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SEASONAL VARIATIONS OF THE PLASMA THYROID HORMONE CONCENTRATIONS AND THE BODY TEMPERATURE IN THE DROMEDARY CAMEL

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ABSTRACT

The study of the season effect on the plasma thyroxin (T_4) and triiodothyronin (T_3) concentrations in camel was performed on 5 castrated male camels, 6 to 8 years old. The herd was bred according to the nomadic system in Guelmim (desert area in the southern Morocco) where the ambient temperature ranged from 6 to 20°C during the humid season (November - April) and from 19 to 40°C during the dry season (May - October). Blood samples were collected every 45 days over the year at early morning before going to the pasture. The mean body temperature varied from 36.7 ± 0.2 to 37.1 ± 0.2°C in the morning and from 38.0 ± 0.2 and 38.7 ± 0.2 °C in the evening. The mean plasma T_3 and T_4 concentration ranged from 78.0 ± 2.7 ng/100 ml to 94.0 ± 5.4 ng/100 ml and from 10.3 ± 0.18 µg/100 ml to 11.3 ± 0.26 µg/100 ml, respectively. There was a significant correlation between the plasma T_3 and T_4 concentrations ($r = 0.82$; $p < 0.01$). The season has a significant effect ($p < 0.05$) on the plasma T_3 and T_4 concentrations with high levels during winter and low levels during summer. Negative correlation was observed between the temperature gap and the plasma T_3 ($r = -0.34$; $p < 0.05$) and T_4 ($r=-0.42$; $p < 0.05$). This effect is related to a combined effect of seasonal variation of the feed supply, the ambient temperature and photoperiod; however, the part of each factor could not be established.

Key words : Camel, season, temperature, thyroid hormones

The effect of season or its parameters (temperature, photoperiod, hygrometry, feed supply) on the thyroid activity of mammals is related to their action on the hypothalamo-hypophyso-thyroid axis (Dauncey, 1990; Filinska *et al*, 1991) the binding protein levels and also on some metabolic pathways of the thyroid hormones like the monodeisiodation of thyroxin (Cottle and Veress, 1966; Woeber and Madax, 1981). In the camel, the relationship between thyroid activity and reproduction or environmental factors is not clearly defined. According to Abdel-Wahab *et al* (1974) and Agarwal *et al* (1986), the seasonal variation of the thyroid function and the reproduction activity are interdependent. However, Dixit *et al* (1970) and Yagil *et al* (1978), reported that the seasonal variation of the thyroid activity in male and female camels are related to the ambient temperature and not to the sexual season. This effect is complex because, in the female camel, ovulation is induced by breeding and the polyoestral activity and spermatogenesis in male are more related to the feed supply than the photoperiod (Tibary and Anouassi, 1997). The aim of this work is to study the effect season on the plasma thyroxin (T_4) and triiodothyronin (T_3) concentrations and the body temperature in castrated males ruling out the effect of reproduction.

Materials and Methods

Animals

The study was performed on five castrated male camel 6 to 8 years old. The herd was bred according to the nomadic system in Guelmim (desert area in the south of Morocco) where the ambient temperature ranged from 6 to 20°C during the humid season (November - April) and from 19 to 40°C during the dry season (May - October).

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Feeding is based on pasture only during the humid season and on cereal stubble during the dry season. The main plants consumed during the humid season were *Aristida pungens*, *Rumex vesicarius*, *Zizphus lotus*, *Europhoboa echinusus*, *Salsola* sp., *Atriplex hatinus*, *Zygophylum gaetulum*, *Fankenia thymifolia*, *launea arborescens* and *Ozyris alba*. The iodine content of these plants ranged from 3.1 to 6.5 µg/g on dry matter basis (Bengoumi *et al*, 1994). Camels were watered twice a week during the dry season and treated for external and internal parasites every 6 months. They were in apparent good health at sampling. The body temperature was measured at the morning at 08 am and in the evening at 06 pm.

Sampling

Samples were collected every 45 days over the year in different areas according to the herd moving. Blood samples were collected at early morning before going to the pasture by jugular venipuncture into 10 ml lithium heparin tubes. After centrifugation (3000 g/min during 15 min.), the plasma was separated and stored at -30°C until analysis.

Analysis

Plasma triiodothyronin (T_3) concentration was measured according to the microparticular enzyme immunoassay (MEIA) and thyroxin (T_4) by the fluorescence polarisation immunoassay (FPIA) using an ABBOT IMX auto-analyser (Dandliker *et al*, 1973; Fiore and Michell, 1988). In our experimental conditions, inter-assay variation was 2% for T_3 and T_4 assays. The sensitivity was 0.15 ng/ml and 1µg/ml of plasma for T_3 and T_4 assays, respectively. No significant interaction with other iodothyronins or iodotyrosins was observed in all assays.

Results were expressed as the mean ± SD (standard deviation). The effect of season was evaluated by the analysis of variance (ANOVA). Correlation between T_3 and T_4 concentrations and the temperature gap was calculated using Spearman method.

Results

The mean plasma T_3 concentration varied from 77.2 ± 5.1 ng/100 ml to 94.8 ± 5.0 ng/100 ml. The plasma triiodothyronin concentration varied significantly ($p < 0.05$) during the year with lower values at summer and the higher values at winter and intermediate values at spring and autumn (Table 1).

The mean plasma thyroxin concentration ranged from 10.0 ± 0.2 µg/100 ml to 11.3 ± 0.3 µg/100 ml. As for the T_3, the season had a significant ($p < 0.05$) effect on the plasma T_4

Table 1. Evolution of the plasma thyroxin (T_4) and triiodothyronin (T_3) concentrations and the body temperature in castrated camels during different seasons. Values having the same letters in the same column are not significantly different for $p<0.05$.

Date of sampling	T_3 (ng/100 ml) M ± SD (Min – Max)	T_4 (µg/100 ml) M ± SD (Min – Max)	T_3/T_4 ratio (%) M ± SD (Min – Max)	Morning body temperature (°C) M ± SD (Min – Max)	Evening body temperature (°C) M ± SD (Min – Max)	Temperature gap (°C) M ± SD (Min – Max)
November 1st	89.6 ± 3.9^{ab} (86 - 96)	10.8 ± 0.2^{a} (10.6 - 11.2)	0.86 ± 0.03^{a} (0.81 - 0.89)	37.1 ± 0.2^{a} (36.9 - 37.3)	38.3 ± 0.2^{a} (38.0 - 38.4)	1.2 ± 0.2^{a} (1.0 - 1.3)
December 15th	94.8 ± 5.0^{a} (88 - 101)	11.1 ± 0.3^{a} (10.8 - 11.5)	0.85 ± 0.03^{a} (0.80 - 0.89)	37.0 ± 0.2^{a} (36.8 - 37.2)	38.0 ± 0.2^{a} (37.8 - 38.3)	1.0 ± 0.2^{a} (0.9 - 1.2)
February 1st	90.2 ± 5.0^{ab} (83 - 97)	11.3 ± 0.3^{a} (10.9 - 11.6)	0.84 ± 0.04^{a} (0.81 - 0.90)	37.0 ± 0.1^{a} (36.8 - 37.1)	38.2 ± 0.2^{a} (38.0 - 38.4)	1.2 ± 0.2^{a} (1.0 - 1.5)
March 15th	86.2 ± 44^{b} (79 - 91)	11.2 ± 0.2^{a} (10.9 - 114)	0.81 ± 0.05^{ab} (0.77 - 0.88)	37.1 ± 0.2^{a} (36.9 - 37.3)	38.3 ± 0.2^{a} (38.0 - 38.5)	1.2 ± 0.2^{a} (0.9 - 14)
May 1st	83.0 ± 4.6^{b} (75 - 86)	10.9 ± 0.2^{a} (10.5 - 11.1)	0.79 ± 0.04^{ab} (0.73 - 0.83)	37.0 ± 0.2^{ab} (36.8 - 37.0)	38.3 ± 0.2^{a} (38.1 - 38.5)	1.3 ± 0.2^{a} (1.0 - 1.5)
June 15th	80.6 ± 3.9^{bc} (73 - 85)	10.4 ± 0.3^{ba} (10.0 - 10.8)	0.76 ± 0.03^{b} (0.73 - 0.79)	36.8 ± 0.2^{b} (36.6 - 37.0)	38.4 ± 0.2^{a} (38.10 - 38.6)	1.9 ± 0^{b} (1.7 - 2.2)
August 1st	77.2 ± 5.1^{c} (70 - 82)	10.0 ± 0.2^{b} (9.7 - 10.3)	0.73 ± 0.04^{b} (0.68 - 0.78)	36.7 ± 0.2^{b} (36.5 - 37.0)	38.7 ± 0.2^{b} (38.4 - 38.9)	2.3 ± 0.2^{b} (2.1 - 2.6)
September 15th	82.2 ± 4.1^{b} (74 - 84)	10.3 ± 0.2^{ba} (10 - 10.5)	0.76 ± 0.03^{b} (0.713 - 0.80)	36.9± 0.1^{ab} (36.8 - 37.1)	38.4 ± 0.1^{a} (38.3 - 38.5)	1.7 ± 0.2^{b} (1.6 - 2.1)

concentration with high levels at winter and low levels at summer (Table 1).

There was a significant and positive correlation (r=+0.82; p< 0.001) between the plasma T_3 and T_4 concentrations. The mean T_3/T_4 ratio which varied from 0.73 ± 0.04 to 0.86 ± 0.03 % decreased also during the hot season (June -September).

The mean body temperature varied from 36.7 ± 0.2 to 37.1 ± 0.2 °C in the morning and from 38.0 ± 0.2 and 38.7 ± 0.2 °C in the evening. The mean temperature gap (i.e. the difference between the evening and the morning temperature varied from 1.0 ± 0.2 °C to 2.3 ± 0.2 °C (Table 1). The temperature gap increased significantly during the hot season (June -September).

There was a significant but negative correlation between the temperature gap and the plasma T_3 concentrations (r=0.34 $p < 0.05$) and the plasma T_4 (=0.42 $p < 0.05$).

Discussion

The mean plasma triiodothyronin concentrations in castrated males (70 - 101 ng/100 ml) are comparable to those reported in castrated males in the same area by Moutaouakil (1991) and Bengoumi *et al* (1999). These results are also similar to those reported by Yagil *et al* (1978) and Agarwal *et al* (1986). In contrast, they are lower than those observed by Afifi *et al* (1978), Heshmat *et al* (1984), Wasfi *et al* (1987) and Abu Damir *et al* (1990).

The plasma thyroxin concentrations (9.7 - 11.6 µg/100 ml) are comparable to those reported in castrated males in the same area by Moutaouakil (1991) and Bengoumi *et al* (1999). These values are also similar to those observed by Yagil *et al* (1978), Agarwal *et al* (1986), Wasfi *et al* (1987) and Abu Damir *et al* (1990). However, Heshmat *et al* (1984) and Afifi *et al* (1978) have observed very low values. These differences concerning plasma T_3 and T_4 could be explained partly by the geographical differences, time of sampling and essentially by the diversity of analytical methods used with different reliability.

The mean body temperature gap increases at the hot season as was reported by Yagil (1985) and Bengoumi *et al* (1993). As the camels were normally watered, the temperature gap did not exceed 2.3°C.

The season had a significant effect on the plasma concentration of T_3 and T_4. The maximal values were observed during winter (December) and the minimal during summer (August). However, the decrease in the plasma triiodothyronin (-18.6%) is more important than that observed for thyroxin concentration (-11.5%). The decrease of the T_3/T_4 ratio during the hot season (-15.1%) could indicate that the T_3 is the active form of the thyroxin. The seasonal variations of the thyroid activity in the camel have been essentially related to the temperature difference between seasons. In fact, there was a negative and significant correlation between the plasma T_3 and T_4 concentrations and the daily temperature gap. Dixit *et al* (1970) observed a significant variation of the thyroid activity measured by the PBI (Protein Binding Iodine) when the temperature gap between the summer and winter was 26°C. Yagil *et al* (1978) reported a diminution (25%) of the plasma thyroxin concentration when the temperature increased by 25°C. So, although the important seasonal variation of the temperature, the plasma T_3 and T_4 concentrations vary slightly. These results suggest the existence of an extrathyroidal mechanism responsible of the relative "heterotherm" adaptation of the camel (Schmidt-Nielsen *et al*, 1967; Louw and Seely, 1982; Yagil, 1985; Dahlborn *et al*, 1987; Wilson, 1989). However, the circadian variation of the thyroid activity does not allow to evaluate the effect of season with only one sample a day. In fact, the morning and evening temperature gap is very important especially when the camels are dehydrated (Yagil, 1985, Bengoumi, 1992). So, the study of the seasonal variation of the thyroid activity imposes to make two samples a day (morning and evening).

To our knowledge, the effect of the seasonal variation of the nutritional status on the plasma thyroxin and triiodothyronin concentrations, reported in the other mammals (Woeber and Madax, 1981; Cox *et al*, 1984; Kalk *et al*, 1986; Jepson *et al*, 1988; Hendler and Bonde, 1988; Swanson and Sawchenko, 1980; Aumont *et al*, 1989a, b), was not studied in the camel. In the south of Morocco, camels are regularly subjected to a seasonal hyponutrition and water restriction but these deficiencies did not affect notably the castrated camels (Bengoumi, 1992). The diminution of the T_3 and T_4 concentrations

coincide with under-nutrition during the dry season (summer). The low metabolic rate induced by the decrease of the circulating thyroid hormone concentrations during summer could be considered as an other side of the camel adaptation to under-nutrition by the diminution of the energetic expenses (Yagil, 1985, Wilson, 1989 ; Bengoumi and Faye, 2002). However, the decrease of the plasma T_3 and T_4 could also be related to the diminution of the serum albumin concentrations during protein deficiency in the summer (Bengoumi, 1992) since this protein is the principal blood carrier of the thyroid hormones in the other mammals (rat, mouse, cat, guinea-pig, ...) (Richardson *et al*, 1994).

Elsewhere, the dehydration decrease the plasma thyroxin and triiodothyronin concentrations, that permit to the camels to reduce their respiratory rate and water loss (Yagil, 1985). In conditions of this study, the camels were watered normally during the dry season and did not suffer from dehydration. Thus, the diminution of the plasma thyroid hormone concentration during the summer is not related to the dehydration.

The effect of the seasonal variation of the photoperiodicity could not be unknown since the difference between the summer and winter is around 3 hours. However, this effect seems to be secondary as in the other ruminants with seasonal reproductive cycles (goat, sheep …) (Swenson, 1977; Clark, 1981; Follett *et al*, 1984; Lamming, 1984).

In conclusion, the plasma thyroxin and triiodothyronin concentrations in castrated males are influenced by a combined effect of seasonal variation of the feed supply, the ambient temperature and photoperiod. The part of each factor could not be established. Further studies are necessary to understand the thyroid function in the camel in relation to the circadian variations and hydration status.

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