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HEAT STORAGE IN RELATION TO SOME COAT CHARACTERISTICS IN SHEEP AND GOATS UNDER DESERT CONDITIONS

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ABSTRACT

To define the heat storage which may be considered as an important factor in adaptability for sheep and goats under desert conditions as well as to spotlight the coat contribution in thermoregulatory responses in summer, 20 Barki rams and 20 Baladi bucks were used in this study from the Desert Research Center flock raised at Maryout Research Station. Animals were kept in open pens exposing to direct sun light. Staple length STL, fibre diameter FD, and different coarse medullated fibres percentage (C1-C2-C3) % were measured. Rectal temperature RT, skin temperature ST, ear temperature ET, coat temperature CT and respiration rate RR were recorded. Plasma thyroxine T4, triiodothyronine T3 and cortisol levels were determined. Rams recorded higher (P>0.01) heat storage values (x=677.815kj) than bucks (x=496.38kj). Live body weights BWs of higher heat storage animals (HHS) were decreased than BWs of low heat storage animals (LHS). The heat storage / body weight (H/B ratio) of HHS groups were higher (P>0.05) than LHS groups of both the two species. Rams of HHS group were lower (P>0.05) in H/B ratio (16.97kj/kg) than the same group in bucks (18.09kj/kg). The HHS groups of rams and bucks had lower values of RT, ST, ET and RR than LHS groups. Rams and bucks of HHS groups recorded an increase in CT compared to LHS groups at 2 p.m. The HHS group of bucks tended to decrease in RT, ST, CT and RR values in comparison with the same group of rams. On the other hand, ET of HHS bucks group was higher than the same group of rams. Moreover, RR values of HHS groups were lower (P>0.05) than LHS groups in the two species which may indicate that the HHS animals appeared to be more able to conserve water by having lower respiratory rate than those of LHS animals under desert conditions in summer. The HHS group of bucks had lower (P>0.05) RR than the same group in rams, which means that bucks of HHS group could more efficiently regulate their water turn over rate than that of rams. Rams and bucks of the HHS groups recorded lower (P>0.05) plasma concentrations of T3 and cortisol than those animals of LHS groups. Plasma T3 concentrations of both HHS and LHS groups in bucks were higher (P>0.01) than those in rams, whereas the former groups of bucks had slightly lower concentrations for each of plasma T4 and cortisol than in rams, which may indicate that rams tended to reduce plasma T3 levels more than bucks in order to likely reduce relatively heat production. The animals of HHS groups had more of coarse medullated fibres percentage for type (C1), fibre diameter (FD) and staple length (STL); whereas they recorded less coarse medullated fibres percentage for type (C3) compared to those of LHS animals in the two species. According to their insulative properties, coarse medullated fibres (C1%) which existed in animals of HHS groups could cause values tendency in their RT, ST, ET, RR, T3 and cortisol leading to more regulated elevation of their core body temperature than animals of LHS groups. It is believed that both the two fleeces of higher heat storage groups of rams and bucks had staple length, fibre diameter and coarse medullated fibres enough to regulate their bodies temperatures than those had lower heat storage under solar radiation during hot summer in desert.

Keywords: Sheep; Goats; Heat storage; Thermoregulation; Physiological parameters; Blood constituents; Wool; Hair

INTRODUCTION

The heat stored by the animal body is the product of the mean specific heat and the mean temperature rise; or the sum of the products of the specific heats and temperature rises of each component tissue or organ. In this total must be included the rise in temperature of the fleece. Heat stress is one of the major causes for concern for the welfare of endurance animals raised in desert. Heat stress arises due to increasing heat storage within the animal resulting from inefficient dissipation, often accompanied by dehydration (Hodgson *et al*, 1994). Heat that not dissipated through sweating is stored (causing an increase in core body temperature) or dissipated via the respiratory tract and other mechanism (Juliana, 2001). Some desert animals do allow changes in body core temperature when this is advantageous. For example of a trend in camel of 500kg body weight is storing 10kj midday heat, worth of 4 liters of water if dissipated by evaporation instead, in its body by allowing a temperature rise from 35 to 41°c (Houpt *et al*, 2000). However, animals in ordinary conditions tend to maintain a resting body temperature, *i.e.* heat acclimation state, of about 30°c (Lindinger *et al*, 2000). Heat exchangers in animals prevent heat from being lost to cold peripheral tissues by removing it from hot arterial blood before it reaches the skin surface and returning it to body core in venous blood. Thus, animals can serve this heat conservation, and can be bypassed when needed. (Geor *et al*, 2000). Higher heat storage-animals showed higher body weights compared with lower heat storage-animals (Khalil *et al*, 1997). Accordingly, higher heat storage-animals appeared to be more able to conserve water by having lower respiratory rate compared with those of lower heat storage-animals (Bianca, 1968). Moreover, Abd-ElGhany (1994) observed that higher heat storage-sheep had significantly by ($p<0.05$) more coarse fibres and less fine fibres compared to that of low heat storage-ones. Coarse fibres and its distribution over the body seemed to be of efficient insulating properties for tolerating heat compared with fine fibres, but denser and longer wool coat acts to maintain heat at long time (Fernandez *et al*, 1992), it also forms a good protective integument of the animal from the penetration of heating rays (Khalifa, 1979). Animals suffered from heat load in summer act to reduce their endogenous heat production in turn heat storage by reducing the functional activity of the thyroid gland *i.e*.,T3 secretion rate (El-Sherbiny *et al*,1983), and increasing the adrenal cortex activity to secret cortisol (Abd-ElGhany,1997). The present study has two goals; firstly is to determine the heat storage in both of Barki sheep and Baladi goats exposed to solar radiation and secondly to find out the relationship between the determined heat storage and some coat characteristics in the two breeds.

MATERIALS AND METHODS

Animals care and management

This study was performed on adult 20 Barki rams and 20 Baladi bucks aged 2-3 years. Animals were respectively (40.18±1.87 kg) and (28.70 ±1.06 kg) of body weight from the Desert Research Center flock raised at Maryout Research Station (31.02° N Latitude) at the North-Western Coastal Desert of

Egypt, where the climate was hot with intensive solar radiation and subsequently poor natural vegetation in summer season. Experimental rams and bucks were offered berseem (Trifolium alexandrimum) hay *ad lib* and 1/2 kg/head/day of concentrate mixture during the study. Water was provided *ad lib* twice a day. All animals were healthy and clinically free from diseases.

The two experimental groups were kept in two open pens exposed to direct solar radiation (for about six hours daily) as long as 60 days started at the first of July 2000 and extended up to the end of August 2000. Meteorological data at the site of the experiments during the course of measurements are presented in Table (1).

Table (1): Means and standard errors ($\bar{X}$ $\pm$SE) of meteorological data as long as the experiments

Meteorological Parameter	July 2000		August 2000	
	Tm 1	**Tm 2**	**Tm 1**	**Tm 2**
AT°C	25.3 ±0.042	39.4 ±0.077	26.6 ±0.034	39.7 ±0.015
SoT°C	24.6 ±0.033	34.3 ±0.001	25.3 ±0.089	36.2 ±0.006
SR°C	28.1 ±0.064	45.8 ±0.063	33.1 ±0.067	46.3 ±0.057
RH%	69.9 ±0.055	55.6 ±0.010	65.2 ±0.185	52.5 ±0.001

AT: ambient temperature °C, SoT: soil temperature °C, SR: solar radiation °C, RH%: percentage of relative humidity, Tm 1: (8:00 a.m.) and Tm 2: (2:00) p.m.

Measurements

Experimental animals were daily observed in order to record any abnormal clinical signs. Animals were weighed at the start and also at the end of the experiment. Staple length STL, fibre diameter FD, and different coarse medullated fibres percentage (C1-C2-C3)% were measured for both rams and bucks, where C1 represents the higher coarse medullated fibres percentage in coat samples measured, whereas C2 and C3 have less percentage of coarseness. Rectal temperature RT, skin temperature ST, ear temperature ET, coat temperature CT and respiration rate RR were weekly measured at 8:00a.m. (Time 1) and 2:00 p.m. (Time 2) for the all experimental groups. Blood samples were bi-weekly collected by jugular vein at 8:00a.m. (Time 1) and 2:00 p.m. (Time 2) for determining the plasma thyroid activity; thyroxine T4 and triiodothyronine T3 secretions and the activity level of adrenal cortex; cortisol secretion. Wool and hair samples of about 20gm for each breed were collected from the right mid-side position for each animal, a small greasy sub-sample (of 10 staples) was taken at random from each mid-side sample and was used to measure STL, FD and (C1-C2-C3) %. In the greasy sub-sample, STL was the average of 10 staples; measurements were made from the base to the dense part of the tip of the staple to the nearest 0.5cm without applying any longitudinal tension. Fiber diameter was measured from the greasy sub-samples on 300 fibers using a microscope and image captured by Image Analyzer (LEICAQ 500 MC). Benzene test was used at times to distinguish between the different medullated fibers; C1, C2 and C3. Rectal, skin, ear, coat and soil temperatures were measured by using a Yellow Spring Telethermometer (model YSI 46). The RR was done by counting flank movement/min. Plasma samples were analyzed by radioimmunoassay (RIA) for determining the blood concentrations of thyroxine, triiodothyronine and cortisol using laboratory kits (California 90746, USA). Ambient temperature °C and relative humidity percent were measured by a digital thermohygrograph. A black body temperature was used to measure the degree of solar radiation °C, which is an indicator of heat exposure in the desert (Dill *et al*, 1973).

Heat storage calculation

Heat storage indices for both rams and bucks exposed to solar radiation were calculated for each animal by the following equation reported by Whittow (1986):

$$\mathbf{S}_h = \Delta \mathbf{T}^{\backslash}{}_b \times \mathbf{t}_g \times \mathbf{p}$$

Where;

$\mathbf{S}_h$: heat storage by kj (kilo joule),

$\Delta \mathbf{T}^{\backslash}{}_b$: change of mean body temperature in °C,

$\mathbf{t}_g$: body mass in kg,

p : the mean specific heat of the body mass (3.5 kj /kg/ °C, reported as a constant for mammals).

The median for the all animals' heat storage was then calculated. Rams and bucks were grouped according to changes in their calculated heat storage for each animal in the two species during exposure to solar radiation, as long as July and August (60 days), into high heat storage group HHS which was higher than the heat storage's median and low heat storage group LHS which was lower than the heat storage's median. The grouping was done as the value was higher or lower than the heat storage's median value as (621.780 kj) for rams and as (453.012 kj) for bucks. The median value divided the calculated heat storage data into 50% percentile. Therefore, each heat storage group contained 10 animals for both the two species studied. The ratio of heat storage/body weight (H/B) kj/kg was calculated. Data were statistically analyzed using SAS program (1998). Split plot design for repeated measurements was applied. Duncan's multiple range test (Duncan, 1955) was used for comparison among means.

RESULTS AND DISCUSSION

1- Heat storage and body weight

With aid of the calculated heat storage's median value (621.780kj) for rams and (453.012kj) for bucks, rams and bucks were partitioned into two heat storage groups; LHS; lower than median value and HHS; higher than median value with very highly significant difference ($P>0.001$). The median value divided the recorded heat storage data from all animals into 50% percentile. Heat storage values of the different groups for rams and bucks are presented in Table (2). The mean value of recorded heat storage of HHS group in rams (677.815±33.091kj) was significantly ($P>0.01$) higher than that in bucks (496.38±19.383kj). Similarly, the same trend was noticed in the lower heat storage groups LHS ($P>0.01$) which was (548.25±24.877kj) in rams and (428.87±22.466kj) in bucks, (Table 2). On Barki ewes, Khalil *et al* (1997) recorded less of heat storage than the present study as (640.47±30.90kj) and (456.63±16.1kj) for higher and lower heat storage ewes, respectively. The difference between this recorded values and the present study's estimates could be initially referred to different sex and/or different climatic conditions.

Table (2): Means and standard errors ($\overline{X}$ ±SE) of calculated heat storage, body weight and heat storage / body weight ratio for two different categories of heat storage groups of Barki rams and Baladi bucks

Species		Rams			Bucks		
Heat storage groups		Heat storage (kj)	BW (kg)	H/B ratio (kj/ kg)	Heat storage (kj)	BW (kg)	H/B ratio (kj/ kg)
LHS	$\overline{X}$	548.250^{B,a}	40.41	13.57 ^{B}	428.87^{B,b}	29.95	14.32^{B}
	± SE	±24.877	±1.570	±0.630	±22.466	±1.221	±0.346
HHS	$\overline{X}$	677.815^{A,a}	39.94	16.97^{A,b}	496.38^{A,b}	27.44	18.09^{A,a}
	± SE	±33.091	±1.013	±0.428	±19.383	±0.940	±0.110

LHS: lower heat storage group; HHS: higher heat storage group; BW: body weight; H/B ratio: heat storage / body weight. a, b within a raw followed by the same superscript letter are not significantly different A, B within a column followed by the same superscript letter are not significantly different

Body weights BWs of the higher heat storage groups HHS of both rams (39.94±1.013 kg) and bucks (27.44±0.940 kg) tended to decrease compared to that of the lower heat storage groups LHS; (40.41±1.570kg) and (29.95±1.221kg) for rams and bucks, respectively. Abd-ElGhany (1994) reached to the same trends on Barki ewes. H/B ratio of the HHS groups in rams and bucks were significantly (P>0.05) higher than LHS groups, (Table 2). Despite having higher heat storage in their bodies than in bucks, rams of HHS group were significantly (P>0.05) lower in H/B ratio (16.97±0.428kj/kg) than the same group in bucks (18.09±0.110kj/kg). The same respective order was found in LHS groups for the two species. This difference between rams and bucks in H/B ratio may refer to the marked differences in live body weight. In smaller body sized-animals, the surface/volume ratio and hence, the relative surface from which heat is dissipated increases (Macfarlane *et al*, 1958). In addition, Bianca (1968) found that small animals require a greater heat production per unit of weight than large animals, if the same body temperature is to be maintained. Moreover, (Mitchell *et al*, 1976) stated that heat storage limitations are primarily depended on the extensive muscle mass, the high mass-specific rate of metabolic heat production and the low mass-specific surface area for heat dissipation. Therefore, H/B ratio is of an important indicator that may determine- to a large extent- the considerable heat storage value in animals exposed to long thermal stress.

2- Heat storage and physiological responses

It is clearly observed from Table (3) that although HHS groups in both rams and bucks were higher in heat storage values than LHS groups (Table

2); they had lower values of RT, ST, ET and RR at Tm2 than LHS groups. On the other hand, CT seemed to have another trend in the two species.

Table (3): Means and standard errors ($\bar{X}$±SE) of some studied physiological parameters for two different categories of heat storage groups of Barki rams and Baladi bucks

Physiological parameter	Ram				Buck			
	LHS		HHS		LHS		HHS	
	Tm1	Tm2	Tm1	Tm2	Tm1	Tm2	Tm1	Tm2
RT°c	39.28^{a}	39.95^{a}	39.34^{a}	39.77^{aA}	38.35^{a}	39.84^{a}	38.62^{a}	39.65^{aA}
	0.238	0.214	0.238	0.564	0.276	0.247	0.240	0.247
ST °c	35.56^{a}	37.81^{a}	35.28^{a}	36.55^{aA}	34.40^{a}	37.97^{a}	33.50^{a}	36.08^{aA}
	0.628	0.375	0.628	0.375	0.524	0.477	0.829	0.677
ET °c	22.44^{b}	35.11^{a}	24.75^{b}	34.82^{aA}	21.60^{b}	35.61^{a}	21.67^{b}	35.50^{aA}
	0.561	0.630	0.561	0.205	0.639	0.616	0.826	0.616
CT °c	27.25^{a}	41.97^{bA}	28.50^{a}	47.86^{aA}	31.80^{a}	35.00^{aB}	32.00^{b}	35.45^{aB}
	0.628	0.445	0.628	0.505	0.709	0.663	0.709	0.663
RR /min	43.50^{b}	88.67^{aA}	47.00^{b}	78.55^{bA}	26.67^{b}	74.00^{aB}	27.50^{b}	60.50^{bB}
	4.925	5.507	6.359	5.507	4.04	3.50	4.95	3.50

RT: rectal temperature; ST: skin temperature; ET: ear temperature; CT: coat temperature; RR: respiration rate; LHS: lower heat storage group; HHS: higher heat storage group; Tm1: 8:00am; Tm2: 2:00pm. a ,b within a raw within species followed by the same superscript letter are not significantly different A, B within a raw between species followed by the same superscript letter are not significantly different

Rams of HHS group recorded a significant (P>0.05) increase in CT (47.86±0.505°c) than LHS group (41.97±0.445°c), at Tm2, which probably because of the insulate properties of the coat, which may decrease heat dissipation, in turn elevates heat storage in HHS groups of rams and bucks compared with LHS groups. With not significance, bucks tended to have the same trend, (Table 3). Higher heat storage group HHS of bucks tended to significantly (P>0.05) decrease in CT and RR values than the respective order in rams, at Tm2. Evaporative water loss in sheep is primarily from the respiratory tract, since Khalifa (1979) found a very low sweat rate in Barki sheep. The other physiological parameters (RT and ST) had the same trend without significant differences. On the other hand, ET of HHS bucks group at Tm2 showed an opposite trend as compared with the same group of rams; (35.50±0.616°c) vs. (34.82±0.205°c), respectively. However, this difference was not significant. Gonzalez *et al* (1999) calculated that convective heat loss from the ears of a Jack rabbit could amount to nearly all of the metabolic heat production and greatly conserve water loss at an air temperature of 30°c, but at air temperatures of 40°c or above, convective heat loss from the ears is not adequate to do more than offset the gains from radiation. For sheep under severe heat stress, blood flow to leg and ear skin increased five-folds, but flow to body skin stayed unchanged (Bligh *et al*, 1965).

Although CT of HHS group for rams at Tm2 was significantly (P>0.01) higher (47.86±0.505°c) than that bucks (35.45±0.663°c), ST was approximately still at the same value for the two species, (Table 3). This could refer to the important insulate role of wool coat in terms of coat depth, crimps and staple structure, which could protect sheep from sever solar radiation in desert than hair. Lower recorded values of rectal temperature RT and ST at Tm2 were concomitant with HHS than LHS groups for the two species. In several species, it has been unequivocally demonstrated that repeated exposure to heat stress over many days improves exercise capabilities and reduces rectal temperature and physiological strain (Raymond *et al*, 2000). It is well established by (Macfarlane, 1968) that blood flow to the skin increased by increasing AT, via decreased total peripheral resistance by vasodilatation, which contributes to higher ST observed in summer. In the present study, RT of HHS groups in both rams and bucks closely followed the changes of ambient temperatures AT at Tm2 (Table 1), whereas animals of low heat storage LHS exceeded AT with approximately 0.5°c. Moreover, RR values of HHS groups were lower than LHS groups in the two species which may indicate that respiratory evaporative cooling was more adequate in the two HHS groups which could regulate body temperature to a certain tolerable level in face of heat stress than the other animals of LHS groups. Thus, the higher heat storage animals appeared to be more able to conserve water by having lower respiratory rate than those of lower heat storage animals. As compared with rams, the HHS group of bucks had significantly ($P>0.05$) lower RR at Tm2; (60.50±3.50/min) than the same group at the same time; (78.55±5.507/min) in rams, which means that bucks of HHS group could more efficiently regulate their water turn over rate than that of rams, in turn, they increased ability to conserve water during long exposure to heat stress. Often, sheep and goats get shallow panting under highly degree of solar radiation for conserving water and blood pH stability (Salem *et al*, 1982).

3 - Heat storage with thyroid and adrenal cortical functions

Plasma concentrations of thyroid and adrenal cortex activity for LHS and HHS groups of the two species were shown in Table (4). Rams and bucks of higher heat storage groups HHS had significantly ($P>0.05$) lower plasma concentrations of both triiodothyronine T3 and cortisol than those animals of lower heat storage groups LHS. On the other hand, plasma thyroxine T4 concentration showed an opposite trend, although it did not reach to the significant level. This may indicate that the incidence of heat storage by animals for coping with LHS groups which exerted a thermal burden in their bodies than that in HHS groups of the two species. This result also suggests that the increase in cortisol levels (as a stress hormone) in LHS groups indicated that animals of LHS groups could more suffer than those of HHS groups under high solar radiation. El-Sherbiny *et al* (1983) found that animals suffered from heat load in summer act to reduce their endogenous heat production by reducing the functional activity of the thyroid gland i.e., T3 secretion rate and/or would exercise vasodilatation of the blood flow to the skin in order to increase their heat dissipation. Badawy (1999) illustrated that high environmental temperature was found to increase the level of cortisol as apple to withstand heat stress by inducing an increase secretion of the gloucocorticoids in Saidi sheep. In addition, Asaad *et al* (1997) found that high solar radiation increases adrenocorticotrophic hormones index in camels. In the present study, it is obviously noticed from

Table (4) that plasma T3 concentrations in both HHS and LHS groups of bucks were significantly (P>0.01) higher than those of rams, whereas the former groups of bucks had slightly lower concentrations for each of plasma T4 and cortisol than in rams. These differences were not significant. It is well known that T3 is recognized as a powerful metabolic agent for increasing heat production in sheep (Abdel-Bary, 1982). Thus, in the present study, during a long exposure to heat stress in summer rams tended to reduce T3 secretion more than bucks in order to likely reduce relatively heat production. However, bucks could not capable of increasing heat dissipation similar to that of rams under heat stress (Azzam and Abd-ElGhany, 2003).

Table (4): Means and standard errors ($\bar{X}\pm$ SE) of some plasma hormones for two different categories of heat storage groups of Barki rams and Baladi bucks.

Plasma hormone	Ram		Buck	
	LHS	HHS	LHS	HHS
T_3ng/dl	85.50 ^{aB} ±5.50	70.80 ^{bB} ±4.90	106.70 ^{aA} ±31.90	86.70 ^{bA} ±19.70
T_4µg/dl	6.68 ^{aA} ±0.55	6.71 ^{aA} ±0.52	5.40 ^{aA} ±0.63	5.47 ^{aA} ±0.70
Cortisolµg/dl	3.93 ^{aA} ±0.45	2.26 ^{Ba} ±0.42	3.47 ^{aA} ±0.33	2.09 ^{bA} ±0.25

T_3: triiodothyronine; T_4: thyroxine; LHS: lower heat storage group; HHS: higher heat storage group; µg = micro-gram; ng = nano-gram; dl. = 0.10 liter. a ,b within a raw within species followed by the same superscript letter are not significantly different A, B within a raw between species followed by the same superscript letter are not significantly different.

4- Heat storage and coat characteristics

Table (5) shows that the animals of HHS groups had more of coarse medullated fibres percentage for type (C_1); that contained a highly degree of coarseness, fibre diameter (FD) and staple length (STL); whereas they recorded less coarse medullated fibres percentage for type (C_3); that contained a lowest degree of coarseness, compared to those low heat storage animals LHS in the two species. This finding might indicate that the higher heat storage animals appeared to be more able to regulate their body temperature compared with those of lower heat storage animals. Although, STL differences between groups were not significant (Table 5), it is considered among those effective fleece features, which may play an important role in thermoregulation. Schmidt-Nielsen (1979) reported that sheep with fleece of 4 cm coat depth sustained a temperature gradient of 45°c between the tip and skin. Acharya *et al* (1995) concluded that longhaired goats tolerate radiant heat better than shorthaired goats.

Table (5): Means and standard errors ($\bar{X}\pm$SE) of some wool and hair coat characteristics for two different categories f heat storage groups of Barki rams and Baladi bucks

Coat	Rams	Bucks

characteristics	LHS	HHS	LHS	HHS
STLcm	7.38 a	8.06 a	11.77 a	13.88 a
	0.25	0.22	1.732	1.342
FD µm	31.02 a	33.94 a	68.04 b	79.38 a
	0.466	0.521	1.093	1.338
C_1%	32.27 b	36.70 a	62.66 b	77.85 a
	1.86	2.15	6.262	8.084
C	35.40 a	31.59 a	23.20 a	17.30 b
	1.46	2.08	2.854	3.684
C_3%	32.33 a	31.71a	14.14 a	4.85 b
	1.92	1.63	4.759	6.145

STL: staple length; FD: fibre diameter; C1%: high percentage of coarse medullated fibres; C2%: moderate percentage of coarse medullated fibres; C3%: low percentage of coarse medullated fibres; LHS: lower heat storage group; HHS: higher heat storage group. a ,b within a raw within species followed by the same superscript letter are not significantly different

In the present study, coarse medullated fibres with their large diameter of HHS groups are likely to be more insulative than fine fibres, therefore leading to increased heat storage into bodies of these animals perhaps in order to reduce heat gain. Khalil *et al* (1997) stated that coarse fibres and its distribution over the body seemed to be of efficient insulating properties for tolerating heat compared with fine fibres. In addition, longer STL acts to maintain heat at long time, and it also forms a good protective integument of the animal from the penetration of heating rays and hindering heat loss by evaporation and reducing conduction and radiation from the skin to the surrounding atmosphere. Moreover, Giuseppe *et al* (2002) showed that the thermal insulation provided by the fleece reduces convective heat loss from the body in cold environments and reduces radioactive heat gain in hot environments. In the case of the present study, more coarse medullated fibres (C_1%) existed in animals of HHS groups (Table 3), could cause a tendency in their values of RT, ST, ET and RR leading to more regulated elevation of their core body temperature than animals of LHS groups under heat stress of solar radiation. Abd-ElGhany (1994) recorded lower RT, ST and RR in the higher heat storage group of Barki ewes under heat stress. Schleger and Turner (1960) and Hayman (1965) pointed out that the double coat and incidence of medulla in the outer coat fibres are of great importance. A higher degree of medullated fibres in summer coat would help animals to be more heat tolerant. Dowling (1959) report a correlation (r=0.95) between medulla and animal ability to regulate body temperature. In addition, Benjamin (1985) believed that high degree of medullation made Indian Jersey, Hereford and Charolaris cows more heat tolerant than European breeds, which helped in reduction of external heat load. As shown in Table (4), LHS animals had higher concentrations of plasma cortisol in the two species than others of HHS animals. It was likely to have resulted in follicle shutdown and fibre shedding and perhaps reduced FD that, in turn, leading to decrease heat storage in these animals by increasing heat dissipation. Ansari and Hynd (2001) reported that increased plasma cortisol concentration in

South Australian, Strongwool Merino rams significantly (P>0.001) reduced wool follicle activity, hence, reduced wool production.

Generally, groups of higher heat storage animals tended to be consistently lower in Bw, RT, ST, ET, RR, T3, cortisol, C2% as well as C3% and had higher CT, T4, STL, FD and C1% as compared with groups of lower heat storage animals (Tables 2,3,4 and 5). Therefore, it is believed that both the two fleeces of higher heat storage groups had staple length, fibre diameter and coarse medullated fibres enough to regulate their body temperature during summer in desert.

Conclusion

Exposure to hot conditions for along consecutive time resulted in thermoregulatory adaptation (heat acclimation) in sheep and goats which enhanced thermosensitive ability to dissipate heat by increased shallow panting and to decrease heat gain by increase heat storage up to a tolerable physiological level. It is evident that the greater thermoregulatory limitations to hot humid conditions in desert imposed- to a large extent- on the animal coat, which plays an important role in thermoregulation.

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علاقة التخزين الحراري في الأغنام والماعز ببعض صفات غطاء الجسم تحت الظروف الصحراوية

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لتحديد أهمية التخزين الحراري كأحد العوامل الهامة لتأقلم الأغنام والماعز تحت ظروف الصحراء وكذلك دور غطاء جسم الحيوان في التنظيم الحراري في الصيف أجريت هذه الدراسة باستخدام ٢٠ كبش برقي و٢٠ تيس بلدي ضمن قطيع محطة بحوث مريوط التابعة لمركز بحوث الصحراء. وضعت الحيوانات في حظائر مفتوحة معرضة لأشعة الشمس المباشرة. تم قياس طول الخصلة وقطر الليفة وتقدير النسبة المئوية للألياف الخشنة ذات النخاع. كما أخذت قراءات كل من حرارة المستقيم وحرارة الجلد وحرارة الأذن ومعدل التنفس . تم تقدير تركيزات هرموني الغدة الدرقية "ثلاثي اليود ورباعي اليود" وهرمون الكورتيزول في بلازما الدم. سجلت الكباش تخزين حراري أعلى معنويا (٦٧٧,٨١٥كيلوجول) من التيوس (٤٩٦,٣٨٠كيلوجول). كانت أوزان الجسم للحيوانات مرتفعة التخزين الحراري أقل من مثيلاتها منخفضة التخزين الحراري. كانت نسبة التخزين الحراري إلى وزن الجسم في المجموعات مرتفعة التخزين الحراري أعلي معنويا منها في المجموعات منخفضة التخزين الحراري في كل من الكباش والتيوس. كباش المجموعة مرتفعة التخزين الحراري كانت أقل معنويا في نسبة التخزين الحراري إلى وزن الجسم (١٦,٩٧كيلوجول/كجم) عن مثيلتها في التيوس (١٨,٠٩كيلوجول/كجم). كان للمجموعات مرتفعة التخزين الحراري لكل من الكباش والتيوس قيما منخفضة في درجة حرارة المستقيم والجلد والأذن ومعدل التنفس عن المجموعات منخفضة التخزين الحراري. سجلت الكباش والتيوس مرتفعة التخزين الحراري زيادة في درجة حرارة غطاء الجسم عند الساعة الثانية ظهرا عن مثيلاتها منخفضة التخزين الحراري. اتجهت تيوس المجموعة مرتفعة التخزين الحراري نحو تسجيل قيما منخفضة في درجة حرارة المستقيم والجلد والغطاء ومعدل التنفس عن الكباش مرتفعة التخزين الحراري. من ناحية أخرى، كانت حرارة الأذن في التيوس مرتفعة التخزين الحراري أعلي منها في كباش نفس المجموعة. أظهرت قيم معدل التنفس للمجموعات مرتفعة التخزين الحراري انخفاضا معنويا عن مثيلاتها منخفضة التخزين الحراري في كل من الكباش والتيوس والذي قد يعني أن الحيوانات ذات التخزين الحراري المرتفع أظهرت مقدرة أكبر في الاحتفاظ بماء الجسم عن طريق تقليل معدل التنفس عن الحيوانات منخفضة التخزين الحراري تحت ظروف الصحراء في الصيف. كانت تيوس المجموعة مرتفعة التخزين الحراري أقل معنويا في معدل التنفس عن نظيرتها في الكباش والذي يعني أن التيوس مرتفعة التخزين الحراري قد تنظم معدل دوران الماء بالجسم بشكل أكثر كفاءة من الكباش. سجلت الكباش والتيوس مرتفعة التخزين الحراري تركيزات منخفضة معنويا لكل من هرمون ثلاثي اليود وهرمون الكورتيزول في بلازما الدم عن مثيلاتها منخفضة التخزين الحراري. كانت تركيزات هرمون ثلاثي اليود في بلازما دم المجموعات مرتفعة ومنخفضة التخزين الحراري للتيوس عالية معنويا عن مثيلاتها في الكباش، بينما كانت تيوس المجموعات السابقة منخفضة قليلا في تركيزات كل من هرمون رباعي اليود وهرمون الكورتيزول في بلازما الدم عنها في الكباش، والذي قد يعني أن الكباش اتجهت إلى تخفيض مستويات هرمون ثلاثي اليود بشكل أكبر من التيوس وذلك لتقليل الإنتاج الحراري النسبي بها. كانت الحيوانات مرتفعة التخزين الحراري بها قيم أعلي في نسبة الألياف الخشنة ذات النخاع من النوع (C1) وقطر الليفة وطول الخصلة بينما سجلت نفس الحيوانات قيما أقل في نسبة الألياف الخشنة ذات النخاع من النوع (C3) مقارنة بالحيوانات منخفضة التخزين الحراري في الكباش والتيوس . من المحتمل أن وجود الألياف الخشنة ذات النخاع من النوع (C1) ذات الصفات العزلية في الحيوانات ذات التخزين الحراري المرتفع قد تسبب في انخفاض قيم كل من حرارة المستقيم والجلد والأذن ومعدل التنفس وهرمون ثلاثي اليود وهرمون الكورتيزول في هذه الحيوانات مؤديا إلى مزيد من الارتفاع المنظم لحرارة أجسامها الداخلية عن الحيوانات منخفضة التخزين الحراري. يمكن القول بأن كلا من غطاء الصوف والشعر في الكباش والتيوس ذات التخزين الحراري المرتفع كان بها متوسط قطر ليفة وطول خصلة ونسبة ألياف خشنة ذات نخاع كافيا لتنظيم درجة حرارة أجسامها تحت حرارة الإشعاع الشمسي بالصحراء أثناء فصل الصيف مقارنة بالكباش والتيوس منخفضة التخزين الحراري .