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A Comparative Study on Seasonal Variation in Body Temperature and Blood Composition of Camels and Sheep

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Abstract: The objective of this study was to investigate the seasonal variation in physiological performance of camels and sheep raised under semi-arid environment of Saudi Arabia. Six sexually mature animals of each of camels and sheep were used in this study. They were housed separately and individually in open partly shaded yards. Ambient temperature averaged 39.83±2.13 and 19.79±3.78°C and relative humidity averaged 6.98±1.18 and 26.22±0.65% during Summer and Winter seasons, respectively. The calculated average Temperature Humidity Index (THI) was 42.73±1.38 and 18.38±0.21 during Summer and Winter seasons, respectively. The shift in season from Winter to Summer had significantly ($p<0.05$) elevated rectal temperature in both camels and sheep. However, the increase in rectal temperature during Summer season was two folds higher in sheep compared to camels. Likewise, skin temperature was significantly ($p<0.05$) increased in both species during Summer season. However, the increase in skin temperature during Summer season was almost four folds higher in sheep compared to camels. Hematological parameters were elevated in both species with the shift of season from Winter to Summer with the exception of Red Blood Cells count (RBC), Packed Cell Volume (PCV) and Mean Corpuscular Volume (MCV) which were decreased in sheep. However, biochemical parameters were more affected by seasonal shift from Winter to Summer in sheep than those in camels. The seasonal variation in body temperature and blood composition was evident in both species with higher effect in sheep than in camels in terms of biochemical parameters and body temperature which indicates better adaptation of camels to hot Summer conditions of the semi-arid environment.

Key words: Seasonal variation, environment, body temperature, camels, species, Saudi Arabia

INTRODUCTION

The average Summer temperature in Saudi Arabia (Najd region) is 45°C but readings of up to 54°C are common (FRD, 1992). Desert animals are adapted by various behavioral and physiological mechanisms to this climate. They are considered an important source of milk and meat for the Bedouin people. The high environmental temperature is a major factor which can adversely affects the productive and reproductive performance of sheep and camels (Eltawill and Narendran, 1990; Bekele *et al*., 2002). Under such conditions homoeothermic animals have to thermo regulate to maintain their body temperature and to prevent hyperthermia (Al-Haidary, 2000; Lowe *et al*., 2001). The maintenance of body temperature within physiological limits is necessary to remain healthy, survive and maintain its productivity (Marai *et al*., 2007). However, reductions in performance of animals during Summer months can be largely due to elevated ambient air temperature (Al-Haidary, 2004). These detrimental effects may be further compounded when elevated ambient temperature is coupled with solar radiation. When these adverse weather parameters exist, the gradient by which heat is transferred from the animal to the environment is reduced (Al-Haidary, 2006). Evaluations of adaptability to hot environments have been carried out using physiological adaptation tests involving respiration, heart rate and body temperature. The present study was designed to investigate the seasonal variation in the thermoregulatory system of camels and sheep and to determine the adaptive performance of both species to hot Summer conditions of the semi-arid environment.

MATERIALS AND METHODS

Experimental animals: Six sexually mature Arabian camels (*Camelus dromedarius*) and six Najdi sheep were used in this study. The camels aged 2-3 years and sheep were 1 year old. The animals were housed individually in open

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partly shaded yards at the Experimental Farm Unit affiliated to the Department of Animal Production, College of Food and Agriculture Sciences, King Saud University, Riyadh, KSA. The animals were fed on a commercial total mixed ration (ME 1950 kcal kg^{-1}, Crude protein 13%, Crude fat 2%, Crude fiber 10%, Ash 8% on DM basis). Feed at a level of 2.5% of the animal body weight was offered twice daily at 7:00 am and 3:00 pm and the animals had free access to clean fresh tap water throughout the study.

Climatic measurements: Ambient Temperature (T_a) and Relative Humidity (RH) were recorded at 30 min intervals throughout the experimental periods using data logger (HOBO Pro Series, ONSET, USA). Temperature-Humidity Index (THI) was calculated using the following equation:

$$THI = T_a - \{(0.31 - 0.31 \times RH)(T_a - 14.4)\}$$

Where:

T_a = Ambient temperature (°C)
RH = Relative Humidity (%)

Experimental procedure: The experiments were conducted for 6 weeks during Summer and Winter seasons. The 1st 2 weeks served as a preliminary period and followed by 4 weeks of experimental period during which rectal and skin temperatures were recorded and blood samples were collected. Skin surface temperature was measured by applying infrared thermometer to cleaned shaved regions in the right and left shoulder and right and left hip of the animals. Rectal temperature was measured by digital thermometer. Recent data (Al-Haidary, 2001) have shown that body temperature of camels exhibited a diurnal rhythm reaching maximum during the middle of the day and minimum in the early morning. Therefore, the times of measurements was determined according to the diurnal rhythm of body temperature of heat stressed camels and were conducted daily at 08:00, 12:00 and 15:00 h.

Blood samples were collected by jugular venipuncture weekly using 10 mL vacutainer tubes coated with sodium fluoride as anticoagulant. The samples were placed immediately on ice. Red Blood Cell counts (RBC), Packed Cell Volume (PCV), Hemoglobin (Hb) concentration, Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC) were determined from whole blood shortly after collection. Plasma samples were prepared by centrifugation of whole blood (5°C, 3000 rpm) for 10 min and transferred into 1.5 mL Eppendorf tubes are stored at -20°C until further analysis. Plasma concentrations of total protein, albumin and glucose were determined using commercial kits (United Diagnostics Industry, Dammam, KSA) while that of globulin was calculated as the difference between total protein and albumin concentrations.

Statistical analysis: Data were statistically analyzed by using the Statistical Software program (SAS Institute, 2000). Duncan's multiple range test in 1955 was used to compare between means at $p<0.05$. The following model was used.

$$Y = U+(S)i+(T)j+(S*T)ij+eijk$$

Where:

U = Overall mean
S = Effect of species
T = Effect of treatment
S*T = Effect of the interaction between species and treatment
e = Random error

RESULTS AND DISCUSSION

The shift from Winter to Summer resulted in an increase of ambient temperature from 19.79±3.78-39.83±2.13°C. However, relative humidity was decreased from 26.22±0.65% during Winter season to 6.98±1.18% during Summer season. Consequently, the calculated average temperature humidity index was increased from 18.38±0.21 during Winter to 42.73±1.38 during Summer season (Table 1).

Significant differences were found between the response of camels and sheep to the seasonal shift from Winter to Summer in all determined parameters. Table 2 shows that exposure to hot Summer condirions had significantly ($p<0.05$) elevated rectal temperature in both

Table 1: Ambient temperature, relative humidity and Temperature Humidity Index (THI) during Summer and Winter season of the experimental period (Means±SE)

Parameters	Time	Summer	Winter
T_a (°C)	08:00	35.63^a	12.83^b
	12:00	41.34^a	20.72^b
	15:00	42.51^a	25.81^b
	Overall mean	$39.83±2.13^a$	$19.79±3.78^b$
RH (%)	08:00	9.25^a	$38.23±0.31^b$
	12:00	6.41^a	$24.14±0.84^b$
	15:00	5.29^a	$16.30±0.30^b$
	Overall mean	$6.98±1.18^a$	$26.22±0.65^b$
THI	08:00	40.00^a	$13.12±0.12^b$
	12:00	43.75^a	$19.20±0.33^b$
	15:00	44.43^a	$22.83±0.21^b$
	Overall mean	$42.73±1.38^a$	$18.38±0.21^b$

Means with different superscripts in each row are significantly different ($p<0.05$)

Table 2: Skin (T_{sk}) and rectal temperatures (T_r) of camels and sheep during Summer and Winter seasons (Means±SE)

Parameters	Time	Summer	Winter	SE	Summer	Winter	SE
T_{sk}	8.00	35.52[a]	32.83[b]	0.18	36.41[a]	24.47[b]	0.14
	12.00	36.20[a]	34.15[b]	0.18	38.98[a]	30.98[b]	0.15
	15.00	36.61[a]	34.16[b]	0.18	39.00[a]	32.43[b]	0.15
	Overall mean	36.11[a]	33.71[b]	0.18	38.13[a]	29.13[b]	0.15
T_r	8.00	37.72[a]	37.52[b]	0.10	38.78[a]	37.48[b]	0.23
	12.00	38.15[a]	37.40[b]	0.10	39.18[a]	38.30[b]	0.23
	15.00	38.08[a]	37.32[b]	0.10	39.02[a]	37.78[b]	0.23
	Overall mean	37.98[a]	37.41[b]	0.10	38.99[a]	37.84[b]	0.23

Means with different superscripts in each row for each species are significantly different ($p<0.05$)

Table 3: Changes in hematological indices (%) of camels and sheep due to seasonal shift from Winter to Summer (Means±SE)

Hematological indices	Camel	Sheep
RBC (millions mm^{-3})	+5.2	-4.70
Hb (g dL^{-1})	+23.7	+8.40
PCV (%)	+9.1	-3.40
MCV (fL)	+3.8	-0.01
MCH (pg)	+17.4	+12.00
MCHC (g dL^{-1})	+13.0	+10.40

Table 4: Plasma protein and glucose concentrations of camels and sheep during Summer and Winter seasons (Means±SE)

	Camel			Sheep		
Blood metabolites	Summer	Winter	SE	Summer	Winter	SE
Total protein (g dL^{-1})	7.88[a]	7.55[b]	1.72	5.65[a]	4.98[b]	0.20
Albumin (g dL^{-1})	5.24[a]	4.18[b]	0.83	3.44[a]	3.64[b]	0.06
Globulin (g dL^{-1})	3.19[a]	2.37[b]	1.66	2.27[a]	1.59[b]	0.19
Glucose (mg dL^{-1})	89.08[a]	128.74[b]	7.43	95.55[a]	72.48[b]	3.21

Means with different superscripts in each row for each species are significantly different ($p<0.05$)

camels and sheep. However, the increase in rectal temperature during Summer season was two folds higher in sheep compared to camels. Likewise, skin temperature was significantly ($p<0.05$) increased in both species during Summer season. However, the increase in skin temperature during Summer season was almost four folds higher in sheep compared to camels. It worth to mention that the rhythm oscillation of skin temperature was reduced by three folds from 7.96-2.59 in sheep compared to insignificant reduction from 1.33-1.09 in camels with the seasonal shift from Winter to Summer. The rhythm oscillation of rectal temperature was reduced by two folds from 0.82-0.40 in sheep compared to two folds elevation from 0.20-0.43 in camels with the seasonal shift from Winter to Summer.

All measured hematological parameters were elevated in camels due to seasonal shift from Winter to Summer. In sheep however, seasonal shift from Winter to Summer resulted in elevation of Hb, MCH and MCHC and reduction of RBC, PCV and MCV (Table 3).

Blood biochemical analysis (Table 4) revealed that seasonal shift from Winter to Summer had increased plasma total protein and globulin concentrations in both species. Plasma albumin concentration was increased in camels and reduced in sheep however, plasma glucose concentration was decreased in camels and elevated in sheep with the seasonal shift from Winter to Summer.

Dromedary camels and Najdi sheep are indigenous to the desert where water and feed are scarce and ambient temperatures are high. Under these conditions, they need to dissipate heat in order to regulate their body temperature. This study was conducted to compare the capability of these species to tolerate the seasonal shift under semi-arid environment. The measured climatic data (Table 1) shows that camels and sheep used in this study were exposed to sever heat stress during Summer season. Because Temperature Humidity Index (THI) values >25.6 are considered as extreme sever heat stress (Marai *et al*., 2001). Furthermore, THI values <22.2 are normally considered as acceptable, i.e., absence of heat stress (Marai *et al*., 2001). Therefore, climatic data recorded during the winter season indicates that both species were exposed to acceptable environmental conditions during that season.

The Average Relative Deviations (ARD) from normal (regardless either positive or negative) due to exposure to hot climates in all traits measured could be used for detection and comparison of adaptability of both species to the hot climate (Habeeb *et al*., 1992; Marai and Habeeb, 1998; Marai *et al*., 2008). The animal's body temperature expressed as rectal temperature increases when the body fails to maintain its heat balance (Marai *et al*., 2007). Therefore, the observed increase in T_r in both species as the season changes from Winter to Summer indicates that heat dissipation was lower than heat gain and therefore, thermal balance could not be maintained, i.e., cooling mechanisms became insufficient since, the gradient difference of temperature between the body and the air was greatly reduced. The mammalian skin is an important pathway for heat exchange between the body surface and the environment. Skin temperature is the result of the adjustment of the skin blood flow that ends with regulation of the heat between the body core and skin (Habeeb *et al*., 1992). The observed elevation of skin temperature in both species can be attributed to the fact that exposure to heat stress alter the blood flow and redistribution of blood flow and increase blood flow to the surfaces (Marai and Habeeb, 2010). This could indicate that both species were heat stressed under the semi-arid Summer conditions of Saudi Arabia. However, the increase in T_r and T_{sk} due to the exposure to hot Summer conditions was greater in Najdi sheep compared to Arabian camels. This could partially, be due to the fact that sweating in woolled sheep is much less effective due to the presence of the wool coat (Marai and Habeeb, 2010). Similarly, Olson *et al*. (2002) has reported lower T_r

and T_{sk} during Summer season in very short, sleek and shiny haired cattle breed compared to normal haired ones. The observed higher oscillation rhythm of both T_{sk} and T_r and its higher variation due to seasonal shift from Winter to Summer in sheep compared to camels could be contributed to the reported higher body thermal inertia of larger mammals compared to smaller ones (Aschoff, 1982).

The results of the present study show that heat stress has different effects on hematological indices of camels compared to sheep. Camels exposed to heat stress during Summer season showed higher hematological indices while these were reduced in sheep. The reduction of hematological indices in sheep during Summer season could be attributed to the hemodilution effect (El-Nouty *et al*., 1990), destruction of erythrocytes (Shaffer *et al*., 1981) and depression of hematopoiesis (Shebaita and Kamal, 1973) under heat stress conditions which might not be the case in camels (Al-Haidary, 2006).

Heat stress is known to result in the activation of hypothalamic-pituitary-adrenal axis and stimulation of glucocorticoids (cortisol) secretion (Marai and Habeeb, 2010). Further, an increase in white blood cell (leucocytes) count under heat stress conditions due to thyromolymphatic involution has been reported (Abdel-Samee, 1987). Therefore, exposure of both species to heat stress during Summer season resulted in elevation of plasma total protein concentration, mainly as a reflection to an increase in plasma globulin concentration. However, plasma albumin concentration was increased in camels and decreased in sheep exposed to heat stress during Summer season. Heat stress induced reduction of plasma albumin concentration in sheep could 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). Such destruction of protein tissue is due to the increase in glucocorticoid hormones (proteolytic hormones), responsible for protein catabolism (Marai and Habeeb, 2010). The increase in catecholamine's (lipolytic hormones) or the decrease in insulin responsible for protein anabolism may also contribute to tissue destruction (Habeeb, 1987; Habeeb *et al*., 1992). On the other hand, the elevated plasma albumin concentration in camels could be attributed partially to the observed elevation of PCV (hemoconcentration) and partially to the rise in thyroid hormones concentration reported under heat stress in camels (Nazifi *et al*., 1999).

Exposure of camels and sheep to heat stress during the Summer season resulted in reduction of plasma glucose concentration in camels and its elevation in sheep. The observed increase in plasma glucose concentration in sheep may be related to the reduction of feed intake and insulin concentration (Habeeb, 1987) and the action of glucocorticoids (Nessim, 2004). However, the reduction in plasma glucose concentration observed in camels could be attributed to the acceleration of respiration in heat stressed camels (Schroter *et al*., 1987) which causes high utilization of glucose by the respiratory muscles (Kamal *et al*., 1962; Shaffer *et al*., 1981). The results reported in the present study indicate better tolerance of camels, compared to sheep, to heat stress prevailing under Summer conditions of the semi-arid environment.

CONCLUSION

The obtained results indicate that body temperature and blood composition were altered in both species due to seasonal changes. However, the changes in body temperature and biochemical parameters were higher in sheep compared to camels. This indicates better adaptive performance of camels to heat stress prevailing under Summer conditions of the semi-arid environment.

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