Proceedings of the Third Annual Meeting for Animal Production Under Arid Conditions, Vol. 1:71-87

A Comparative Physiological Study Between Camels and Goats During Water Deprivation.

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ABSTRACT

Objectives of this study were to investigate the physiological differences between camels and goats during 72 hours of water deprivation. Three sexually mature females of each of camels and goats were used in this study. They were housed separately in open partly shaded yards. Ambient temperature and relative humidity averaged 31.4 ^{0}C and 55.9%, respectively during the experiment. Results showed that dehydration caused progressive decreases in roughage feed intake for both camels (-54.6%) and goats (-27.8%). Physiological body reactions showed a non-significant increase in rectal temperature and respiration rate in camels, while goats showed a decrease in their rectal temperature and a significant ($P<0.05$) increase in respiration rate. Pulse rate decreased significantly ($P<0.05$) in both species due to dehydration. Hematological parameters (packed cell volume, hemoglobin, white blood cell count) were less affected by dehydration in goats than those in camels. However, red blood cell count was increased insignificantly in both species. A significant ($P<0.05$) decrease in blood glucose level was found in both species. Camels showed a significant increase in blood urea nitrogen (249%) over the preliminary period. No changes were observed in values of serum total protein, albumin, globulin and albumin/globulin ratio in camels. However, decreases were found in these values except for albumin/globulin ratio in goats after 72 hours of water deprivation. Both camels and goats showed slight elevations in Ca^{++} and Na^{+} and a significant increase in K^{+} due to dehydration. The effect of 72 hours water deprivation was evident in the two species with a higher effect in goats than in camels in terms of physiological body reactions and some biochemical parameters and

minerals which might indicate a better adaptive performance of camels to water deprivation in desert conditions.

Key Words: Water deprivation, Physiological performance, Goats, Camels.

INTRODUCTION

The desert climate of the United Arab Emirates is very hot in summer (above 45 ^{0}C), with high humidity on the coast, while winter is mild with low rainfall. Desert animals (camels and goats) are adapted by various behavioral and physiological mechanisms to this climate. They are considered an important source of milk and meat production for the bedouin people. The wide distribution of camels and goats, from the temperate zones to the semi-arid and high humid tropical environments, is possibly due to their ability to feed on a wide variety of feed stuffs, mainly trees, shrub leaves and grasses, because they are able to utilize feeds that are normally not eaten by cattle or sheep (Schwartz and Dioli, 1992). Moreover, Camels can tolerate water loss up to 25% of their body weight, and they excrete concentrated urine. Other internal modifications enable them to maintain a steady water level in the blood and to drink amounts of water at a single time that would kill other animals (Pesce and Pesce, 1984).

Since the prevailing environmental conditions are harsh and the animals are subjected to seasonal scarcity of grazing and water, they usually have to walk long distances searching for grass and water. Under these circumstances, animals are expected to face dehydration.

The objectives of this study were to study the physiological performances of the two species (camels and goats) during an environmental stress factor (water deprivation).

MATERIALS AND METHODS

Experimental animals

Three sexually mature female camels *(Camelus dromedarius)* and three native goats *(Capra hircus)* were used in this study. The age average in camels was 79$\pm$6 months and in goats was 22$\pm$4 months. Animals were housed separately in open partly shaded yards at the Faculty of Agricultural Sciences Experimental Farm, located at about 120 Km from the Gulf coast. Each camel was offered 2-2.5 Kg concentrate mixture (12% CP), 250 grams of date and hay adlibtum. Also, each goat was given 400 grams concentrate mixture (14% CP), and hay adlibtum daily.

Experimental design

The experimental period (during month of October) lasted for 72 hours of water deprivation followed by 72 hours of recovery (water, ad libtum). Physiological observations and samples were collected the day before starting treatment, on the 3rd day of dehydration and finally on the 3rd day of recovery. The experiment was divided into three periods namely, preliminary (P), treatment (T) and recovery (R), respectively.

Measurements and recordings

Measurements of climatic conditions (ambient temperatures and humidity) were obtained from a weather station (about 500 meters away from the animal yards). The average ambient temperature and relative humidity during the experimental period were 31.4 ^{0}C and 55.9%, respectively.

Physiological body reactions (rectal temperature, respiration rate, pulse rate) and blood samples were collected from animals, one day before water deprivation, on the 3rd day of treatment and the 3rd day of recovery. Blood samples were collected into heparinized tubes from the jugular vein from all animals before feeding. Packed cell volume (PCV), hemoglobin (Hb) concentration, red blood cells (RBC's) and white blood cells (WBC's) counts were measured in whole blood.

The biochemical parameters that were determined in blood plasma samples were glucose (GLU), blood urea nitrogen (BUN), creatinine (CREA), total protein (TP), albumin (ALB), globulin (GL), albumin/globulin (ALB/GL), calcium (Ca^{++}), sodium (Na^{+}), potassium (K^{+}) and sodium/potassium (Na^{+}/K^{+}). Blood hematology and biochemical analyses were determined by using Dimension clinical chemistry system (Coulter counter, T890) at the Veterinary laboratory, Department of Agriculture and Livestock, Al-Ain, UAE.

Statistical Analysis

Data were statistically analyzed by using the statistical program MSTATc according to Snedecor and Cochran (1980). The following model was used:

$$Y = U + (S)_i + (T)_j + (S*T)_{ij} + e_{ij\,k}$$

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.

Duncan's (1955) multiple range test was used to compare between means at $P<0.05$.

RESULTS

Significant ($P<0.05$) differences were found between camels and goats in all determined parameters. The effect of treatment (dehydration) was significant ($P<0.05$) with roughage feed intake (RFI), concentrate feed intake (CFI), water ingested with food (WI), respiration rate (RR), pulse rate (PR), glucose (GLU), creatinine (CREA), sodium (Na^+), potassium (K^+), and (Na^+/K^+), while no significant effect was observed for the treatment with other parameters (PCV, Hb, RBC's, WBC's, BUN, TP, ALB, GL, ALB/GL and Ca^{++}. The interaction effect (species x treatment) showed variable response for each species to dehydration, as shown in tables (1 and 2). Significant interaction effect was found for RFI, CFI, WI, RT, RR, CREA, and K^+.

Feed intake and water ingested in food in camels and goats are presented in Table 3. Camels showed significant ($P<0.05$) reductions in RFI and WI during water deprivation than that in the preliminary period, while goats insignificantly reduced their RFI and WI during treatment. Consumption of CFI did not differ between preliminary and treatment periods in both species. Tables (3 & 4) show effects of water deprivation during 72 hrs on some physiological body reactions and biochemical parameters and levels of some minerals in plasma in camels and goats.

Physiological body reaction

In camels, values of RT and RR increased at the end of the treatment period (T) compared to the preliminary period (P); from 37.33 to 40.23 ^{0}C, and from 11 to 15 res./min and the percent changes were 7.8% and 39.4%, respectively. Then they decreased in R comparable to P. The value of pulse rate decreased ($P<0.05$) at T from 48 to 34 pl./min, and the percent change was -29.2%; then it increased at R comparable to P (Table 3).

In goats, RT decreased insignificantly after T from 39.8 to 38.8 ^{0}C (opposite to camels) and the percent change was -3.62%, then it increased at R comparable to P value. Values of RR and PR followed the same trend as in camels and the percentages of change over control period were 54.3% and -37.3%, respectively.

Hematological parameters

In camels, values of PCV, Hb, RBC's and WBC's increased insignificantly after the treatment period from 31 to 34%, from 14.5 to 15.97 mg%, from 9.7 to 10.96x10^6 /ml, and from 14.13 to 15.23x10^3 /ml and the percent changes were 9.68%, 10.14%, 12.99 and 7.78%, respectively; then they decreased insignificantly at R comparable to the P period.

In goats, values of PCV, Hb and WBC's decreased insignificantly at T 20.33 to 19.33%, from 7.70 to 7.43 mg%, and from 21.63 to 20.13x10^3 /ml (opposite to camels) and the percent changes were -0.05%, -3.51%, and -6.93%, respectively; then they increased insignificantly at R comparable to the P period. While the value of RBC's increased after the treatment period from 2.48 to 2.97x10^6 /ml, and the percent change was 19.76%, then it decreased after recovery comparable to preliminary period.

Biochemical parameters

In camels, values of GLU decreased ($P<0.05$) at T from 129.33 to 92 mg% and the percent change was -28.86%, then it increased to 96.33 mg% after recovery. The value of BUN and CREA increased ($P<0.05$) at T from 4.67 to 16.33 mg%, and from 1.60 to 1.67 mg%, and the percent changes were 249.68%, and 4.37%, respectively. Then they decreased to 10.67 and 1.20 mg%, respectively, after recovery. While the value of TP and GL increased at T from 7.50 to 7.57 g%, and from 4.27 to 4.33 g%, and the percent changes were 0.93%, and 1.40%, respectively, they then decreased to 6.80 and 3.87 g%, respectively, after recovery. There were no changes in the value of ALB and ALB/GL ratio at the end of T period (3.23 and 0.77 g%, respectively), and at R it decreased to 2.93 and 0.73 g%, respectively.

In goats, value of GLU decreased ($P<0.05$) at T from 62 to 36.67 mg% and the percent change was -40.85%; then it increased to 41.33 mg% at R. The value of TP, ALB and GL decreased at T from 8.00 to 7.37 g%, from 1.40 to 1.30 g% and from 6.60 to 6.07 g%, and the percent changes were -7.87, -7.14 and -8.03%, respectively. At T, the value of TP did not change, while the value of ALB decreased to 1.23 g% and the value of GL increased to 6.13 g%. The value of BUN increased at T from 22.67 to 24.67 mg% and the percent change was 8.82%, it decreased at R comparable to preliminary period. There were no changes in the values of CREA and ALB/GL ratio during experimental periods.

Plasma minerals

In camels, values of Ca^{++}, Na^{+}, and K^{+} increased ($P<0.05$) at T from 11.33 to 11.97 mg%, from 163.67 to 172.67 mmol/l and from 4.07 to 7.60 mmol/l and the percent changes were 5.65%, 5.50%, and 82.25%, respectively; then they decreased at R to 10.77 mg%, 148.67 mmol/L and 4.07 mmol/L respectively. While the value of Na^{+}/K^{+} ratio decreased ($P<0.05$) at T 39.47 to 22.70 and the percent change was -42.49%, then it increased at R comparable to preliminary period. In goats, value of Ca^{++} increased insignificantly at T from 10.00 to 10.13 mg% and the percent change was 1.30%, then it decreased to 9.77 mg%. While the values of Na^{+} and K^{+} increased ($P<0.05$) at T from 162 to 167 mmol/l and from 4.57 to 11.00 mmol/l and the percent changes were 3.09% and 140.70%, respectively; then they decreased at R to 141.33 mmol/l and 4.13 mmol/l respectively. The value of Na^{+}/K^{+} ratio decreased ($P<0.05$) at T from 36.23 to 15.47 and the percent change was -57.3%, then it increased at R comparable to preliminary period.

Table 4: Effects of water deprivation (72 hrs) on some hematological and biochemical parameters in camels and goats (Mean±S.E)

Parameter	Camel P	Camel T	Camel R	% Change	Goats P	Goats T	Goats R	% change
PCV (mg%)	31.00 ± 2.89	34.00 ± 1.15	30.33 ± 2.33	9.68	20.33 ± 3.84	19.33 ± 3.28	23.00 ± 2.31	-0.05
Hb (mg%)	14.5 ± 1.56	15.97 ± 0.52	14.20 ± 1.18	10.14	7.70 ± 1.17	7.43 ± 1.15	8.20 ± 1.38	-3.51
RBC's ($x10^6$/ml)	9.70 ± 0.93	10.96 ± 0.26	9.80 ± 0.68	12.99	2.48 ± 0.72	2.97 ± 0.85	2.63 ± 0.8	19.76
WBC's ($x10^3$/ml)	14.13 ± 1.19	15.23 ± 0.84	14.30 ± 0.94	7.78	21.63 ± 2.45	20.13 ± 1.09	19.40 ± 2.38	-6.93
GLU (mg%)	129.30^{a} ± 10.27	92.00^{b} ± 4.51	96.33^{b} ± 8.35	-28.86	62.00^{a} ± 5.03	36.67^{b} ± 2.03	41.33^{b} ± 2.19	-40.8
BUN (mg%)	4.67^{b} ± 0.67	16.33^{a} ± 2.19	10.67^{ab} ± 0.33	249.68	22.67 ± 1.76	24.67 ± 4.41	22.67 ± 3.76	8.82
CREA (mg%)	1.60^{a} ± 0.06	1.67^{a} ± 0.03	1.20^{b} ± 0.06	4.37	0.63 ± 0.03	0.63 ± 0.03	0.60 ± 0.06	0
TP (mg%)	7.50 ± 0.10	7.57 ± 0.12	6.80 ± 0.25	0.93	8.00 ± 0.50	7.37 ± 0.09	7.37 ± 0.28	-7.87
ALB (gm%)	3.23 ± 0.07	3.23 ± 0.12	2.93 ± 0.25	0	1.4 ± 0.10	1.3 ± 0.20	1.23 ± 0.13	-7.14
GL (gm%)	4.27 ± 0.14	4.33 ± 0.07	3.87 ± 0.14	1.4	6.60 ± 0.60	6.07 ± 0.28	6.13 ± 0.42	-8.03
ALB/GL	0.77 ± 0.03	0.77 ± 0.03	0.73 ± 0.07	0	0.23 ± 0.03	0.23 ± 0.03	0.23 ± 0.03	0
Ca^{++} (mg%)	11.3^{ab} ± 0.15	11.97^{a} ± 0.27	10.77^{bc} ± 0.22	5.65	10.00 ± 0.45	10.13 ± 0.41	9.77 ± 0.29	1.3
Na^{+} (mmol/L)	163.7^{b} ± 2.19	172.7^{a} ± 4.33	148.7^{c} ± 2.03	5.5	162^{a} ± 1.15	167^{a} ± 1	141.33^{b} ± 0.33	3.09
K^{+} (mmol/L)	4.17^{b} ± 0.22	7.60^{a} ± 0.23	4.07^{b} ± 0.33	82.25	4.57^{b} ± 0.52	11.00^{a} ± 1.13	4.13^{b} ± 0.23	140.7
Na^{+}/K^{+}	39.47 ± 2.28	22.70 ± 0.59	36.53 ± 0.79	-42.49	36.23 ± 3.54	15.47 ± 1.50	34.37 ± 2.07	-57.3

^{a,b,c} Denote differences between means in the same species at $P<0.05$. P = Preliminary, T = Treatment, R = Recovery, % Change = (T- P)/P X 100.

DISCUSSION

The results presented indicated that dehydration caused progressive decreases in roughage feed intake for both camels and goats. MacFarlane and Howard (1972) reported a close relationship between water requirement and food intake. Disturbances of water balance in sheep have been shown to hamper feed intake (More and Sahni, 1981) and to influence the body heat balance as well as the partitioning and composition of the body fluids (Aganga *et al*., 1989). Abdelatif and Ahmed (1994) reported in Sudanese desert sheep that decreasing water intake by increasing watering interval caused reductions in both dry matter intake and body weight. In the present study the percent reduction in RFI in camels (54.6%) was higher than that in goats (27.8%). Mousa *et al*., (1983) observed that water restriction in sheep, goats and camels for five days caused a decrease in dry matter intake in the three species, but the reduction was higher in camels than the other two species, which agrees with our findings.

In terms of energy production, water restricted goats reduced RFI and hence endogenous heat production, and so reduced the water requirement for evaporative cooling. The decrease in metabolic heat production was indicated by the slight decrease in rectal temperature. However, in camels, rectal temperature increased after dehydration indicating a different physiological response in this species. Schmidt-Nielson (1964) stated that camels could adapt to hot and arid conditions by raising its body temperature. Dahlborn *et al.,* (1987) found that dehydrated camels exposed to desert conditions kept their brains temperatures at 38 ^{0}C while their body temperature increased to 40.5 ^{0}C. Also, as a water conservation measure, the body temperature of the camel is permitted to increase during the day so that the excess heat can be dissipated at night when the desert air is cool (Reece, 1997). Respiration rate as a means for heat dissipation increased non-significantly in camels but increased significantly in goats and the pulse rate decreased significantly in both species due to dehydration (Table 3). Dromedary camels are indigenous to the desert where water and food are scarce and ambient temperatures are high. Under these conditions, camels need to dissipate heat in order to regulate their body temperature. Sweating is the main evaporative heat loss mechanism and commences soon after heat exposure but it drops progressively when the animals lose about 20% of their initial body weight (Zine-Filali, 1987). Robertshaw and Dmi'el (1983) found that dehydrated Bedouin goats reduced their cutaneous moisture loss and increased their respiration rate to 40-60% above the level found in hydrated ones. This response was observed in our results since goats increased their respiration rate to 54% in order to dissipate the heat load encountered by dehydration while it is likely that camels have used both sweating and respiration in this regard.

Compared with most other mammals, where losses of water over 15% of body weight are fatal, ruminants can tolerate larger losses amounting to at least 18% in cattle, 20% in sheep, 25% in camels and >40% in desert black Bedouin goats (Shkolnik *et al.*, 1980). The rumen contains a larger store of water than the gastrointestinal tract of nonruminant animals (MacFarlane, 1964). So, ruminants are able to draw on the water in the rumen during times of dehydration and changes in extracellular and intracellular fluids up to three days are less apparent (MacFarlane *et al.*, 1961). In addition, during water deprivation, the camel conserves its water mainly by reducing urinary and fecal water excretion (Schmidt-Nielsen, 1964) and can produce highly concentrated urine and fairly dry feces (Siebert and MacFarlane, 1975; Yagil, 1985). Our results showed a similar trend to the previous findings in PCV in camels and goats after 72 hrs of dehydration. It seems that local goats were less affected by dehydration than camels in PCV, hemoglobin concentration and W.B.C's count. However, R.B.C's concentration was increased non-significantly in both camels and goats due to dehydration. More investigation should be applied to local goats as to the effect of dehydration for periods of more than 72 hours on changes of their hematological parameters.

Variable responses were observed between camels and goats in the determined biochemical parameters due to water deprivation. A significant decrease in GLU level was found in both camels and goats and the level of decrease was more pronounced in goats than that in camels. The decrease in glucose level during water deprivation was a result of the decrease in feed intake (RFI) in both species (Table 3). In true ruminants, the plasma glucose level is lower compared with monogastric mammals. Camels on the other hand, have glucose levels similar to monogastric mammals (Dahlborn *et al.*, 1992). This explains why camels maintained a higher level of glucose than goats after 72 hours of water deprivation. One of the most important mechanisms for countering the effects of losses of body water is the adjustment of renal function (Ganong, 1981). Abdelatif and Ahmed (1994) found in desert sheep subjected to water restriction (to 46% *ad. lib.* intake), a decrease in total urine output and enhanced urea recycling to the forestomach as evidenced by high plasma urea concentration. In the present study, blood urea nitrogen was increased in camels and goats after water deprivation. The camels showed a significant increase (249%) in BUN over the preliminary value. The high urea-recycling rate in camels in this experiment accords with the early observation of Schmidt-Nielsen *et al*., (1957) that the urine of camels maintained on low protein diets or in reduced feed intake contained trace amounts of urea. Mousa *et al.*, (1983) also reported that the low metabolic rate in camels is consistent with the significantly longer half-life of urea. In dehydrated animals the decline in the glomerular filtration rate (GFR) and renal plasma flow was accompanied by increased concentrations of ADH and aldosterone (Yagil and Etzion, 1979). These two hormones act to conserve body water by absorption of salt and water from the gut and from renal conservation. In the distal portion of the nephron, ADH increases the permeability to urea as well as water (Jamison *et al*., 1985). No changes were observed in values of TP, ALB, GL and ALB/GL ratio in camels. However, decreases were found in these values for goats after the dehydration period. Siebert and MacFarlane (1975) compared between dehydration of cattle and camels and attributed the dehydration tolerance of camels to plasma volume maintenance through the conservation of albumin, which contributes significantly to the osmotic pressure modulation. It seems in camels, that most of the water loss was from the intracellular fluid compartment and from the gut, particularly from the rumen. Camels and goats had slight elevation in Ca^{++} and Na^{+} due to dehydration but significant increase in K^{++} over the control period. This is likely due to secretion of antidiuretic hormone, which increases water reabsorption from kidney and gut. Yagil and Etzion (1979) dehydrated camels for 10 days and found a 341% increase in plasma ADH. MacFarlane and Siebert (1967) reported a very sensitive response in a hydrated camel to ADH injected at a very low dose. This level was far below that used in cattle and sheep (MacFarlane *et al.*, 1967), or goats (Konar and Thomas, 1970). This confirms our results and other findings that camels are more resistant to water deprivation for longer times than other farm animals.

CONCLUSION

In this study, the effect of dehydration was evident in the two species with higher effect in goats than in camels, in terms of physiological body reactions, and some biochemical parameters and minerals which might indicate a better adaptive performance of camels to water deprivation in desert conditions.

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Proceedings of the Third Annual Meeting for Animal Production Under Arid Conditions, Vol. 1:71-87