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Factors affecting feed intake, body weight, testicular size, and testosterone, follicle stimulating hormone (FSH) and luteinizing hormone (LH) serum concentrations in peri-pubertal male camels

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Body weight, testes development and serum testosterone, follicle stimulating hormone (FSH) and luteinizing hormone (LH) levels were determined and compared in two groups of peri-pubertal male dromedaries. Daily maximum and minimum ambient temperatures and dry and wet-bulb temperatures were recorded. Temperature-humidity index was calculated. The camels were divided into two equal groups of nine camels each, of comparable body weight: Group (A) received a diet of 13% crude protein and 2.9 MCal metabolizable energy (ME) with added premix, while Group (B) received a non-pelleted diet of alfa-alfa and wheat straw at the ratio of 1:3 giving 12.4% CP and 2.7 MCal ME. Individual feed intake was calculated after 14 days of adaptation. Feed offered and orts were recorded daily throughout the experimental period (24 months). Animals were fed diets containing 1:3 alfa alfa:wheat straw. Blood samples were collected from 5 camels in each group at 15-day intervals during the experimental period. None significant difference in total body weight was found between groups A and B throughout the entire experimental period ($p > 0.05$). Group averages of daily feed intake for the entire period were 5.82 kg in group A and 7.08 kg in group B, respectively ($p < 0.05$). The latter group had significantly larger testicular size than group A ($p < 0.05$), seasonal difference in testicular size was also significant ($p < 0.05$); serum FSH level was significantly higher in group B than group A ($p < 0.05$), whereas serum testosterone and LH levels were comparable in the two groups.

Key words: *Camelus dromedaries*, body weight gain, testicular size, testosterone, follicle stimulating hormone (FSH), luteinizing hormone (LH).

INTRODUCTION

In addition to nutrition and health, one of the most important factors affecting camel productivity is its low reproductive performance and long reproductive cycle (Aboul-Ela, 1991). These are major obstacles to the growth of dromedary camel populations (Tibary and Anouassi, 1997) since in camels, as in other farm

animals, a high level of fertility is an important perquisite for breeding, genetic improvement and increased production.

Al-Qarawi et al. (2000) classified reproductive stages of male camels according to age as follows: pre-pubertal, (<3 years); peri-pubertal (3 to less than 5 years); mature, (5 to <15 years), and aged (≥15 years). They reported that plasma testosterone concentration in peri-pubertal male camels was 3.2±0.4 ng/ml. Others reported that male camels as young as 3 years old may be sexually active and may be used for mating (Matharu, 1966; El-Wishy and Omer, 1975; Gombe and Odour-Okele, 1977; Arthur et al., 1985).

Studies in India showed that the breeding season of camels extends from December to March that is, during the period of short day length (Matharu, 1966). Similar short day breeding seasons were reported in the Sudan (Musa and Abusineina, 1978). However, limited attempts have been made to manipulate the onset of the breeding season or to extend it in camels (Ott, 1991; Musa et al., 1993; Tompson and Johnson, 1995). Osman et al. (1979) reported that the size and weight of the testes in camels are affected by the age and season of the year. Animals on a good plane of nutrition reach puberty relatively early. The influence of body weight on puberty appears to be more marked than the influence of age; Abdel-Rahim et al. (1994) and Abdel-Rahim (1997) reported a highly negative correlation between testicular dimensions and age at the onset of spermatogenesis. Testosterone controls most of the reproductive functions in male animals (Hafez and Hafez, 2000) and its level is significantly increased in male camels during rut (Azouz et al., 1992). El-Bahrawy and El-Hassanein (2011) reported that serum testosterone concentration in camels started to rise during pre-rut, attaining maximum level during rut, then decreased towards basal level during post-rut. Rateb et al. (2011) reported that the average serum testosterone value was significantly lower in sub-fertile compared to fertile camels. Overall, immature camels had a significantly lower serum testosterone level (Al Qarawi and ElMougy, 2008).

In a previous study on the association between feed and body weight gain, testicular development and serum testosterone in pre-pubertal camels, a non-significant difference was recorded in total body weight gain between two camel groups receiving diets similar to those used in the present study (Al Saiady et al., 2013). Also no significant difference in testicular size was recorded between the two groups at the start of the experiment. On the other hand, serum testosterone level was significantly higher in group A receiving the pelleted feed as compared to group B receiving the non-pelleted feed. The aim of the following study was to evaluate the effect of pelleted versus non-pelleted, and season of the year, on daily feed intake, body weight, testes development and serum testosterone, follicle stimulating hormone (FSH) and luteinizing hormone (LH) levels in peri-pubertal male camels.

MATERIALS AND METHODS

Animals and diet

The experiment was conducted at the Camel Breeding, Range Protection and Improvement Center in Al-Jouf area, Kingdom of Saudi Arabia during 2011 - 2012. Eighteen dromedary peri-pubertal male camels (*Camelus dromedarius*) aged around 3 years, were used in the study. The animals belonged to the *Mijahim* breed, the main dairy camel breed in Saudi Arabia, and were housed and hand fed. They were divided into two groups, A and B, of matched average body weights. Each group consisted of 9 camels. Group A camels received a commercial diet with 13% crude protein (CP) and 2.9 Mcal metabolizable energy (ME) in addition to mineral-vitamin premix, while Group B received a traditional non-pelleted diet used at the Center, with 12.43% CP and 2.7 MCal/kg ME and without premix (Table 1).

Individual feed intake was calculated after 14 days adaptation period. Feed offered and orts were weighed and recorded daily throughout the experimental period (24 months). Both diets had a roughage:concentrate ratio of 1:3. Group A diet was offered in pelleted form incorporating both roughage and concentrate components. Fresh water was available *ad lib*. For serum biochemical analyses, morning blood samples were collected by jugular venipuncture at 15-day intervals from five animals designated for blood sampling in each group. Serum was then separated from clotted blood samples by centrifugation and frozen at -20°C until analyses. Total protein, albumin, glucose and cholesterol values were determined in the samples, while total globulin was estimated as the difference between total protein and albumin and the albumin globulin ratio was calculated.

Ambient temperature

Maximum and minimum ambient temperatures and dry and wet–bulb temperatures were recorded daily, using a dry and wet bulb thermometer. Temperature-humidity index (THI) was calculated (Maust et al., 1972):

$$THI=0.72 (Tdb +Twb) + 40.6$$

Where Tdb = dry bulb temperature; Twb = wet bulb temperature.

Measurements and laboratory analysis

The following parameters were determined: (i) body weight (in Kg) at 15 day intervals. The animals were weighed after 10 h of fasting using a platform scale Mettler Toledo©, 3000 kg capacity; (ii) total body weight gain in kg (iii) daily weight gain in kg/ day. The serum testosterone, FSH and LH concentrations were determined using specific ELISA kits (Diagnostic Automation Inc. CA. SA). Testicular volume was determined as the method described by Weibel (1989) using the following formula:

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Table 1. Diet composition and chemical constituents (Dry mater basis).

I t e m s	Diet A	Diet B
Raw materials %		
Barley	60.22	62.23
Wheat bran	9.63	12.08
Soya Meal 48%	4.25	-
Salt	0.47	-
Limestone	2.10	-
Acid buf	1.00	-
Molasses	3.00	-
Premix	0.30	-
Alfalfa	19.03	15.23
Wheat straw	-	10.46
Nutrients %		
Dry matter (DM)	90.20	92.52
Crude Protein (CP)	13.08	12.43
Crude Fiber (CF)	10.19	15.35
Calcium	1.67	0.35
Phos.	0.42	0.27
Salt	0.78	1.38
ME Mcal/kg	2.9	2.7

Where ME= Metabolisable Energy.

$(\pi \times L \times B \times T)/6$

Where π = 3.14, L = length of the longitudinal axis of the testis, B = breadth of the testis, T = Thickness of the testis.

Statistical analysis

Data were subjected to statistical analysis using Windows SAS program (SAS, 2000). Data for changes in body weight were analyzed according to the following model:

$Y_{ij} = \mu + T_i + e_{ij}$

Where Y_{ij} is the observation of the dependent variable obtained from J^{th} animal of I^{th} treatment, μ is the overall mean, T_i is the effect of i^{th} treatment (i = A or B); and e_{ij} is the residual term.

For testicular size and hormone levels the model was:

$Y_{ijk} = \mu + T_i + S_j + e_{ijk}$

Where Y_{ijk} is the observation of the dependent variable obtained from K^{th} animal of I^{th} treatment, of J^{th} season, μ is the overall mean; T_i is the effect of i^{th} treatment (i = A or B); S_j is effect of j^{th} season (j = 1 to 4); and e_{ijk} is the residual term.

The General Linear Model (GLM) and Least Squares Means (LSMEANS) procedures were used.

RESULTS AND DISCUSSION

Meteorological conditions

Meteorological data were recorded during the experimental period, giving an average THI of 81 (Figure 1). The hottest months of the year were July, August and September. The maximum temperature during these months ranged from 45.6 to 46.6°C while THI ranged from 78.9 to 83.1. It is documented that in the central region of Saudi Arabia, animals suffer from heat stress during summer (Al-Saiady et al., 2006). Mean initial body weight values of groups A and B camels were 381.83±36.34 and 458.00±33.64 kg, respectively. The difference was not significant (Figure 2). Total body weight gain for the entire trial period tended to be higher, but not significantly, in group A compared to group B. Average daily weight gain (DWG) in both groups was around 0.3 kg/day. This value was higher than that reported by Kadim et al. (2008), Faye et al. (2001) and Sahani et al. (1998), who stated that the daily weight gain for male camels from 18 to 24 months of age ranged from 0.111±0.015 to 0.219±0.24 kg/day. Animals in group A consumed significantly less (P<0.05) feed compared to group B. These results agreed with Mohamed (2006) who reported variation in camel performance when fed different types of rations. Season also significantly affected feed intake: the highest (P<0.05) feed intake was recorded during autumn compared to other seasons (Table 2).

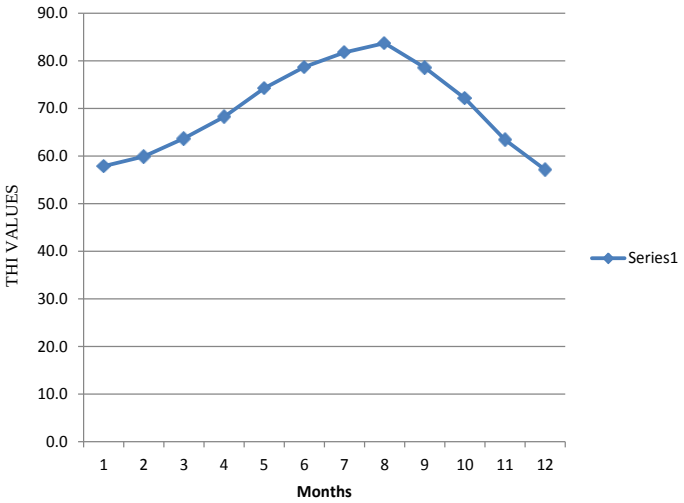

Figure 1. Average THI Rcords / two years.

Changes in testes size

The testicular size was significantly larger (P<0.05) in group B than group A (Table 3), while significant difference in size was found between the right and left testicles. A positive seasonal effect on the size of both right and left testicles was observed. The largest testicular size was recorded in summer and autumn, coinciding with increased levels of feed intake. These results agreed with Al-Asaad et al. (2007) who reported considerable effects on testicular dimensions due to season

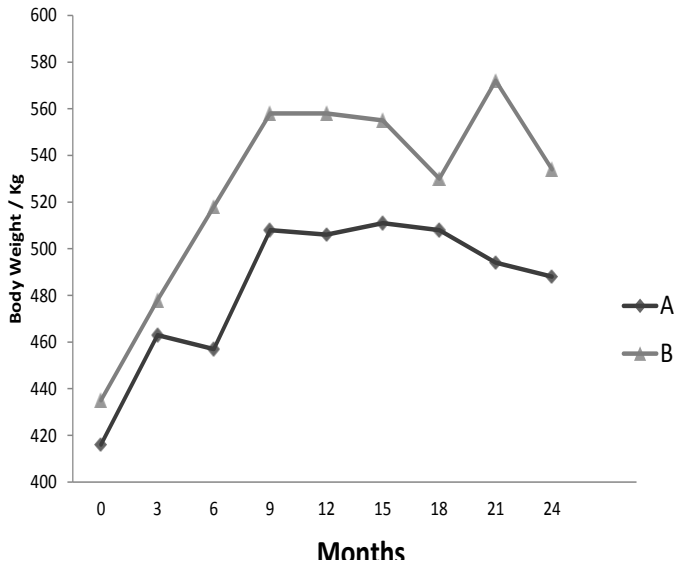

Figure 2. Changes in body weight.

Table 2. Mean ± SE for the effect of diet and seasonal effects on feed intake during the trial period.

Item	Feed Intake/kg
Diet	
A	5.82±0.03[b]
B	7.08±0.03[a]
Season	
Autumn	6.89±0.04[a]
Spring	6.15±0.04[d]
Summer	6.51±0.04[b]
Winter	6.23±0.03[c]

[a,b,c,d] Different letters within the column indicate significant difference (*P*≤ 0.05).

Table 3. Mean ± SE for the effect of diet and season on right and left testicle size.

Items	R. Testicular /cm^3	L. Testicular /cm^3
Diet		
A	456.59±18.5[b]	428.70±17.54[b]
B	565.10±16.95[a]	515.22±15.95[a]
Season		
Autumn	537.65±21.27[c]	488.99±19.98[b]
Spring	435.10±23.02[b]	422.49±21.63[a]
Summer	655.12±36.80[a]	583.02±34.56[b]
Winter	414.61±20.87[b]	393.32±19.96[a]

[a,b,c] Different letters within the column indicates significant difference (P≤ 0.05). R= right L= left.

Table 4. Effects of diet and season on serum concentrations of reproductive hormones (Mean ± SE).

Items	Testosterone ng/ml	FSH/ IU/L	LH/ IU/L
Diet			
A	2.98±0.29[ns]	0.96±0.23[b]	0.95±0.13[ns]
B	2.85±0.29[ns]	1.97±0.23[a]	1.08±0.13[ns]
Season			
Autumn	3.32±0.53[a]	0.84±0.40[b]	0.85±0.23[ns]
Spring	3.16±0.37[a]	1.83±0.29[a]	1.29±0.16[ns]
Summer	3.43±0.37[a]	1.78±0.29[a]	0.94±0.16[ns]
Winter	1.63±0.37[b]	1.43±0.29[a]	0.95±0.16[ns]

[a,b] Different litters within the column indicates significant difference (P≤ 0.05)

Table 5. Treatment effect on mean 'total protein, albumin, globulin, glucose, and cholesterol' in camel serum (Mean ± SE).

Items	Treatment (A)	Treatment (B)
Total Protein g/l	6.23±0.13	6.00±0.13
Albumin g/l	4.52±0.12	4.24±0.12
Globulin g/l	1.71±0.10	1.76±0.10
Alb/Glo	3.11±0.18	2.91±0.18
Glucose mmol/L	8.33±0.21	8.88±0.21
Cholesterol mmol/L	66.04±3.22	60.82±3.22

and age.

Serum concentrations of reproductive hormones according to diet and season are summarized in Table 4. The effect of diet on testosterone and LH concentrations was non-significant; however, Group B had higher FSH concentration compared to Group A. In the present study, the lowest levels of serum testosterone and FSH concentrations were recorded in winter and autumn, respectively. Testosterone level matched that recorded during the non-rutting season (2.89±0.26 ng/ml) by El-Bahrawy and El-Hassanein (2011) and Yagil and Etzion (1980).

Physiological status

The diets used in the present study had no significant effect on blood biochemical parameters (Table 5) and the values of the tested metabolites in both groups A and B were within normal physiological ranges (Abdel Gadir et al., 1984; Higgins and Kock, 1985; Faye and Mulato, 1991; Nyang'ao et al., 1997).

Conclusion

Nutrition affects live body weight gain, and consequently

age at puberty. Peri-pubertal camels receiving a balanced diet with 13% CP, 2.9 Mcal ME and vitamin and mineral requirements, had improved body weight gain, testes size, and FSH concentration in the blood. These results support our earlier findings on pre-pubertal animals. However, more research is needed on the effect of nutrition and season of the year in decreasing age at puberty of male camels, with special emphasis on the role of vitamins or minerals.

Conflict of Interest

The authors have not declared any conflict of interest.

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