J.Animal and Poultry Prod., Mansoura Univ., Vol.2(10): 439 - 456,2011

EFFECT OF SEASONAL VARIATION ON THE TEMPERATURE, THICKNESS, HYDRATION AND ELECTRICAL CONDUCTIVITY OF THE SKIN OF ONE-HUMPED CAMELS (*Camelus dromedaries*)

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ABSRACT

Skin temperature is essentially a resultant of heat production and heat loss, and as these two factors may be altered by wide ranges in environmental conditions, the present study was conducted to compare the influence of hot (summer) and cold (winter) environmental temperatures on the diurnal variations of surface skin temperature (SST), skin thickness (ST), skin hydration (SH%), skin electrical conductivity and live body weight (LBW) changes of the dromedary camels during both seasons.

The study was carried out at Maryout Research Station, 35km Southwest Alexandria, which belongs to Desert Research Center (DRC), Egypt. Five adult healthy she-camels (*Camelus dromedarius*), 6-8 years old, with initial body weight of 522.0±3.52 and 613.0±6.63 kg for summer and winter seasons, respectively, were used. The animals were kept in unshaded outdoor pen.

Surface skin temperature (SST), skin thickness (ST) and skin hydration (SH%) were measured at seven regions including Neck (NE), Shoulder (SH), Hump (HU), Hip (HI), Fore-limb (FL), Hind-limb (HL) and Abdomen (AB) on both right and left sides of the animal's body. Measurements were taken three times daily (06:00, 12:00 and 18:00 hr) during the middle ten days of each month in both summer (from June till August) and winter (from December till February) seasons. The daily diurnal ambient temperature, relative humidity and solar radiation were also measured at 06:00, 12:00 and 18:00 hr.

The results indicated that SST differed significantly ($P<0.01$) between hump (the site more exposed to sun) and abdomen (less exposed to sun). The differences between the two values were 5.13 and 6.44ºC during summer and winter seasons, respectively.

The differences between SST at the selected sites were the highest ($P<0.01$) under cold climatic conditions (winter) than warm climatic conditions (summer). As expected, measured SST at mid-day (12:00 hr) was consistently higher than measured SST at morning (06:00 hr) and evening (18:00 hr), but was significantly higher during summer than winter. As for skin thickness, the NE, SH, HU and HI sites were significantly ($P<0.01$) thicker and higher of its water content than the other sites during both summer and winter seasons. Values of ST and SH% were higher during winter compared with summer values. This rise may be attributed to the increase in fat stored in subcutaneous layers and to the increase in body fluids. The values of the electrical conductivity of the skin were higher in winter months than in summer months. The neck region had the highest values while the fore limb had the lowest values in both summer and winter. There was a positive correlation between the electrical conductivities of the different skin regions and the water content of the same region in summer and winter.

Keywords: One-humped camel, skin temperature, skin thickness, skin hydration, seasonality

INTRODUCTION

The basic chemical constituents (moisture, fat and nitrogen) of skin were influenced by the weight, age, sex and nutritional condition of the animal under different nutritional conditions, but only the fat content of skin varied significantly, being higher in skin of animals on a high plane of nutrition (Stosic, 1994).

The skin contributes to the normal physiological functioning of the animal by controlling exchanges with its surrounding, in either direction, of heat, water and electrolytes. In many instances, the skin may play a dynamic role in homeostasis and may reflect the nature of the environment where the animal exists (Bentley, 1982).

The dromedary camels that live in harsh desert environments have skin that selectively restricts evaporative cooling to help the animal to conserve water and the volume and composition of body fluids while enhancing thermoregulation. Therefore, the special adaptation of camels to these desert conditions is often associated with its special skin characteristics. Consequently, the ability of camels to withstand excessive heat and water deficit does not depend on water storage, but on numerous physiological peculiarities such as reducing heat flow from the environment to the body across the skin and lessening the loss of water through perspiration (Kohler-Rollefson, 1991).

The present study was intended to highlight the effects of seasonal variations on the extent of changes in skin surface temperature, skin thickness and its water content and electrical conductivity in addition to live body weight changes of one-humped camels during summer and winter seasons.

MATERIALS AND METHODS

The study was carried out at Maryout Research Station, which belongs to the Desert Research Center (DRC), 35 km to southwest of Alexandria, Egypt. The study was planned to investigate the effects of seasonal variation on surface skin temperature, skin thickness, skin hydration, skin electrical conductivity and live body weight of one-humped camels.

Animal housing and management

The study involved five adult healthy she-camels aged between six and eight years and weighing 522.00±3.52 and 613.00±6.63 kg during summer and winter seasons, respectively. They were housed in an unshaded enclosure. The entire period of investigation was classified into two seasons: summer season (from June till August) and winter season (from December till February). Animals were fed on maintenance ration composed of pelleted concentrate feed mixture (consisted of undecordicated cotton seed cake, 50%; wheat bran, 18%; yellow maize, 15%; rice polish, 11%; molasses, 3%; lime stone, 2% and common salt, 1%), in addition to hay and straw rice. The proximate analysis of feeds was determined according to A.O.A.C. methods

(1990). Drinking water was given once daily *ad.lib*. The animals were clinically healthy and free from internal and external parasites.

Meteorological measurements

Climatic data were recorded during the middle ten days of each month and at three times daily, namely 06:00, 12:00 and 18:00 hr, and monthly averages were calculated. Measurements included ambient temperature (Ta, ^{0}C), relative humidity (RH, %) and solar radiation (SR), using automatic thermo-hygrometer and a black-bulb thermometer (HANNA instruments, Italy). Temperature-humidity index (THI) was calculated to portray the environmental heat load on the animal (Olson *et al.* 2002), where Ta is ambient temperature and RH being a fraction (RH% / 100):

$$THI = 0.8\ Ta + RH \times [(Ta - 14.3) + 46.3]$$

Climatic and animal data were recorded during the ten middle days of each month of the experiment. Measurements were taken three times daily at 6:00, 12:00 and 18:00 hr.

Live body weight (LBW)

Individual she-camel weights were recorded bi-weekly. Monthly growth rates were computed for each animal.

Skin surface temperature (SST)

Skin surface temperature was recorded using a suitable probe, a thermistor thermometer (McCaffrey *et al*., 1979). Body surface sites selected for temperature measurements were neck (NE), shoulder (SH), hump (HU), hip (HI), fore-limb (FL), hind-limb (HL) and abdomen (AB) on both right and left sides of the animal’s body. Sampling schedule is indicated above and monthly averages of the right and left values of these regions were calculated for statistical analysis.

Skin thickness (ST)

Thickness of the skin at the various selected sites was measured by using a caliber called specified-micrometer with sensitivity 0.01 mm. The skin-fold thickness was measured and the value was divided by 2 according to Booth *et al*., (1966).

Skin hydration (SH%)

Water content (% per cm^2) of skin at various selected sites of the body was measured during summer and winter seasons according to (Murray *et al*., 1991) as follows:

(1) An area of about 4 cm^2 was shaved thoroughly on different sites of the body,
(2) A 1x1 cm square (1 cm^2) was marked by a marker on each site,
(3) An incision was done at the marked square using sharp scalpel blade. This graft was separated gently from the underlying tissue using artery forceps and blunted the edge of the blade,
(4) These skin-grafts were put gently on a clean piece of cloth for few seconds, then they were weighed in the Metler balance with accuracy up to 0.001g,
(5) These grafts were carefully dried to constant weight in an oven at 102 ± 2 °C. The total drying time was not allowed to exceed eight hours,

(6) The final weight was subtracted from the initial weight (before drying) to get the effective amount of the water contents in each of these different skin grafts,

(7) The percentage of water content of each graft was calculated as follows:

Skin hydration (%) = (weight before drying - weight after drying) / (weight before drying)*100

Measurement of electrical conductivity

Electrical conductivity (Ohm^{-1} or σ) is defined as the resistance of a conductor of unit length and unit cross-section area. In other words, it is the inverse of resistivity (R). The resistivity of the skin was measured by using digital multimeter instrument (Model HC 5010 EC "F" specifications).

The resistivity of the different skin regions (shoulder, hip, hump, neck, flank, fore-limb, hind-limb and abdomen) were measured by introducing both leads of the machine (after joining a veterinary needle to the free blunted end of both leads to be introduced easily) through the very hard and thick skin of the camel. The distance in-between these two leads was about 10cm, and depth about 0.5cm inside the skin. This technique was approximately more or less used by Booth *et al.* (1966), Riley *et al.* (1983), Smith (1992) and Konthuri *et al.* (1993).

Electrical conductivities of the different regions of the skin were measured three times daily (6 a.m., 12 p.m., and 6 p.m.) during summer and winter months. Electrical conductivity

(σ) was calculated as follows:

$$\sigma = RA/L$$

R = Resistance of interadermis of the skin

A = πr^2, cross-section area of the sample's tube, i.e. $\pi(0.5)^2$

L = Length of tube's sample inside the tube (skin).

Statistical analysis

Means, standard errors, minimum and maximum values were calculated using Excel spreadsheets of Microsoft Office 2003. Data were statistically analyzed by one way ANOVA, using GLM procedure of SAS (Goodnight *et al*., 1986). Duncan's new multiple range test **(**Duncan, 1955**)** was used for the multiple comparisons between means.

RESULTS AND DISCUSSION

Meteorological information is graphically presented in Figure 1. The average THI for seasons were 77.11 and 53.77 during summer and winter, respectively. Summer maximum THI was recorded in August (88.0) while the minimum THI was recorded in June (80.0). Corresponding values during winter season were (68.0 and 62.0) in December and January, respectively**.** In general, maximum THI was recorded at mid-day (12:00 hr) and the minimum THI was recorded early in the morning (06:00 hr).

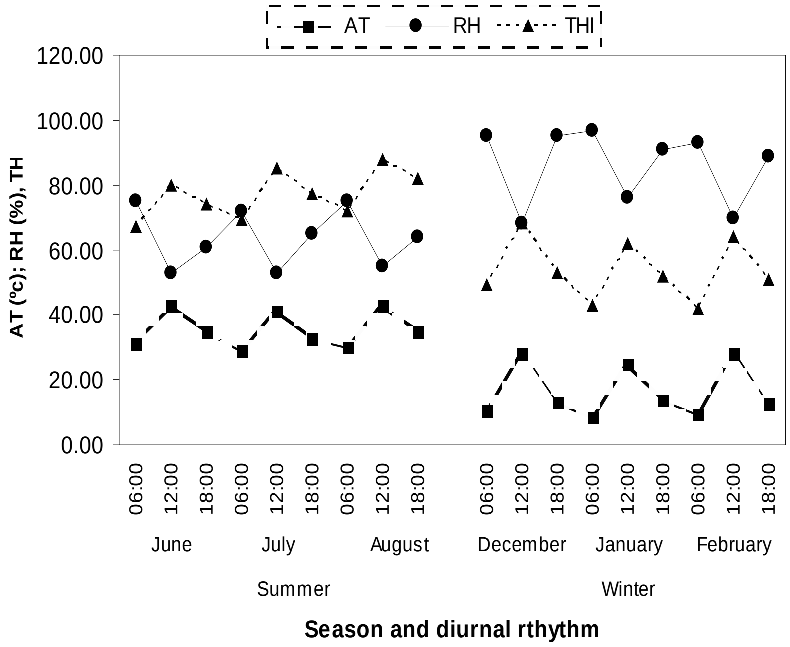

Figure (1): Diurnal patterns of ambient temperature (AT, ºC); relative humidity (RH,%) and temperature-humidity index (THI) during summer and winter seasons.

Live body weight (LBW)

The increase in live body mass is controlled genetically and environmentally. The available nutrients, hormones, the metabolic and physiological status, as well as the climatic elements, are the main factors affecting average daily gain (Hafez, 1987 and Habeeb *et al*., 1992).

The monthly means of live body weight of the five she-camels during summer and winter seasons are presented in Table (1). Initial body weights recorded were 522.0±3.52 and 613.0± 6.63 for summer and winter, respectively. During summer, average body weights were 522.00±3.52; 548.00±3.52 and 576.00±4.63 kg in June, July and August, respectively. The corresponding values during winter season were 613.00±6.63; 648.00±6.60 and 685.60±5.15 kg in December, January and February, respectively. Body weight changes were positive during both seasons. The rate of change in LBW was slightly higher during winter (11.84%) than summer (10.49%). Growth rate was significantly (P<0.05) lower in summer (600 g/d) compared to winter (806.7 g/d). These results were in agreement with those by Bahga *et al*. (2009).

Table (1): Mean live body weight (LBW, kg) of one humped camel during summer and winter seasons

Season	Month	Animal Number					Mean ± SE
		1	2	3	4	5	
Summer							
	June	520	522	510	528	530	**522.00 ±**3.52
	July	548	547	537	555	557	**548.80 ±** 3.50
	August	570	579	563	583	589	**576.80±** 4.63
	means	**546.00**	**549.33**	**536.67**	**555.33**	**558.67**	**549.20 ± 3.89**
Winter							
	December	600	610	600	620	635	**613.00 ±** 6.63
	January	638	643	633	657	669	**648.00 ±** 6.60
	February	678	681	677	687	705	**685.60±** 5.15
	means	**638.67**	**644.67**	**636.67**	**654.67**	**669.67**	**648.87** ± 6.13**

It can be concluded that summer stress reduces growth rate and it may be due to lower food intake and impaired energy metabolism. Marai and Habeeb, (1998) reported that the effects of elevated ambient temperature on growth performance are the product of a decrease in anabolic activity and the increase in tissue catabolism. This decrease in anabolism is essentially caused by a decrease in voluntary feed intake of essential nutrients. The decreased metabolizable energy (ME) for both body maintenance and weight gain causes a loss in the production per unit of feed. Moreover, Abdel-Samee and Marai (1997**)** indicated that the camels' body weight gain declined significantly in the non-breeding season (summer) than in the breeding season and milder weather as a function of heat stress, similar to that recorded in most animals such as rabbits, sheep, goats, cattle and buffaloes (Habeeb *et al.*, 1992; Marai and Habeeb, 1998, Ibrahim, 2001; Marai *et al*., 2002, 2007, 2008).

Skin surface temperature (SST)

It is important to remember that heat exchange is a two-way process. The daily rhythm of skin temperature is an outcome of two physiological processes, namely heat production and heat dissipation. Robertshaw (1985) mentioned that the skin of various parts of the body varies in its ability to exchange heat. This may be attributed to the different peripheral blood flow (Svotwa *et al.*, 2007) and the water content of the skin, and the nature and number of sweat glands at different sites (El-Zeiny 1986).

Mean surface skin temperatures at the seven various sites (NE, SH, HU, HI, FL, HL and AB) of the animal's body are given in Table 2 and graphically presented in Figure 2. The results indicated that SST varied between the selected sites over the animal's body and between seasons. Mean values of SST recorded were 31.50, 32.17, 34.10, 32.57, 32.10, 32.70 and 28.97 ºC in summer as compared to 13.50, 15.23, 19.07, 15.27, 16.60, 15.10 and 12.63 ºC in winter at NE, SH, HU, HI, FL, HL and AB sites. Concerning the effect of season on SST, the results revealed that the differences between SST at the selected sites were the highest (P<0.01) under cold climatic conditions (winter) than warm climatic conditions (summer). SST decreased by – 18.0, -17.5, -15.0, -17.3, -15.5, -17.6 and -16.34 ºC at NE, SH, HU, HI, FL, HL and AB sites, respectively. These results indicated that SST was dependent on climatic conditions, and they are in agreement with Terada *et al*., (1987) on Holstein steers.

Table (2): Mean ± SE of diurnal variations in surface skin temperature (SST) of one-humped camel during summer and winter seasons

Season	Time of day	Skin Sites							Mean ± SE
		NE	SH	HU	HI	FL	HL	AB	
Summer	06:00	29.9	30.50	31.2	31.0	30.3	31.1	27.6	**30.23[e] ±0.106**
	12:00	34.3	34.9	37.5	35.3	35.0	36.1	31.4	**34.93[d] ±0.158**
	18:00	30.3	31.1	33.6	31.4	31.0	30.9	27.9	**30.89[e] ±0.142**
	mean	**31.5[b]**	**32.17[b]**	**34.1[a]**	**35.27[a]**	**32.1[b]**	**32.7[b]**	**28.97[c]**	**32.01[**] ± 0.135**
Winter	06:00	10.3	10.2	14.2	10.7	12.2	9.9	8.7	**11.06[f] ±0.135**
	12:00	16.3	21.6	24.3	20.4	22.6	20.5	17.3	**20.89[d] ±0.209**
	18:00	13.9	13.9	18.7	14.7	15.1	15.0	11.9	**15.19[e] ±0.138**
	mean	**13.5[c]**	**15.23[b]**	**19.07[a]**	**15.27[b]**	**16.6[a]**	**15.0[b]**	**12.6[c]**	**15.71± 0.161**

a ,b and c as superscript in the same raw show significant differences among time of day; d, e and f as superscript in the same column show significant differences among months ; ** = P<0.01

The SST differed significantly (P<0.01) between hump (represent site exposed to sun) and abdomen (represent site not exposed to sun); the differences were 5.13 and 6.44ºC during summer and winter seasons, respectively (Table 2). This result was in agreement with Allan *et al.* (2010), who reported that the highest mean skin temperature was recorded on back location (exposed to sun) compared with abdomen location (not exposed to sun) in cattle and water buffaloes during summer seasons.

This result agrees with that of Singh *et al*., (1982), who reported regional differences in skin temperature of buffalo calves before and after exercise. Campbell *et al*., (2006) found that different parts of buffalo's skin have different surface temperature. The maximal temperature of buffalo's skin is in the range from 35.53 °C to 37.18 °C. Similar results were reported by Berman (1971), Korthals *et al.* (1997), and Silanikove (2000). This result agrees with EL-Zeiny, (1986), who reported similar regional differences in the activity of the sweat glands. Sweat rich in mucopolysaccharides was greater in flank and hump (exposed to the sun) than that of the abdomen (not exposed to the sun). The sweat glands of the camel occupy morphologically a position intermediate between those of man (eccrine) and cattle (apocrine) (Dowling and Nay, (1962), Lee and Schmidt-Nielsen, (1962), and EL-Zeiny, (1986).

The results in Table (2) also indicated that SST had a tendency to increase concomitantly with the rise of environmental temperature (Figure 2) during summer. This rise in SST is attributed to peripheral vasodilatation by increasing skin's blood flow and can approach core temperature as a way of dissipating excess heat to the environment (Svotwa *et al.*, 2007). EL-Zeiny, (2011) reported that camels produce more sweat in summer than in winter. Decreased temperatures in winter were followed by decreased (P<0.01) SST at all the selected sites, which were largest at 06:00 hr, 9.90 and 8.70 ºC for FL and AB sites, respectively (Table 2).

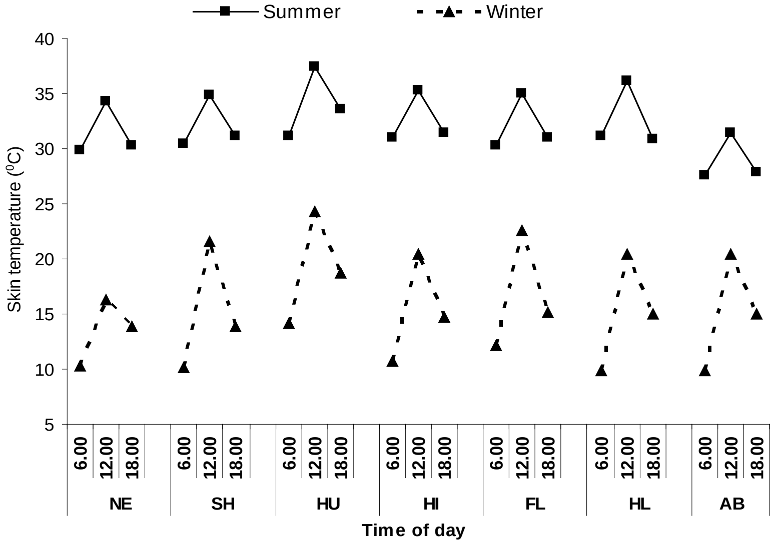

Figure (2): Diurnal temperature patterns of surface skin temperature of one-humped camel during summer and winter seasons

The magnitude of variation for the mean SST for the five animals was 50.9% greater during summer than during winter (Table 2). Thus, environmental temperatures may have some effects on the SST by changing one of the parameters affecting the rhythm and the amplitude. Summer amplitudes may have been greatest because during this time the animals had a minimal coat, compared to the protective highly insulating winter coat, Parker and Robbins, (1984), and, therefore, were more susceptible to environmental changes.

Regarding the diurnal rhythm of SST, Figure 2 illustrates diurnal temperature patterns at all selected sites on the animal's body at 06:00, 12:00, and 18:00 hr during both summer and winter seasons. The results indicated that SST was low at 06:00 hr, increasing to reach a peak at mid-day (12:00 hr) and then gradually declined toward the evening (18:00 hr). The morning SST (06:00 hr) was especially low during the winter season. This result was in close agreement with that of Quarterman, (1962) in New Zealand Jersey cows and Mendel and Raghavan, (1964) in sheep.

Skin thickness and its water content

Means of skin thickness and its water content (skin hydration, SH%) at the selected sites (NE, SH, HU, HI, FL, HL and AB) of the animal's body during summer and winter seasons are given in Table 3 and illustrated graphically in Figure 3. Generally, the results indicated that ST and SH% varied between summer and winter seasons.

Table (3): Means ± SE of skin thickness (ST) and skin hydration (SH) at various sites of one-humped camel during summer and winter seasons

Anim.	SUMMER: skin sites															
No.	NE		SH		HU		HI		FL		HL		AB		Means	
	ST	SH	ST	SH	ST	SH	ST	SH	ST	SH	ST	SH	ST	SH	ST	SH
1	7.5	45	5.3	31	4.4	30	4.9	36.5	3.6	21.5	4.3	28	3.9	34.5	**3.23 NS**	**42.34 NS**
2	7.8	44	4.9	30	4.5	30	5.0	34.5	3.9	20.5	4.2	27.5	3.9	35	**3.21 NS**	**42.29 NS**
3	7.6	43.5	5.3	31.5	4.3	31	5.1	36.5	3.8	22.5	4.4	27.5	4.0	34.5	**3.24 NS**	**43.06 NS**
4	7.8	44.5	5.3	32	4.3	31	4.9	37.5	3.8	23	4.3	28.5	4.1	35	**3.31 NS**	**42.87 NS**
5	7.8	45.5	5.2	31	4.5	32	5.1	37	3.9	22.5	4.3	28.5	4.1	34.5	**3.30 NS**	**43.43 NS**
Mean	**7.7**	44.5	**5.2**	31.1	**4.4**	30.8	**5.0**	37	**3.8**	22	**4.3**	28	**4.0**	34.7	**3.26**	**42.798**
± SE	0.63	0.35	0.78	0.33	0.45	0.37	0.47	0.24	0.548	0.45	0.32	0.22	0.45	0.12	**0.1935**	**0.2164**
	WINTER: Skin sites															
	NE		SH		HU		HI		FL		HL		AB		Means	
	ST	SH	ST	SH	ST	SH	ST	SH	ST	SH	ST	SH	ST	SH	ST	SH
1	8.2	67.5	5.4	49.5	5.9	46	5.6	45.5	4.1	28.5	5.5	35.5	5.0	55	**4.66 NS**	**51.95 NS**
2	8.3	67	5.6	48	5.8	47	5.8	45.5	4.0	29	5.4	36.5	5.1	53.5	**4.73 NS**	**51.61 NS**
3	8.4	68.5	5.5	48.5	5.8	47	5.8	46	4.1	29.5	5.3	36.5	4.9	55	**4.70 NS**	**52.00 NS**
4	8.5	69	5.6	48.5	5.7	45.5	5.7	46	4.2	30	5.6	37	4.9	53	**4.72 NS**	**52.32 NS**
5	8.6	68.5	5.4	49.6	5.8	47.5	5.8	46	4.1	30.5	5.7	35.5	5.1	53	**4.67 NS**	**51.68 NS**
Mean	**8.4**	68.1	**5.5**	48.8	**5.8**	46.6	**5.7**	45.8	**4.1**	29.5	**5.5**	36.2	**5.0**	53.9	**4.69****	**51.913****
± SE	0.71	0.37	0.45	0.31	0.32	0.37	0.40	0.12	0.36	0.35	0.71	0.30	0.447	0.458	**0.1238**	**0.1257**

NS = non-significant between animals; ** = P<0.01

The skin at the NE, SH, HU and HI sites was significantly (P<0.01) thicker and higher of its water content than the other sites during both summer and winter seasons. The values of ST and SH% were (7.7 mm, 44.5%), (5.2 mm, 31.1%), (4.4 mm, 30.8%) and (5.0 mm, 37.0%) at NE, SH, HU and HI, respectively during summer season. The corresponding values during winter were (8.4 mm, 68.1%), (5.5 mm, 48.82%), (5.8 mm, 46.6%) and (5.7 mm, 45.8%). In a study on different breeds of cattle, Dowling (1955) found that skin thickness varied over the animal's body. Also, Garcia *et al*., (1983) reported that skin thickness differed between regions in Retinto cattle breed; the leg region showed intermediate values. The average thickness of the skin in the Retinto breed was 5.5 mm with significant differences between males (6.09 mm) and females (4.30 mm).

As seen in Figure 3, the values of ST and SH% were higher during winter compared with summer values. This rise may be attributed to the increase in fat stored in subcutaneous layers and an increase in body fluids. Similarly, Ghosal *et al.* (1974) observed significant reduction in blood and plasma volumes during winter months. They also found that the interstitial fluid volume significantly increased during the same season. This maybe the reason why the skin is more hydrated in winter. Nevertheless, inverse relationship between interstitial fluid and plasma volume prevailed most of the time (El-Hassanein, 1989). This relationship illustrates the fact that plasma expands in volume on the expense of the interstitial volume. In other words, water is forced—under conditions of increased demands for water expenditure, such as heat stress—to pass through the blood vessels and hence to increase plasma volume by water from the interstitial compartment. The probable mechanism behind this could be osmotic pressure gradients between the two compartments. It was also reported that camels could face heat stress and dehydration by the withdrawal of water from the interstitial fluid (Schmidt-Nielson *et al.* 1967, Kawashti and Omar, El-Hassanien 1989, Assad *et al.*, 1997 and Kataria *et al.* 2003) or from the rumen (Macfarlane *et al.*, 1963, Hoppe *et al.*, 1975, Farid *et al.*, 1979, and Zine-Fillali and Show 2004) and also from the intracellular fluid compartment (Ghosal *et al.* 1974, Khalil 1990 and Achaaban *et al.*, 2002). This may be the cause behind the low hydration of the camel's skin in summer observed in the present experiment.

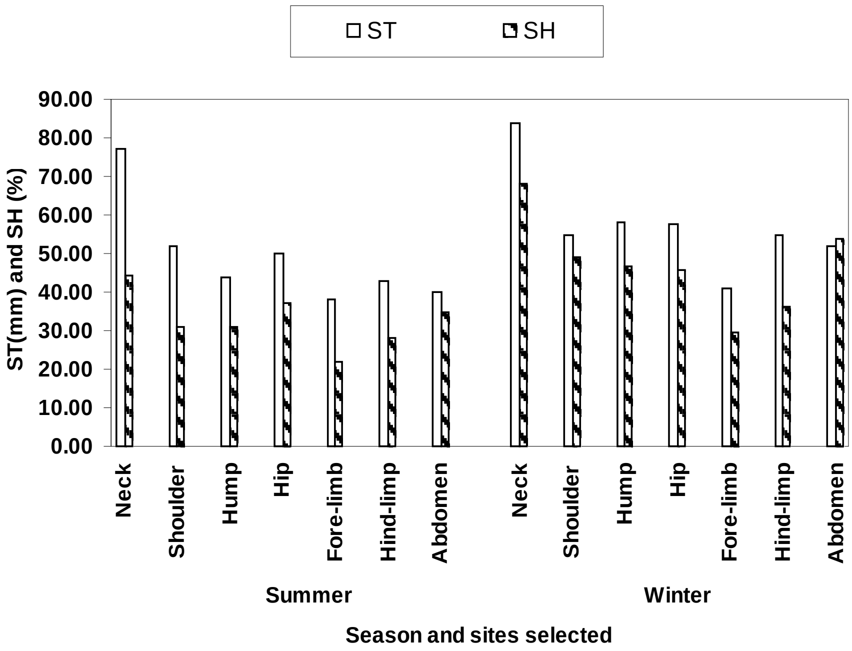

Figure (3): Skin thickness (ST) and its water content (SH) at various sites of adult she-camel during summer and winter seasons

Stosic, (1994) reported that in goat skin the whole thickness of the dermis layer and its architecture is known to be altered in response to the hair growth cycle, becoming thicker when the hair is actively growing (anagenesis phase) during winter season and thinning during the resting period (telagen phase). Campbell *et al*, (2006) found that there was a strong positive correlation ($r^2 = 0.58$, $P<0.05$) between skin water and both live body weight and total body water in piglets.

The results in Table 3 revealed that ST and SH% at FL site had lower ($P<0.01$) levels of water (SH%) compared with HL site during summer and winter seasons. The values of ST and SH% were (3.8 mm, 22%) and (4.3 mm, 28%) for FL and HL sites, respectively during summer season. The corresponding values during winter season were (4.1mm, 29.5%) and (5.5 mm, 36.2%) at FL and HL sites, respectively. This result was in agreement with a study by Kamalu *et al*., (1985), who reported that the fore-limb site had a lower ($P<0.05$) skin thickness than the hind-limb location of three breeds of cattle.

Electrical Conductivity

The average of electrical conductivities ($Ohm^{-1}/m^{-1}x10^6$) as shown in Table 4 revealed that their values are more in winter months than in summer months. It is also found that, in the summer season, the smallest values are recorded in June and the highest values are recorded in August. In addition to the fact that in winter season the highest values are reported in January, while the smallest values are reported in December.

The average of the electrical conductivities of the different skin regions in both summer and winter season recorded in Table 4 showed that the electrical conductivity of the skin of the neck region had the highest values (33.3 and 122.3 $Ohm^{-1}/m^{-1}x10^6$) in both summer and winter seasons, respectively. While the lowest value of the electrical conductivity found on the skin of the fore-limb was 0.82 and 42.10 in both summer and winter seasons, respectively.

Table 4: Average of electrical conductivity (Ohm^{-1}/m^{-1} multiplied by 10^6) at different skin regions

	Season	Summer							
Animal no.	Regions	Shoulder	Hip	Hump	Neck	Flank	Fore limb	Hind limb	Abdomen
1		12.30	29.60	7.80	32.50	28.20	0.82	2.20	19.80
2		12.70	30.00	8.00	33.30	28.30	0.82	2.50	19.50
3		12.40	30.50	8.20	33.40	28.30	0.81	2.60	20.00
4		12.80	29.50	7.50	33.60	28.80	0.81	2.30	19.60
5		13.20	30.00	8.30	33.70	28.80	0.83	2.30	20.00
Mean		12.7	29.90	8.00	33.30	27.50	0.82	2.40	20.00

	Season	Winter							
Animal no.	Regions	Shoulder	Hip	Hump	Neck	Flank	Fore limb	Hind limb	Abdomen
1		87.20	91.20	61.50	121.30	101.30	42.00	49.40	93.50
2		88.60	92.50	60.80	123.00	99.50	42.00	48.80	93.70
3		88.60	92.00	62.10	122.30	100.30	41.30	49.50	95.00
4		87.80	92.30	62.60	121.60	103.30	41.70	50.60	96.00
5		88.40	92.60	62.60	123.30	102.30	41.50	50.00	95.60
Mean		88.10	92.10	62.00	122.30	101.30	42.10	49.60	94.80

It is clear that the analysis of variance performed on the electrical conductivity of the different skin regions as shown in Table 4 proved that the variations between the seasons regions were statistically highly significant ($P<0.01$). On the other point of view, the electrical conductivities were varied greatly and directly, according to both the differences in the sites of the skin and the different seasons (summer and winter).

Table (5): Analysis of variance performed on electrical conductivity (Ohm^{-1}/m^{-1} multiplied by 10^6) of different skin regions of the camels.

Sources of variations	Degree of freedom	Mean Square
Seasons	1	83399.26 **
Regions	7	3989.10 **
Seasons X Regions	7	667.98 **
Error	64	0.43

**** P<0.01 S.D. = 38.0 S.E. = ±4.3**

It is clear in Table 6 that there is a positive correlation between the electrical conductivities of the different skin regions and the water content of the same region. These correlations coefficient were (r=+0.3 and +0.44) in summer and winter seasons respectively. Figure 4 showed that the increase of the water content of the skin was accompanied by the increase of the electrical conductivities of the corresponding skin regions. The same figure also showed that the rate of the increase of both water content and the electrical conductivity were more in winter than in summer season.

Table (6): The mean of water content (arcsin √gm %) at the different skin regions, mm (x 10) and electrical conductivity (Ohm^{-1}/m^{-1} x 10^6) of the same regions in summer and winter

Regions	Summer		Winter	
	Water content	Electrical conductivity	Water content	Electrical conductivity
Shoulder	33.80	12.70	44.30	88.10
Hip	37.70	29.90	42.60	92.10
Hump	33.70	8.00	43.60	62.00
Neck	41.80	33.30	55.60	122.30
Flank	37.50	27.50	48.60	101.30
Fore-limb	27.90	0.82	47.30	42.10
Hind-limb	31.90	2.40	32.80	49.60
Abdomen	36.20	20.00	37.20	94.80

r = Correlation coefficient r = +0.30 in summer season
r = +0.44 in winter season

It was observed that the electrical conductivity differs in the different skin regions according to the variability of the transepidermal quantity of fluids (Loden *et al.* 1992 and Dick and Scott 1992). Moreover, it was found that the electrical conductance and capacitance of the surface area of the skin was much increased with the increase of its humidity rather than with its lipidization (Serup 1992). It was revealed that the capacity of the skin for binding water was influenced directly by the electrical conductivity. The more hydrophobic, the rapid desperation of water and consequently the more electrical conductivity (Wickett *et al.* 1993). Electrical conductivity is used as an indicator of water content. It differs according to different climatic conditions as these conditions affect the skin water content (SH%).

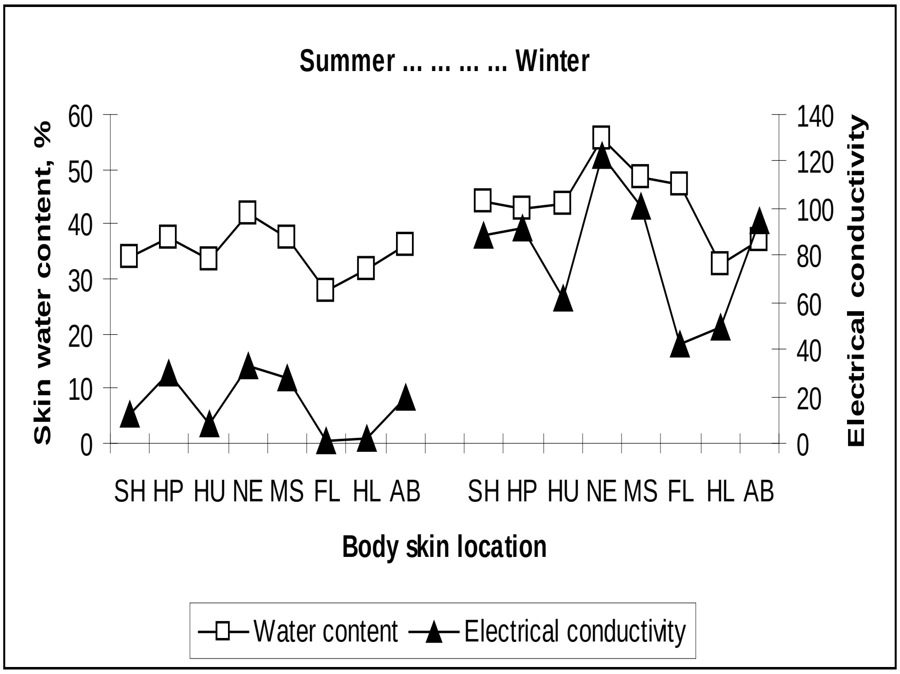

Figure 4. Water content (%) and electrical conductivity ($Ohm^{-1}/m^{-1} \times 10^6$) of the different skin locations in summer and winter.

Conclusion

Generally, it can be stated that skin surface temperature, skin thickness and skin hydration of one-humped camel differed as a consequence of the factors of sites of the animal's body, seasons and changes in live body weight. Summer stress reduced growth rate, possibly due to lower energy generation and impaired metabolism. Values of ST and SH% were higher during winter compared with summer values. This rise may be attributed to the increase in fat stored in subcutaneous layers and to the increase in body fluids. The values of the electrical conductivity of the skin were higher in winter months than in summer months. There was a positive correlation between the electrical conductivities of the different skin regions and the water content of the same region in summer and winter. Electrical conductivity is used as an indicator of water content, and it differs according to different climatic conditions that affect the skin water content (SH%). Further experiments can be conducted concerning the relationship between the water content of the skin and different body fluids.

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تأثير اختلاف الفصول على وزن الجسم ودرجة حرارة الجلد وسمكه ومحتواه المائي وتوصيله الكهربائي

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تعتبر حرارة الجلد هي المحصلة بين الحرارة التي ينتجها الجسم والحرارة التي يفقدها ، وقد صممت هذه التجربة لمقارنة تأثير درجة حرارة الجو في الحر (الصيف) والبرد (الشتاء) علي الاختلاف اليومي في درجة حرارة سطح الجلد وسمكه ورطوبته، وكذلك الاختلاف في وزن جسم الجمل أثناء هذين الفصلين ، ولذا أجريت هذه التجربة فى محطة بحوث مريوط – 35 كم شمال غرب الاسكندرية—التابعة لمركز بحوث الصحراء بالقاهرة. اختيرت خمس نوق من 6-8 سنوات بوزن ابتدائي 352±522 و 6.63± 613.0 لفصلي الصيف والشتاء بالترتيب. ووضعت الجمال في حظيرة غير مظللة. وقيست درجة حرارة الجلد وسمكه ومحتواه المائي وتوصيله الكهربائي في سبع مناطق وهي: الرقبة، والكتف، والسنام، والجنب، والأرجل الأمامية والخلفية في جهتي جسم الحيوان. وأخذت القياسات الساعة (6 و 12 و 18) أثناء العشرة أيام الوسطي من كل شهر في الصيف (من يونية إلي أغسطس)، والشتاء (من ديسمبر إلي فبراير). وقيست أيضاً الحرارة اليومية والرطوبة النسبية في الساعة (6 و 12 و 18) .

أظهرت النتائج أن درجة حرارة جلد السنام (الأكثر عرضة للشمس) اختلفت جوهرياً عن درجة حرارة البطن (الأقل عرضة للشمس). وكان الفرق بينهما 5.13 و 6.44 خلال فصلي الصيف والشتاء علي الترتيب. واختلفت درجات حرارة الجلد في المناطق المختارة جوهرياً في الشتاء عن الصيف. وكالمتوقع كانت درجة حرارة الجلد ظهراً (12:00) أعلي من درجة حرارة الصباح (06:00) والمساء (18:00)، وكانت الزيادة جوهرية في الصيف عن الشتاء.

أما سمك الجلد فقد كانت مناطق الرقبة والكتف والسنام والجنب هي الأكثر سمكاً واحتواءً للماء من المناطق الأخري أثناء الشتاء والصيف ، كما كان سمك الجلد ومحتواه المائي أعلي في الشتاء عن الصيف. ويمكن أن يعزي ذلك إلي زيادة الدهون المخزنة تحت الجلد، وزيادة سوائل الجسم في منطقة الجلد. كان التوصيل الكهربى للجلد أعلى فى الشتاء عنه فى الصيف فكانت منطقة الرقبة أعلى المناطق من حيث التوصيل الكهربى للجلد. أما الارجل الامامية فسجلت أقل الدرجات للتوصيل الكهربى للجلد صيفا و شتاء و كانت هناك علاقة ارتباط بين التوصيل الكهربى للجلد فى المناطق المختلفة و بين المحتوى المائى لنفس المناطق.

قام بتحكيم البحث

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