of Salman and Afzal (2004) and Amin et al. (2007) who reported that season did not affect the haemoglobin concentration, but disagree with the results found by Al-Haidary (2006) and El-Harairy et al. (2010) who reported that the Hb concentration decreases during winter season and Badaway et al. (2008) who found that Hb concentration decreases during summer season. The overall mean of Hb in this study is comparable with that found by Amin et al. (2007), Barakat et al. (2007), El-Harairy et al. (2010) and Faroog et al. (2011), and higher than that obtained by Babeker et al. (2013).

MCV decreased during autumn compared to summer and winter. This reduction on MCV during autumn is on line with Badaway et al. (2008) who obtained a significant lower value of MCV during autumn compared to values obtained for winter and summer. Amin et al. (2007) and Babeker et al. (2013) reported that MCV increased during autumn compared with summer, while Salman and Afzal (2004) found that MCV was significantly higher in summer than winter. Due to a positive relationship between MCV and PCV, the reduction of PCV during autumn led to a decrease on MCV during autumn. Amin et al. (2007) referred the increases of MCV during autumn to the negative correlation between the size and count of erythrocytes. The overall mean of MCV obtained in this result is comparable with that reported by Amin et al. (2007) and Barakat et al. (2007), higher than that of AL-Busadah (2007), Badaway et al. (2008), and lower than that obtained by Faroog et al. (2011) and Babeker et al., 2013).

The result showed that MCH did not vary with the seasons. This agrees with Badaway et al. (2008) who reported that there was no significant seasonal variation in MCH, while it disagree with Al-Haidary (2006) who obtained raised values during summer and Amin et al. (2007) and Babeker et al. (2013) who reported that the MCH increases during autumn. The overall mean of MCH in this work is comparable with that calculated by Al-Haidary (2006), Amin et al. (2007), AL-Busadah (2007), Faroog et al. (2011), higher than that found by Badaway et al. (2008), and lower than that found by Babeker et al. (2013).

During autumn the animal registered higher MCHC value than that values obtained in summer and winter. This result on MCHC agrees with Badaway et al. (2008) who reported that MCHC increases during autumn and disagree with Amin et al. (2007) who did not found any seasonal variation on MCHC and Babeker et al. (2013) who found it was increase during summer. Due to an inverse relationship between MCHC and PCV, the reduction of PCV during autumn leading to this increase on MCHC during autumn. The overall mean of MCHC in this study on line with that reported by Badaway et al. (2008) Faroog et al., 2011) and Babeker et al. (2013), lower than that found by Amin et al. (2007) and AL-Busadah (2007).

Grazing camels registered significantly higher RBCs values than the penned ones, Barakat et al. (2007) recorded that red blood cells count did not vary between grazing and penned camels. The hyperthermia during movement under heat may induce a water loss caused by thermo regulation. This increase may be attributed to a splenic contraction rather than to dehydration (Carlson, 1990). Acute exposure to stressful stimulation is manifested by a significant activation of the sympathetic-adrenal medullary system, including increased synthesis, circulating levels and release of catecholamines into the circulation (McCarty et al., 1988), resulting in splenic contraction and the release of red blood cells into the circulation. This mechanism is induced by the action of catecholamines on α-adrenergic receptors which are located in the splenic capsule (Tauler et al., 2003). Grazing camels registered significantly higher PCV than the penned ones. This result on PCV disagree with Barakat et al. (2007) who recorded that PCV in penned camels is higher than grazing ones. The increase in PCV on free grazing camels is attributed to an increase in RBCs. The results showed that Hb did not vary between systems. Barakat et al. (2007) obtained that penned camels registered high value compared with grazing ones. MCV raised in penned camels compared with grazing ones. This result on MCV agrees with Barakat et al. (2007) who found that penned camels registered significantly higher value compared with grazing ones. MCH and MCHC did not affect by management system. This agrees with Barakat et al. (2007) who found that MCHC registered by penned camels and grazing ones did not vary.

The results showed that RBCs increased on pregnant camels compared with non-pregnant ones. This disagrees with Ayoub et al. (2003) who reported that pregnancy did not influence RBCs. The slight increase on RBC obtained on pregnant camels compared with non-pregnant ones could be attributed to physiological status due to fetal development (Muhammad et al., 2011). PCV increased on pregnant camels compared with non-pregnant ones. This result on PCV disagrees with Ayoub et al. (2003) and Muhammad et al. (2011) who reported that pregnancy did not influence PCV. The increases on RBCs justified the higher PCV value on pregnant camels due to the positive relationship between RBCs and PCV. The results showed that MCV decreased on pregnant camels compared with non-pregnant ones. This disagrees with Ayoub et al. (2003) and Muhammad et al. (2011) who reported that pregnancy did not influence MCV. The increases on RBCs caused a reduction in MCV on pregnant camels due to the inverse relationship between RBCs and MCV.

TWBCs were varied significantly during all the seasons, being higher during autumn lower during summer. Contradicting results were found among different researchers with regard to the effect of the season on total leukocyte count. Salman and Afzal (2004) did not find seasonal variation. Badaway et al. (2008) obtained increases during winter, El-Harairy et al. (2010) reported decreased during autumn, while Babeker et al. (2013) found that TWBCs was increased during summer. Decreases on TWBCs during summer compared with winter attributed to a reduction in corticosteroids secretion due to prolonged exposure to high environmental temperature during the summer (Badaway et al., 2008). The overall mean of TWBCs is on line with that found by Badaway et al. (2008) and Faroog et al. (2011), lower than that reported by Sarwar et al. (1993) and AL-Busadah (2007), and higher than that found by El-Harairy et al. (2010) and Barakat et al. (2007).

The results showed that neutrophils increased during summer. This agrees with Badaway et al. (2008) and Babeker et al. (2013) who reported that neutrophils decrease during winter and increase during hot season, while its disagrees with Amin et al. (2007) who reported that the neutrophils increase during autumn compared with summer. El-Banna et al. (1981) and Al-Arfaj et al. (1992) explained elevated level of neutrophils during summer in camels due to exposure to the dusty polluted warm environmental conditions. The overall mean of neutrophils in this study comparable to that reported by Rezakhani et al. (1997) and Badaway et al. (2008), and higher than that found by Amin et al. (2007) and Babeker et al. (2013).

Lymphocytes increased during winter and decreased during summer. This result on lymphocytes agrees with Badaway et al. (2008) who found that lymphocytes increase during winter and disagrees with Amin et al. (2007) who reported that the lymphocytes lower during autumn compared with summer. Camels' erythrocytes do not synthesize heat shock protein (hsp73) after temperature elevation and camel's lymphocytes exhibited strong production of constitutively expressed heat shock protein (hsp73), providing thermotolerance to camel's blood cells, because lymphocytes have a higher resistance of general protein synthesis to elevated temperature (Guerriero and Raynes 1990 and Ulmasov et al., 1993). The overall mean of Lymphocytes reported in this result is comparable to that obtained by Rezakhani et al. (1997), AL-Busadah (2007), Badaway et al. (2008), Faroog et al. (2011) and Babeker et al. (2013).

The results showed that eosinophils did not vary during seasons. This agrees with Amin et al. (2007) who did not find seasonal variation in eosinophils, while disagree with Badaway et al. (2008) who found that eosinophils increased during winter and decreased during summer. The overall mean of eosinophils on line with that found by Sarwar et al. (1993) and Rezakhani et al. (1997), AL-Busadah (2007), lower than reported by Faroog et al. (2011) and Babeker et al. (2013).

Basophils did not vary during seasons. This result in basophils agrees with Badaway et al. (2008) who did not find seasonal variation in basophils, while disagree with Amin et al. (2007) who found that basophils increased during summer. The overall mean of basophils reported in this study comparable to that found by Sarwar et al. (1993), Rezakhani et al. (1997), AL-Busadah (2007), Amin et al. (2007) and Faroog et al. (2011), and lower than reported by Babeker et al. (2013).

The results showed that monocytes did not vary during seasons. This agrees with Amin et al. (2007) and Badaway et al. (2008) who were not find seasonal variation in monocytes. The overall mean of Monocytes is comparable to that reported by Rezakhani et al. (1997) and Faroog et al. (2011), and lower than that found by Amin et al. (2007) and Babeker et al. (2013).

Pregnant camels registered increases on TWBCs compared with non-pregnant ones. Muhammad et al. (2011) found slight increase in TWBCs on pregnant compared to non-pregnant she-camels, while Ayoub et al. (2003) found slight decrease in pregnant ones. Sarwar et al. (1993) reported that TWBCs do not affect by physiological status. Muhammad et al. (2011) attributed that to physiological changes associated with fetal growth and development. The results showed that neutrophils increased on non-pregnant camels, while eosinophils increased on pregnant ones. This result agrees with Ayoub et al. (2003) who found that eosinophils higher in pregnant camels compared with non-pregnant ones, and disagree with their result that neutrophils higher in pregnant camels compared with non-pregnant ones.

Total protein increased during autumn. These results on total protein concentration not on line to the controversial results were found by different researchers with regard to the effect of the season in camel plasma total protein concentration. Salman and Afzal (2004), El-Harairy et al. (2010) and Javad et al. (2013) were not report any significant changes in total proteins between the seasons. Al-Haidary (2006) and Abdoun et al. (2012) reported that total protein increases during summer compared with winter. Abokouider et al. (2001) and Amin et al. (2007) recorded that total protein increases during summer season. Badawy et al. (2008) found that the total protein decreases during winter compared to summer and autumn. Serum total protein increase during autumn was attributed to improve the quality and quantity of feed in this season. Lynch and Jackson (1983) reported that serum total protein level is usually considered as useful indices of the nutritional status of animals. Amin et al. (2007) suggested that the increase in the concentration of serum total protein during the dry season could be attributed to the stresses to which the camels were subjected under dry condition. The overall mean of total protein concentration comparable to that found by Badawy et al. (2008), AL-Shami (2009), El-Bahrawy and El Hassanein (2011) and Babeker et al., 2013), lower than reported by Osman and Al-Busadah (2003), and higher than Omidi et al. (2014).

The results showed that albumin varied during all the seasons. Autumn registered higher value, while summer registered lower one. Controversial results were found by different researchers with regard to the effect of the season in camel plasma albumin concentration. This result on serum albumin concentration comparable to that found by Mohammed et al. (2007a) that is the albumin increases during autumn, and Salman and Afzal (2004) who reported that albumin level was lower in summer than winter, and Badawy et al. (2008) who found a decrease during winter compared with autumn. While it not on line with Al-Haidary (2006) and Abdoun et al. (2012) who reported that the albumin was increased in the summer compare to winter. Amin et al. (2007) and El-Harairy et al. (2010)

were not finding a variation in albumin values with the season. Salman and Afzal (2004) attribute lower albumin levels during summer to temperature stress. Heat stress during hot season induces reduction of plasma albumin concentration and this may be due to the incapability of protein synthesis to counteract the protein catabolism which leads to a negative nitrogen balance under such conditions (Marai and Habeeb, 2010). The overall mean of albumin concentration is on line with that found by Amin et al., 2007 Babeker et al., 2013 and Omidi et al. (2014) lower than Osman and Al-Busadah (2003), AL-Shami (2009), and Dierenfeld et al. (2014).

Cholesterol increased during autumn. This result in serum cholesterol concentration comparable with that result obtained by Badawy et al. (2008) who found that serum cholesterol increases significantly during autumn, not comparable to El-Harairy et al. (2010) who obtained that the concentration of cholesterol increases during winter season compared to summer and autumn, and Javad et al. (2013) who reported that there was no significant difference on cholesterol and Ahmed et al. (2013) who recorded that the cholesterol concentration determined during summer increased significantly compared with winter. Serum cholesterol increasing during autumn can be attributed to the improved quality and quantity of feed in this season, Nazify et al. (1999) reported that cholesterol concentration was higher during winter than summer in dromedary camels, and they suggested that the seasonal changes in blood lipids and proteins might result from changes in the nutritional and energy balances or changes in environmental temperature, humidity and day length. Ahmed et al. (2013) attributed the increase in cholesterol of serum during the dry season to low dietary requirements. El-Masry et al. (1989) reported that the increases in cholesterol under hot months might be attributed to the increased non-esterified fatty acids and fat catabolism occurring in heat-stressed goats. The overall mean of cholesterol is comparable to that found by Omidi et al. (2014), lower than the finding of Al-Sultan (2003), Badaway et al., 2008, and higher than that reported by El-Bahrawy and El Hassanein (2011).

The results showed that triglycerides decreased during summer. Javad et al. (2013) reported that triglycerides increased during summer season. Ahmed et al. (2013) found that the triglyceride increased significantly during summer compared with winter. The reduction of triglycerides during summer may be attributed to the load of ambient temperature caused a decreases in basal metabolism. The decrease in basal metabolism inhibits lipolysis in the animal body (Yagil, 1985). In camels, serum triglycerides level has been reported to be affected by the diet (Wasfi et al., 1987). The overall mean of triglycerides on line with that found by Al-Sultan (2003), Osman and Al-Busadah (2003), Amin et al. (2007) and Omidi et al. (2014), and lower than AL-Shami (2009).

Glucose increased during summer compared to autumn and winter, and increased during winter compared with autumn. The increases on plasma glucose concentration during summer comparable with Nazifi et al. (1999) who found that the concentration of serum glucose significantly higher in summer compared with winter. The increases on glucose during winter comparable with Badawy et al. (2008) who found it was increased during winter compare to autumn, This result not on line with (Al-Haidary, 2006; Abdoun et al., 2012 and Ahmed et al., 2013) who obtained that glucose concentration was increased during winter compared to summer and Amin et al. (2007) and Mohammed et al. (2007a) who reported that the glucose concentration increased significantly during autumn compared with summer. The increased blood glucose level during summer may be due to a decreased basal metabolic rate reducing the use of glucose for energy production under hot climatic conditions. Badawy et al. (2008) attributed this discrepancy in effect of the season on blood glucose in camels to breed differences and to the environmental conditions particularly feeding and watering systems. From another point of view, the increases on plasma glucose concentration during summer may be due to lack of available water for the animals that occur in summer. Charnot, (1967) reported that the Islet camels have more cells secreting glucagon than insulin secreting cells. The proportion of these cells decreased in the dehydrated camel as in diabetes. However, after water deprivation for 10 days, blood glucose increased from 20 to 80% according to Banerjee and Bhattacharjee (1963) Macfarlane et al. (1968), whereas glucosuria is zero. This hyperglycemia is due to the absence of renal excretion of glucose and a decrease in its use. During dehydration, insulin decreased more than 30%. The dehydrated dromedary reduces water loss by maintaining its high glucose and glucosuria practically zero. Amin et al. (2007) and Ahmed et al. (2013) suggested that the decrease in plasma glucose concentration during the dry season can be attributed to the decrease in available forage. The overall mean of glucose concentration is comparable to that found by Badawy et al. (2008), AL-Shami (2009), El-Bahrawy and El Hassanein (2011) and Omidi et al. (2014), lower than that reported by Osman and Al-Busadah (2003), and higher than that found by Al-Sultan (2003) and Babeker et al. (2013).

Total protein registered by penned camels significantly lower than the value registered by grazing ones. The findings of the current study about total protein concentration in camels do not support AL-Shami (2009) who found that serum total protein concentration did not vary with the management system. The results showed that management system did not influence albumin. This result about albumin agrees with AL-Shami (2009) who found that serum albumin concentration did not vary with management system. Penned camels registered higher cholesterol than grazing ones. This increase on cholesterol in penned camels agrees with AL-Shami (2009) who found that cholesterol was significantly higher in indoor camels compared to free grazing ones. Higher level of cholesterol in indoor over that of grazing camels indicate that nutritional factor can influence normal values of blood metabolites (Mokhtar and El-Hisanonein, 1998). As a result of greater amount of concentration diet supplementation in indoor camel's cholesterol concentration was expected to increase (Sako et al., 2007). Triglyceride did not vary with the management system. This disagrees with AL-Shami (2009) who obtained that triglyceride level was significantly higher in indoor camels compared to free grazing camels. Grazing camels registered higher glucose than penned ones. This result on plasma glucose concentration disagrees with AL-Shami (2009) who reported increases in indoor camels compared with grazing one. The increases of plasma glucose in free grazing camels attribute to permanent transportation in the pastures. El Khasmi et al. (2013) reported that transportation increase plasma glucose levels in camels. This hyperglycaemia may be primarily might be due to an activation of the sympathetic nervous system, catecholamines secretion (Sanders and Straub, 2002) which is able to decrease the glycogen reserves by stimulating glycogenolysis in rat (Dronjak et al., 2004).

Total protein and triglyceride were not affected by the physiological status. These results were agreement with the findings of Muhammad et al. (2011) and Omidi et al. (2014) who did not find significant variation between pregnant camels and non-pregnant ones and disagree with AL-Zamely (2011) who reported an increase of total protein in non-pregnant camels. Non-pregnant camels registered higher value of albumin compared with pregnant ones. The findings of the current study about albumin is in agreement with the findings of Saeed et al. (2009) AL-Zamely (2011) who found that albumin concentration increased in non-pregnant camels compared to pregnant ones, while it does not support Muhammad et al. (2011) and Omidi et al. (2014) who were not find significant variation between non-pregnant camels and pregnant ones with regard to albumin. AL-Zamely (2011) attributed this decrease in albumin of pregnant camels to a reduction of albumin biosynthesis due to increase pregnancy hormones especially progesterone which rises in pregnant camels, this increased may have effect in the liver and caused a decrease of albumin production (Pineda and Doole, 2003). Also there is an increase of albumin elimination by the kidneys during pregnancy which may play a role in the reduction of albumin level (Halliwell, 1988). The results showed that non-pregnant camels registered higher cholesterol compared with pregnant ones. The higher cholesterol in non-pregnant camels agrees with Omidi et al. (2014) who obtained that cholesterol higher in non-pregnant camels compared with pregnant ones. During pregnancy, the synthesis of cholesterol fell markedly in rat (Leoni, 1984). Non-pregnant camels registered higher glucose compared with pregnant ones. The findings of the current study about plasma glucose concentration support Omidi et al. (2014) who found its higher in non-pregnant camels. Omidi et al. (2014) attribute the low level of glucose in pregnant camels due to developing fetus and mobilization of glucose from mother for providing the adequate energy of the fetus.

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