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Fasting and basal metabolism in the camel (*Camelus dromedarius*)

Rachid ZINE FILALI*✧, Naima SOUBAI* & Abdelhay GUEROUALI*

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الجـوع و عمليـة التمثيـل العضـوي عند الجمـل ذو السنم الواحـد

استعملت خمس ناقات في هذا البحث حيث منعن من الأكل لمدة خمسة أيام. لوحظ خفض و زنهن ب 93 % بالمقارنة مع الأيام العادية. درجة حرارة حسمهن و سرعة التنفس ضعفتا تدريجيا مع مرور الأيام مشيرتان إلى خفض الاستحالة العضوية. إنتاج الحرارة انخفض ب 25 % ابتداء من اليوم الثاني كما أنه و قع انخفـاض كذلك في الهرمونـات الدرقيـة T4 بنسبـة 80 % وT3 بنسبـة 60 % . في اليوم الخامس أجبرت النوق على تحمل جو حار اصطناعي (42-40 درجة). عندها لوحظ عدم المحافظة على حرارة الجسم الحي مع ارتفاع في درجة الحرارة الباطنية موازية مع وقت السخونة. كانت حرارة الجسم أقل بدرجة واحدة عن الحرارة المعتادة. تبين النتائج أن انخفاض الاستحالة العضوية هي من أهم و سائل حسن التدبير عند الجمل لمقاومة الجوع و قلة الأكل.

الكلمات المفتاحية : جوع – استحالة عضوية – المحافظة على حرارة الجسم الحي

Privation de nourriture et métabolisme de base chez le dromadaire

Cinq chamelles ont été privées de nourriture pendant 5 jours. Leur poids corporel a diminué de 9.3% par rapport à la période témoin. La température corporelle et la fréquence respiratoire ont diminué progressivement avec le jeûne suggérant une réduction du métabolisme. La production de chaleur a diminué de 25% à partir du 2ème jour et retrouve la valeur témoin après alimentation. Les hormones thyoidiennes, T4 et T3 ont diminué de 80 et 60% respectivement après 2 jours de privation de nourriture. Quand les animaux ont été stressés par la chaleur (40-42°C), les réponses thermorégulatrices ont été supprimées et la température corporelle a augmenté avec le temps d'exposition. Cette température est restée inférieure de 1°C par rapport au temoin. Ces resultats suggèrent que la réduction du métabolisme est une stratégie importante utilisée par le dromadaire pour supporter le jeûne.

Mots clés: Dromadaire - Privation de nourriture - Métabolisme - Thermorégulation

Fasting and basal metabolism in the camel

Five female camels were used in this study. They were totally deprived of food for 5 days. Their body weight decreased by 9.3% when compared to the control. Body temperature and respiratory rate declined with progressive starvation suggesting a reduced metabolism. Heat production decreased by 25% on the second day of food deprivation and regained the control value after refeeding. Plasma Thyroid hormones, T4 and T3, decreased by 80% and 60% respectively after 2 days of starvation. On the fifth day, when the camels were heat-stressed in an ambiance of 40-42°C, thermoregulatory responses were suppressed and body temperature increased with the time of heat exposure. Body temperature was shifted by 1°C lower than the control. These results suggest that the reduction in metabolism is one important strategy used by the camel to endure food deprivation.

Key words: Dromedary - Fasting - Metabolism - Thermoregulation

* Département de Physiologie, Institut Agronomique et Vétérinaire Hassan II, BP.6202 -Instituts, 10101 Rabat, Morocco
✧ Auteur correspondant

INTRODUCTION

The dromedary camel is well adapted to the scarce feed and water resources of the arid and semi-arid regions. It is well known for its capacity to regulate fluid balance and body temperature in stressful situations (Zine-Filali, 1987) and survives for a longer period of time than true ruminants when food is rare and of low quality. When the necessity arises, the camel cannot only decrease its feed intake, but can also reduce its metabolic rate (Schmildt-Nielsen *et al.*, 1967). In true ruminants, a decrease in thyroid hormone activity occurs during food deprivation indicating a lowered metabolic rate (Tveit & Almlid, 1980). During prolonged starvation, the camel draws upon its stored adipose tissue (Mirgani, 1981); particularly, the hump and perinephric fat reserves decrease markedly. However, during 4 days of food deprivation, body weight loss was only 6% of the control (Dahlborn *et al.*, 1992).

Some of the mechanisms used by the camel to withstand water shortage and heat stress of the desert are already known. Dromedaries allow their morning body temperature to drop progressively with days of water deprivation and they stopped sweating when exposed to heat and/or solar radiation (Zine-Filali, 1991). The suppression of sweating occurred all over the body surface of the camel (Zine-Filali *et al.*, 1991). The mechanisms enabling these animals to withstand fasting are still poorly understood.

During water deprivation, camels decreased their feed intake; and since feed and water intake are closely correlated (Castle & Thomas, 1975), it is worthwhile to investigate the responses of this animal specie to food deprivation particularly the thermoregulatory and metabolic responses.

MATERIALS AND METHODS

This study was conducted at the department of Physiology and Therapeutics, IAV. Hassan II, Rabat, Morocco. Five adult female camels (10-12 years old) were used. They were fed barley grains (2 kgs) and wheat straw (1 kg) before starvation, and according to the recommended maintenance energy requirements (MEm) of 75 kcal/kg.^{75} (Zine-Filali & Guerouali, 1994). The mean weight of the camels was 300 kg (range: 254-340 kg). Food was withdrawn from the camels and the animals starved for 5 days. Water, however, was given *ad-libitum* during the period of food deprivation. Animals were adapted to faecal collection bags and to the indirect calorimetry chamber for two weeks before the study. An indirect calorimetry system of an open circuit type was used to measure oxygen consumption and heat production (HP) was estimated using the equation of McLean (1972). Ambient temperature was between 18-20°C with 60-65% relative humidity (RH), except during the last day of food deprivation where the animals were heat-stressed under an ambiance of 40°C (45%RH). Rectal temperature and respiratory rate were measured each morning at 0830 hr and animals weighed thereafter.

Blood samples were collected from jugular vein in heparinized vacutainer tubes. Hematocrit was determined immediately as well as total plasma protein concentration using a TS refractometer (Americain Optical, Buffalo, NY). Plasma was analyzed for total thyroxine (T4) and triiodothyronine (T3) using radioimmunoassay kits (Coat-A-Count: IAEA, Vienna).

During the heat exposure day, body temperature was measured continuously with a copper-constantan thermocouple and recorded in 15-channel recorder (Leeds & Northrup, Speedomax W). Respiration rate was counted visually from flank movements throughout the day and sweat rate measured using ventilated capsules (McLean, 1963).

Data are presented as means ± SEM and Student's t-test was used to assess the significance of differences between means. Probability (P) values less than 0.05 were considered significant.

RESULTS AND DISCUSSION

Total or partial starvation is a real possibility and occurs commonly in many parts of the world, particularly during drought seasons. Therefore, mammals living in the desert environment are expected to develop mechanisms to economize body fluids and energy in order to withstand periods of water and food shortage. When the camels used in this study were fed on a maintenance basis, their water intake averaged 1.3 ± 0.3 liters per day (4.3 ml/kg BW).

The ratio water:dry matter intake was 0.5 which is low as compared to 1.3 in the Moroccan goats (Hossaini-Hilali, 1993) and to 3-4 in the European goat breeds (Chaiyabutr *et al.*, 1980). When the food was denied, body weight dropped progressively

until the day of refeeding where the animals had lost 9.3% of their initial weight (Table 1). The same result was obtained in an earlier study (Dahlborn *et al.*, 1992) but the camels did not lose weight in the first day.

Table 1. Effect of food deprivation on camel body weight

Time (days)	Live weight (kg)	± SEM
0	299.7	17.24
1	289.4	16.85
2	284.8	15.72
3	280.4	16.27
4	277.6	15.69
5	275.0	16.01
6	271.9	15.79
7	273.5	15.95
8	276.1	15.91
9	277.9	15.54

Desert goats restricted for 4 days lost 11.6% of their body weight (Ali *et al.*, 1984). Water intake increased during the first day of starvation by 90%, although non significant (Table 2) and declined on the third day by 65% from the control value. The increase in water intake during the first day might be a behavioral reaction of replacement for eating (Macfarlane, 1964) and was not related to body needs. This behavior has been observed in goats (Chaiyabutr *et al.*, 1980) and camels (Dahlborn *et al.*, 1992).

Other studies showed that sheep and goats decreased their water intake immediately after the first meal was omitted (Holtenius & Dahlborn, 1984). It could be suggested that the ability to maintain water intake during starvation might be a strategy used by desert animals to maintain body fluids.

After refeeding, water intake was higher than in the control may be to compensate the water loss. Body weight did not return to control level even though water intake increased because of the tissue loss.

No change was observed in the total plasma protein and hematocrit. This suggested that plasma volume was not altered.

In ruminants and monogastric animals, hypovolemia appears to be a general response to food deprivation (Dahlborn, 1987). It appears that maintenance of plasma volume and thereby an intact blood supply to vital organs, is an important regulatory mechanism making it possible for camels to endure such challenges for much longer period of time.

Table 2. Effect of fasting on camel water intake

Time (days)	Water (liters)	± SEM
0	1.29	0.31
1	2.42	1.05
2	1.34	1.11
3	0.44	0.44
4	0.96	0.96
5	0.52	0.25
6	1.98	1.13
7	3.42	0.79
8	3.52	1.54
9	1.46	0.45

During fasting, morning body temperature decreased by 1.7°C and the respiratory rate decreased by 50% (Figure 1). Control values were obtained right after feeding. These results suggested a lower metabolic rate (MR) to conserve body resources during food deprivation. The lowered body temperature decreased the need for heat dissipation through water evaporation, thus reducing water loss.

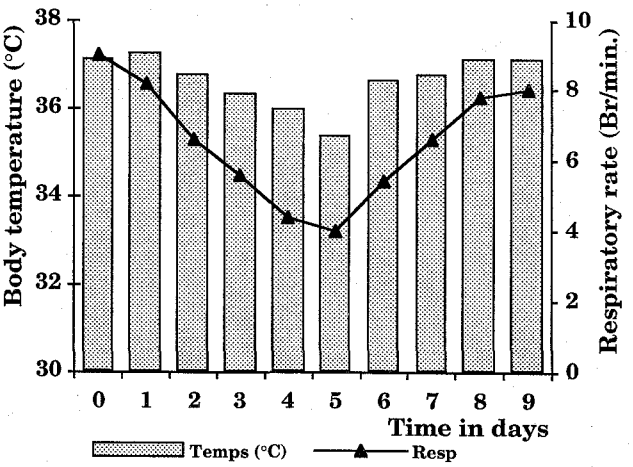

Figure 1. Thermoregulatory responses to food deprivation

Camels are known to reduce their MR during water deprivation (Schmildt-Nielsen *et al.* 1967), but does the reduced food intake have a part of it? In this study, heat production declined by 25% the second day after the food was denied to the animals (Table 3) and stayed at this level until the end of starvation. After refeeding, heat production (HP) went back to control value. Plasma T4 and T3 declined as well in parallel with HP (Figure 2). It should be

stated first that T4 and T3 values for the control are within the range of values found in the literature (Agarwal *et al.*, 1986 ; Wasfi *et al.*, 1987). Thyroid hormones vary with seasons, age, and physiological stages. They have a number of physiological effects, like those on oxygen consumption, and body temperature.

The decrease in T4 and T3 was also observed in rat (Burger *et al.*, 1980) and ruminants (Blum & Kunz, 1981) and was concomitant with a decrease in serum TSH (Thyroïd stimulating hormone). The decrease in T3 is felt to be due largely to decreased conversion of T4 to T3 and/or to the restriction of the carbohydrate and protein content of the diet.

Table 3. Effect of fasting on camel heat production (HP)

Time (days)	HP (kcal/day)	± SEM
0	4868	190.9
2	3655	226.9
5	3611	105.7
6	4528	169.1
7	4291	381.7
8	4335	270.6
9	4643	289.2

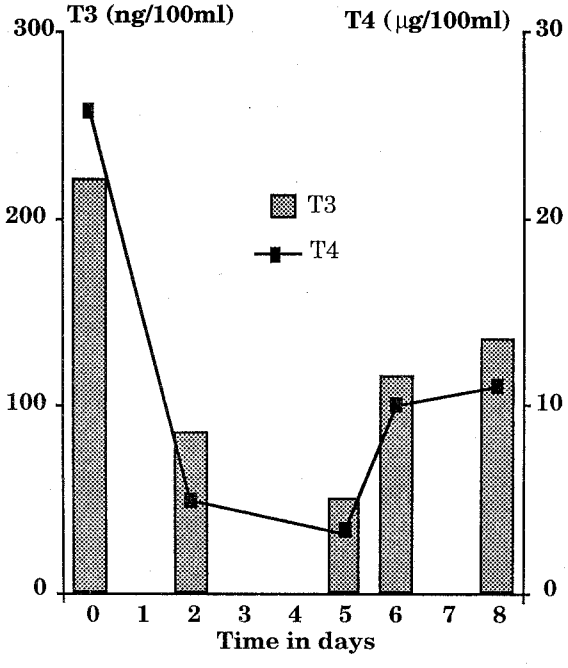

Figure 2. Thyroïd hormones variation during food deprivation

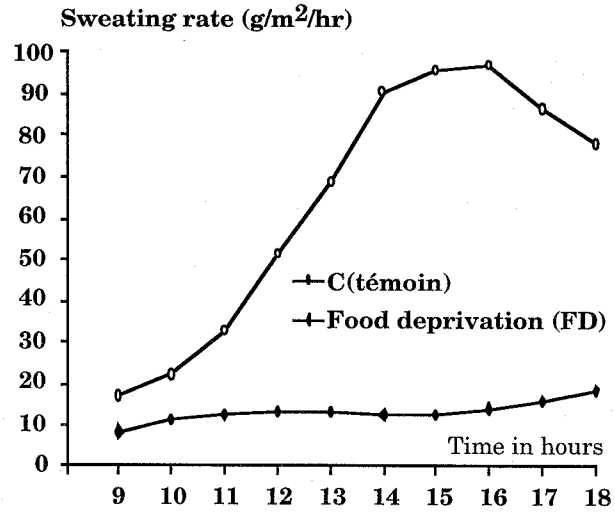

Figure 3. Effect of heat stress on camel heat loss during starvation

When the camels were heat-stressed on their fifth day of starvation, sweating was suppressed (Figure 3) in the same manner as during water deprivation (Zine-Filali *et al.*, 1992) and body temperature increased with the time of heat exposure but with a lower starting value.

CONCLUSION

This study suggests that the camel lowers its metabolic rate to save energy and water and maintains its plasma volume to withstand desert conditions.

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